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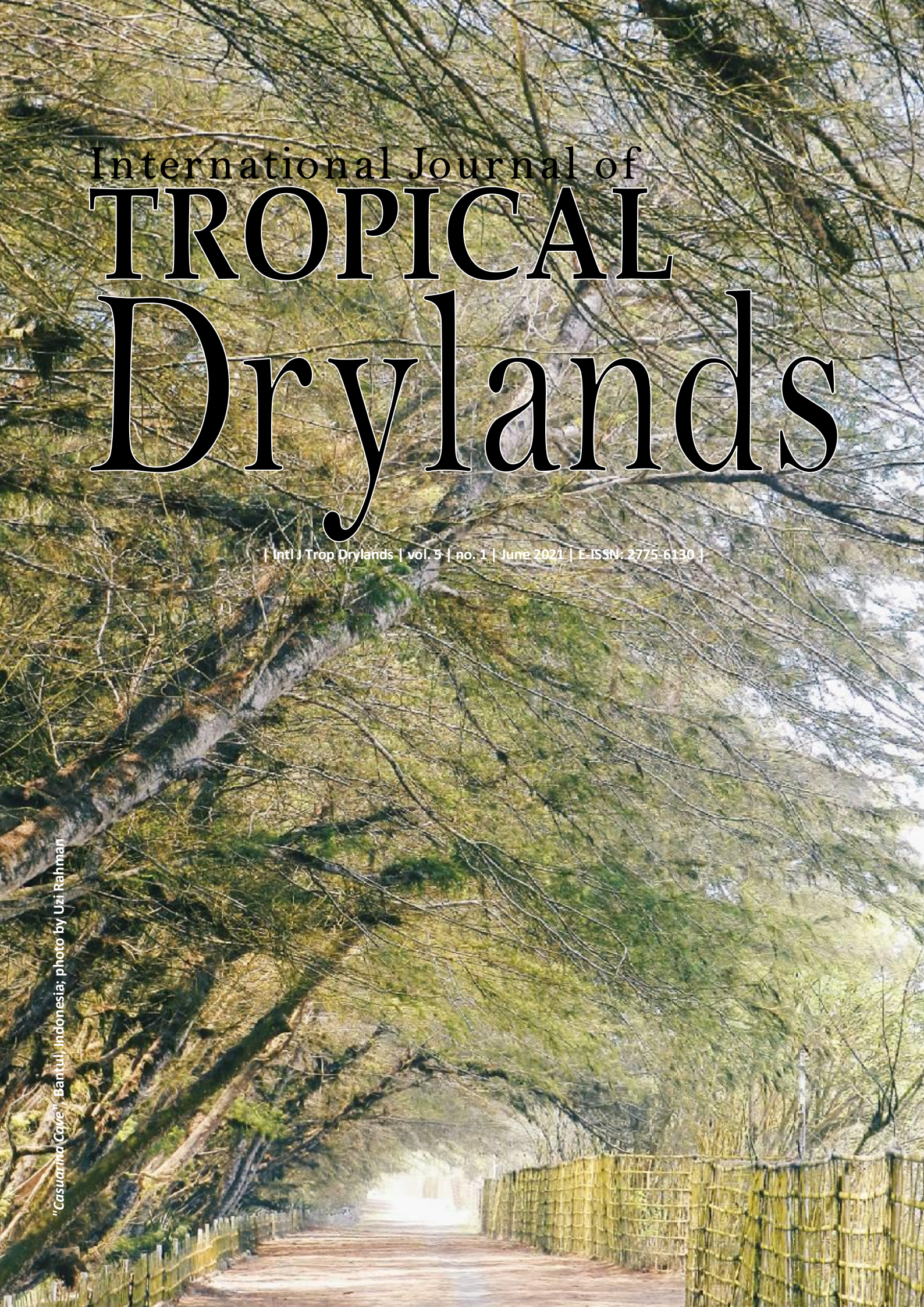

"Casuarina Cave", Bantul, Indonesia; photo by Uzi Rahman

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Smith J, Jones M Jr, Houghton L et al. 1999. Future of health insurance. N Engl J Med 965: 325-329. DOI: 10.10007/s002149800025.

Book:

Rai MK, Carpinella C. 2006. Naturally Occurring Bioactive Compounds. Elsevier, Amsterdam.

Chapter in the book:

Webb CO, Cannon CH, Davies SJ. 2008. Ecological organization, biogeography, and the phylogenetic structure of rainforest tree communities. In: Carson W, Schnitzer S (eds.). Tropical Forest Community Ecology. Wiley-Blackwell, New York.

Abstract:

Assaeed AM. 2007. Seed production and dispersal of *Rhazya stricta*. 50th annual symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds.). Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

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Short Communication: Agroforestry as sustainable agroecosystem in terrestrial semi-arid region, Indonesia: Evidence from soil organic carbon

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Abstract. *Moata MRS, Takalapeta AM. 2021. Short Communication: Agroforestry as sustainable agroecosystem in terrestrial semi-arid region, Indonesia: Evidence from soil organic carbon. Intl J Trop Drylands 5: 1-4.* Agroforestry system has been recognized as a better system for food security, especially during dry season in a tropical region. Therefore, the sustainability of this system becomes crucial for rural livelihood, especially in dryland areas. One indicator for sustainable agriculture system is the total amount and quality of the soil organic matter (SOM) which is expressed as soil organic carbon (C-org). Therefore, this study focused on soil quality of three land uses (forest, dryland agriculture with less input, and agroforestry) under Inceptisol, Entisol, and Alfisol from 36 locations at dryland terrestrial ecosystem in West Timor-Indonesia. The results showed that all soils are dominated by clay and silt loam textures (54%) and neutral pH (83%) but still have very low SOM and C-org < 1% (48%). However, a mixed cropping system (agroforestry) provides a higher C-org compound (5% C-org) than other land uses (< 1% C-org). Carbon has a strong correlation with nitrogen (r=0.90, p= 0.0004), weak correlation with potassium (r= 0.51, p= 0,13) and correlation with phosphorus-P (r= 0.30, p = 0.40). The SOM in these terrestrial ecosystems has a moderate correlation with Cation Exchange Capacity (CEC) (r= 0,64, p = 0.04). It is indicated that most of the soil nutrients and CEC were influenced by SOM (C-org) except P (likely from mineral soil). It is a promising finding that agroforestry is a sustainable system for agriculture where SOM could be key driver for land productivity in the terrestrial ecosystem.

Keywords: C/N of soil, land uses, West Timor

INTRODUCTION

From the perspective of agro-ecology, dryland can be defined as un-irrigated land, up-land, or not permanently irrigated land (Anonymous 1997). East Nusa Tenggara (ENT), as one of 34 provinces in Indonesia, is located in the semi-arid region and is dominated by dryland (94%) and only 6% wetland (Nur 2018). This province comprises 11 agro-ecological zones based on climate, temperature, slope, physiography, land uses, type of commodity, and soil (BPTP NTT 2007). West Timor area, the Indonesian part of Timor Island and administratively under ENT Province, consists of four regencies (Kupang, Timor Tengah Selatan/TTS, Timor Tengah Utara/TTU, and Belu) and one municipality. The variation of climate, physiography, and soil in West Timor produces different land use systems which are the combination of agriculture, forestry and grazing lands (Aldrik 1984) developed in dryland agroecosystems. The mixed farming system is established in every village in ENT and is called a community garden or *Mamar*. Large numbers of local trees are grown in the Mamar which are adaptive to certain areas for a long time. This system has supported the sustainability of agriculture, forest, environment and socio-cultural.

For agroecosystem development, land productivity is a critical factor besides stability, sustainability, and equitability. One indicator of land productivity is soil fertility related to soil organic matter (SOM) (Haynes 2005). In this regard, soil organic carbon (C) can be used as an indicator of soil quality that benefits soil management strategy, food production, and agricultural sustainability (Ramesh et al. 2015). There are several pools of SOM, such as stabile pool (*humus*), labile pool (particulate organic matter-POM), and inert organic matter pool (IOM) (Baldock and Skjemstad 1999; Six 2001; Clapp 2005; Haynes 2005). Carbon (C) storage in the soil varies among SOM pools which are impacted by land-use changes. Therefore, SOM structure is an essential factor in understanding the effect of land uses and soil quality. For example, grassland could increase C level at whole soil, humus, and POM but not for IOM. Carbon in coarse fraction (POM) has a significant correlation with P than a fine fraction (humus), and only organic P pools have a close correlation with C, especially soil microbe pools (Moata et al. 2016). When the land is used for intensive agricultural systems, the C level decreases, especially for the un-stabile fraction. Stoichiometry between the organic and inorganic forms of soil nutrients will affect C-sequestration or nutrient release. Therefore, understanding the relationship between C and nutrients cycle is necessary.

Stoichiometry of C and soil nutrients varies depending on soil type, land uses, climate, and SOM fractions (Barrett 2007). A study on fine fraction of soil (< 0.4mm) from some agro-ecological zone in Australia found that high clay

soil has C:N (10.6) and C:P (40) comparable to loamy soil (11.9 and 40). However, sandy soil has higher C:N and C:P with 13.3 and 60, respectively, and the highest one is sandy clay loam (C:N=12.3 and C:P=97) (Kirkby et al. 2011; Kirkby et al. 2013). Forest land has similar C:N with that of grassland but it has different C:P and N:P ratios (Clevel and Liptzin 2007). The stoichiometry of C:N:P also varied among agricultural systems (Moata et al. 2015). The variation was probably due to the source of C and N that are mainly from vegetation biomass, while P is mainly from mineralization of SOM and weathered rock. The C:N ratio of soil biomass from forest and mineral soils does not change much with time (Yang and Luo 2011). Stoichiometry of C:N:P varies among clime zones. Tropical and sub-tropical regions with high temperatures and rainfall could produce large biomass and increase C input returned to the soils. Therefore the C:P and N:P were higher in a cooler areas, ice, warm, or four seasons places while C:N was not changed (Tian et al. 2010). This might have happened due to enzymatic activities where P_{tot} and C will increase along with the increase of temperature and precipitation (Sinsabaugh et al. 2008). Thus, soil factors, land uses, and climate become essential factors in determining the stoichiometry of soil nutrients besides other factors that influence N and P availability in the terrestrial ecosystem.

This study aimed to assess the stoichiometry of C:N:P in semi-arid region in ENT Province, Indonesia. In doing so, we focused on dryland areas in West Timor region by taking adequate samples representing various agro-ecological zones. We expected the results of this study can inform strategy for developing agricultural systems in the region based-on the stoichiometry of C:N:P.

MATERIALS AND METHODS

Sampling sites were determined based on geology, slopping, and land cover maps using Arc-GIS 10.3 software for all west Timor regions. Those three maps were overlaid and produced 56 sample sites with total land of > 1 ha each, then 36 locations were selected based on accessibility and administrative positions (Figure 1A) for physical and chemical soil analysis. This study focused on three land uses (i.e. dryland cropping system, mixed cropping, and forest) (Figure 1B). All soils were collected from a 0-30 cm depth, and only ten soil samples were chosen from Kupang Regency to analyze total C (combustion-gravimetric analysis), N (Kjeldahl), and P (spectrometer). Data were analyzed using linear regression analysis to determine the relationships among those variables.

RESULTS AND DISCUSSION

The research location map was produced based on geology, slope, and land uses by referring to the AEZ map (BPTP NTT 2007) and updated current information from GIS. Soil development in Timor Island was mainly affected by parent material (geological formation) than organic matter. From the last ten years, the erratic rainfall pattern fluctuates from 500 to 2000 mm $year^{-1}$ with an average annual rainfall of 1528 mm $year^{-1}$ due to climate change. The intensity of rainfall decreased in the last five years and affected soil quality, causing changes in commodities and land use patterns. The sampling sites were located in a semi-arid region with 3 - 4 months wet season (December-March) and 8-9 months dry season (April-November) and an average temperature of 28°C.

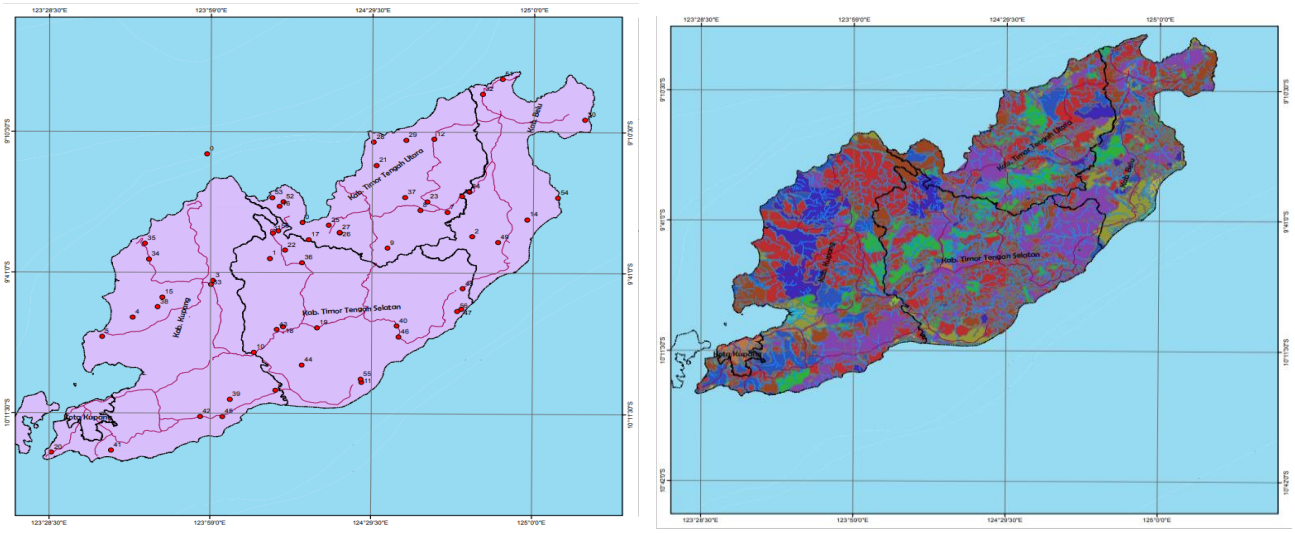

Figure 1. A. Sampling sites in West Timor region; B. Land uses map in West Timor region, Indonesia

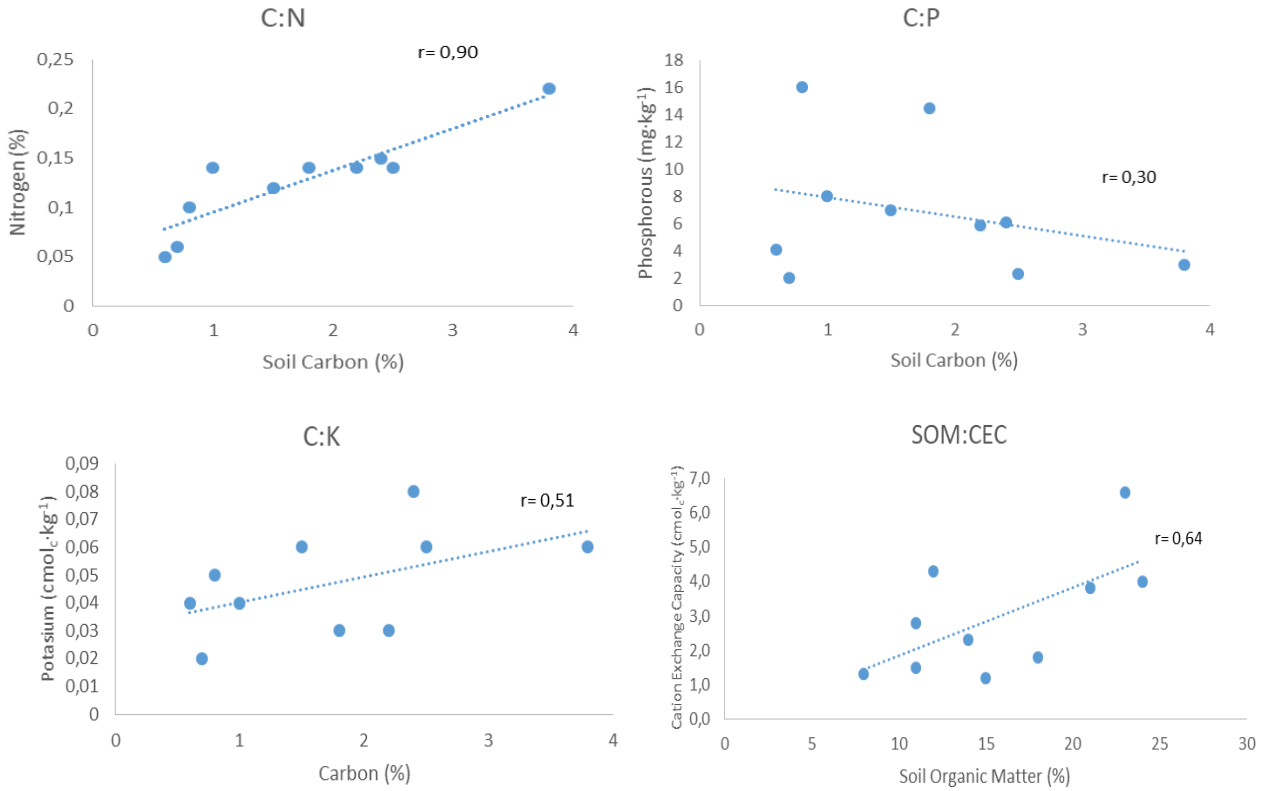

Figure 2. Regression of soil Carbon to N, C:P, K dan Soil organic matter to Cation Excgane capacity

The quality of soils is comparable among regencies in Timor Island of ENT. The previous study (Moata et al. 2018) revealed that the Kupang Regency area has mainly clay loam and clay soils (43%) with average clay content 37%. The soils have neutral soil pH 6.6-7.3 (85%), C-org is low to very low <1-2% (67%) though few soils have high C-org of 3-4% (11%) of total soils. Meanwhile, the TTS Regency area has silty loam soil (65%) and sandy loam (17%). These soils are slightly acidic with pH of 6.5 (35%) and the rest are neutral (65%). For Kupang soils, C-org was low to very low level (55%), and medium level 2-3% (27%), and the rest 8% was high to very high C-org levels (3-5%). On the other hand, Belu Regency soils have mainly 50% silty loam soils, 100% neutral pH, and mostly 83% low to very low C-org and 17% very high C-org.

Stoichiometry C:N:P of SOM plays an important role in soil biogeochemistry (Knops and Tilman 2000; Clevel and Liptzin 2007). This is related to C sequestration in the soil and amount of nutrients that can be stored and released into the soil. For instance, if the biomass has C:N< 25, the mineralization will happen. Otherwise, if C:N> 35, immobilization will occur. Also, if the C:P<300, the mineralization occurs, and at C:P >400, immobilization will occur (Macdonald and Baldock 2010). In particular, analysis of soils from Kupang and TTS regencies showed that mixed cropping has the highest C-org than the dryland cropping system and forest lands. Soils from Kupang Regency have C-org in mixed cropping, agriculture, and forest, respectively, 1.8%, 1.1%, and 1.1% (Moata et al. 2018). Meanwhile, TTS soils have C-org in mixed cropping, agriculture, and forest of 4.5%, 0.7%, and 0.1%, respectively.

This preliminary study showed that there was a strong correlation between soil organic carbon and C:N (*r*= 0.90; p=0.0004) and correlation with SOM:CEC (cation exchange capacity) (*r*= 0.64; P=0.04). However, there was weak correlation with C:K (*r*= 0.51; p=0.13). Finally, C:P had a very weak correlation (*r*= 0.30; p=0.40) (Figure 3).

These results showed that SOM that consists mainly of C-org could be used as an indicator of soil nutrients and exchangeability. The increase of SOM (C-org) will increase N, K, and CEC in the soil. On the other hand, the C-org could not be an indicator of Ptot in the soil. Nevertheless, this evidence can not be absolutely accepted because the correlation of C:P was very weak, almost no correlation. This weak correlation could be due to no correlation between C:Ptot and C:Porg (Moata et al. 2016). For dryland soils in the semi-arid region, this study resulted that these soils having C:N=14. Most likely, P soil is mainly weathered soils from the break down of Apatit mineral rather than SOM since these soils are dominated by low to very low SOM (C-org). Potassium (K) also has a weak correlation with C most probably is not from SOM, but other sources like Feldspar mineral.

To conclude, in general, West Timor soils have a dominant texture of clay and silty loam with neutral soil

pH. However, the SOM, C-org and soil nutrients (N, P, K) were categorized as low to very low levels. Stoichiometry of C:N:P in terrestrial semi-arid dryland soils has shown to have strong correlation of C:N comparable to SOM:CEC. But the correlation was not clear for C:K and C:P. It means SOM and C-org will direct N and the availability of nutrients in the soil from the increase of CEC. The stoichiometry of C:N can help to predict mineralization and fertilizer input. But, still need further study on P_{org} and K soils to get better and clear understanding of the C:N:P:K in dryland semi-arid soils.

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Characterization of the production system and breeding practices of sheep producers in Tahtay Maychew District, Northern Ethiopia

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Abstract. *Melak A, Hailu A, Assefa A, Aseged T, Sinkie S, Tsion S. 2021. Characterization of the production system and breeding practices of sheep producers in Tahtay Maychew District, Northern Ethiopia. Intl J Trop Drylands 5: 5-11.* Sheep rearing plays an important role in the livelihoods of rural people in Ethiopia, yet limited information is available regarding the management system of the sheep. The study was conducted in Tahtay Maychew district of the central zone of Tigray, Northern Ethiopia. The objective of the study was to understand the sheep production system, the breeding practices, selection criteria, and sheep production constraints to identify sheep farming practices about future production strategies in the study area. A total of 70 households from 2 kebeles (lower administrative structure) were selected purposively based on sheep population and production potential and accessibility. Data was collected through semi-structured questionnaires, focus group discussions, and key informants. An index was calculated to provide an overall ranking of the purpose of keeping sheep, culling rams and ewe, according to the formula: Index = Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3]. It is concluded that both female and male sheep are maintained mainly for income generation followed by breeding. A variable that was given a higher priority in selecting breeding males and females was body size. Disease, feed shortage, lack of grazing, and predators are the major constraints of sheep production mentioned in the study area. Therefore, addressing these constraints is important to design a successful genetic improvement scheme in the area for sheep.

Keywords: Production systems, selection criteria, Tahtay Maychew

INTRODUCTION

It is believed that the livestock population in Ethiopia is the largest in Africa (Lijalem and Zeru 2016). Livestock is an important source of income for the agricultural community and is also one of Ethiopia's major sources of foreign currency through the exportation of live animals, meat, and skin (Lema 2015). The ongoing climate change is predicted to affect livestock sector in the country due to the long dry period and erratic rainfall, yet this issue has been only modestly considered (Niemi and Ahlstedt 2014). To overcome such problem, there is a need to conserve and sustainably use available local animal genetic resources which can adapt to the climatic condition. Conservation and sustainable utilization of local AnGR however requires information on their morphology and production system (Osei-Amponsah et al. 2017).

The huge livestock resources and diversified genetic pools in Ethiopia are adaptive to different agro-ecologies. Farm animals are raised across the highland, midland, and lowland areas of the country and they are integral parts of Ethiopia's agricultural system. Similar to livestock production in most developing countries, livestock management in Ethiopia is mostly subsistence-oriented and fulfills multiple functions that contribute more to food security (Duguma et al. 2010). Despite the large livestock resources with high potential for meat and milk production, several factors that influenced the development of the livestock sector in Ethiopia include the poor genetic performance of the indigenous animals, inadequate veterinary services, shortage of animal feeds as well as the absence of good management systems (Ergano 2015).

Sheep rearing is among the most crucial agricultural activities in the highlands of Ethiopia where crop production is unreliable. Sheep provide farm households with cash income, meat, fiber, and manure. As compared to large ruminants, small ruminants like sheep have shorter production cycles, faster growth rates, ease of management, and, low capital investment (Tadesse et al. 2015). In the absence of enough grazing land, small ruminants are efficient meat and milk producers for the smallholder farmers. They require small space and feed. These days, as a result of crop encroachment and degradation of communal grazing lands, there is a general shift in livestock holding from cattle to small ruminants because of the consistently dwindling grazing land (Taye et al. 2010). Feed scarcity, water shortage, disease/parasite, and shortage, market problem, inbreeding, capital problem, poor management, awareness problem, and untimely credit access are among the constraints for the sheep production system in Ethiopia (Feleke et al. 2015).

The main objective of this study is to characterize the production system, describe the production objectives and breeding practices of the sheep producers, generate information on the sheep breeds and breeding systems, and provide baseline information for designing breeding

programs for Tigray sheep in the Tahtay Maychew District, Ethiopia.

MATERIALS AND METHODS

Study area

The study was conducted in Tahtay Maychew District of the central zone of Tigray in northern Ethiopia (Figure 1). The study district was selected for the reason that it is known as the center of distribution for Tigray sheep breeds. The study district covers a total area of 18,618 km^2 and with an altitudinal range of 1992-2333 m.a.s.l. and lies approximately between 130 52' and140 19' North and 38 0 29' and 380 42' East. The mean annual temperature is about 19.90 ºC and the minimum and maximum temperatures are 9.9ºC and 30.3 ºC recorded in December and June respectively. The estimated livestock population in the study district is about 247,907, consisting of 84,102 poultry; 75,707 cattle; 55,517 goats; 25,195 sheep; 6,716 donkeys; and 110 mules (Genet et al. 2015). The prominent farming system of the study area is mixed crop-livestock production.

Sampling procedure and data collection

Data was collected through interviews to randomly selected 70 sheep owners from Tahtay Maychew District. To check the clarity of the questionnaire to respondents and appropriateness of the questions, the questionnaire was designed, pre-tested, and modified before the commencement of the actual administration. Staff from the Ethiopian biodiversity institute administered the modified and finalized questionnaire. The questionnaire gathered information on socio-demographic characteristics of the households (age, gender, educational background, family size), livestock holding, flock characteristics (number and composition), source of income of the respondents, livestock and their importance, farming system characteristics, the purpose of keeping sheep, selection criteria of sheep, culling criteria of sheep, sheep diseases in the study area, and reproductive characteristics and constraints of sheep production in the study area.

Data analysis

The data was entered and analyzed by SPSS 23.0 software. Descriptive statistics of SPSS 23.0 software were used to describe the survey. An index was calculated to provide an overall ranking of the source of income of the respondents, importance of livestock, major crops cultivated, the purpose of keeping sheep, culling criteria of sheep, selection criteria of sheep, a major disease in the study area, and constraints of sheep production, according to the formula: Index = Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for particular qualitative variables divided by Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all-qualitative variables. The rank was calculated by Microsoft excel 2010. The map of the study area was mapped with quantum GIS (QGIS 3.10.0).

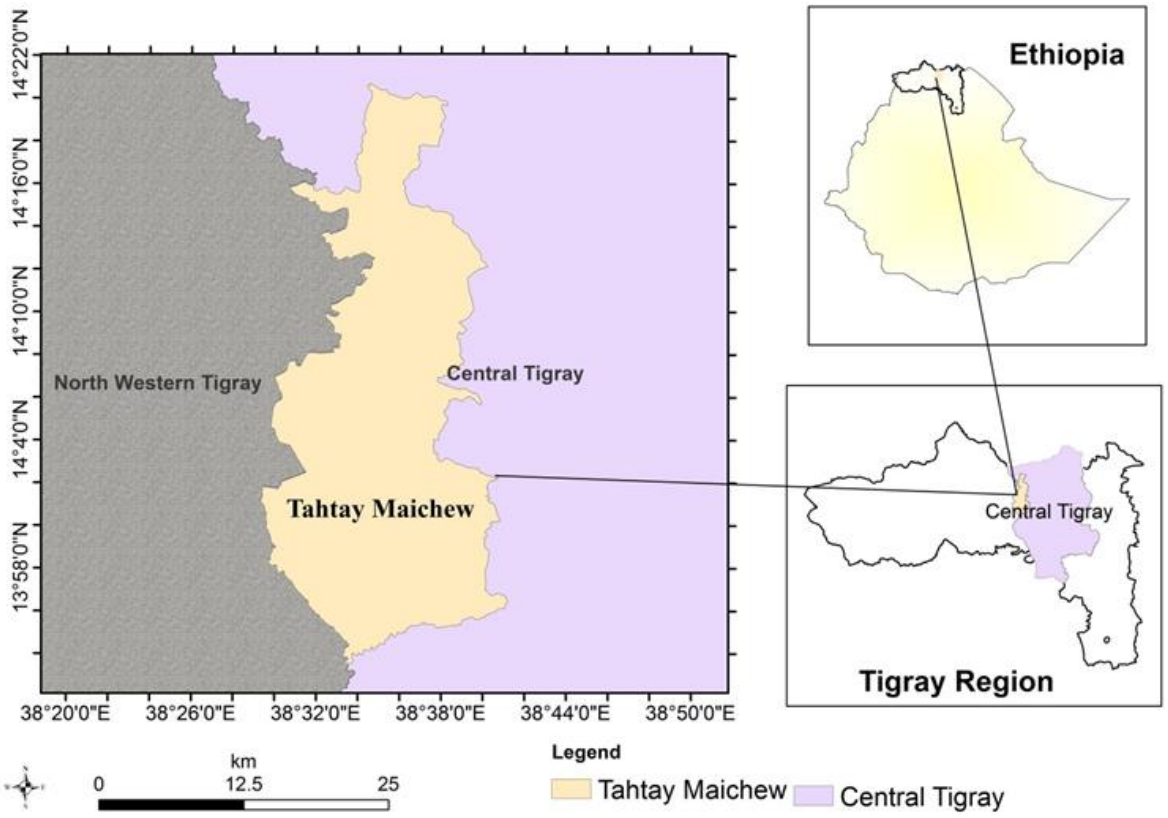

Figure 1. Map of the study area Tahtay Maychew District, Ethiopia.

RESULTS AND DISCUSSION

Individual and household characteristics of the respondents

In the study area, the majority of the small ruminants owning households were male-headed (93.2%) while the remaining were (6.8%) were headed by females. The average family size of the households was 6.32 ± 0.23 (ranging from 2-11) and this result is lower than the report of Shimels Mengistu (2020) which is 7.66 persons. This may be due to low awareness of family planning. Many members within the family seem to be considered as an asset and security in times of retirement. The educational status of the respondents was illiterate, elementary, secondary, and informal education with proportion of 37.0%, 52.1%, 6.8%, and 4.1%, respectively.

Livestock holding and composition

The average reported livestock holding in the household is presented in Table 1. In Tahtay Maychew, the mean (±SEM) number of cattle, sheep, goat, chicken, donkey, horse, mule, camel, and bee hives per household were 3.5068±0.33, 8.16±0.59, 1.55±0.33, 4.19±0.41, 0.74±0.11, 0.03±0.03, 0.03±0.03, 0.07±0.04, and 0.4±0.15, respectively. Mostly the household head (husband) and spouse jointly are flock owners.

Income sources of the respondents

The source of income of the respondents is presented in Table 2. The respondents are mostly depending on crop cultivation followed by livestock rearing. The result also showed that trade is not such an important income source.

Livestock and their importance in the study area

The uses of livestock in the study area are presented in Table 3. As the result showed, cattle are the leading livestock species used for the lives of the respondents. Sheep and chicken are the second and third important livestock species, respectively.

Farming system characteristics

Most of the respondents in the study area practiced mixed farming system, both crop-livestock productions are integrated. According to the respondents, the major crops grown in the study area were teff (index=0.38), maize (index=0.24), sorghum, milt, wheat, barley, and bean with an index value of 0.14, 0.14, 0.05, 0.03, and 0.03, respectively (Table 4). Crop cultivation was the most important sector in the crop-livestock production system and crop residues were the main source of feed for livestock. Livestock were invaluable components of the farming system in the study area and contribute enormously towards ensuring food security.

Purpose of keeping sheep

The reasons for keeping sheep depend on the long or short-term needs of the producers. The results of this survey revealed that sheep play multi-functional roles in the study district. Small ruminants are kept to meet both tangible and non-tangible benefits. The purpose of keeping sheep is presented in Table 5. Sheep are highly valued livestock species by the Tahtay Maychew people next to cattle and reared to fulfill diverse socio-cultural needs (Table 3). Sheep are slaughtered at wedding ceremonies, cultural festivals, and in honor of special guests and given as dowry.

Table 1. Mean (±SEM) livestock holdings in the study district

Livestock	Mean ± SEM (N=70)
Cattle	3.5068±0.33
Sheep	8.16±0.59
Goat	1.55±0.33
Chicken	4.19±0.41
Donkey	0.74±0.11
Horse	0.03±0.03
Mule	0.03±0.03
Camel	0.07±0.04
Beehive	0.4±0.15

N= number of respondents; SEM = standard error of the mean

Table 2. Source of income of the respondents

Item	Rank 1	Rank 2	Rank 3	Index
Crop	68	2	0	0.36
Livestock	2	67	0	0.24
Salary	0	0	3	0.01
Trade	0	0	0	0
Other	72	1	12	0.4
Total	142	70	15	1

Table 3. Importance of livestock in the study area

Livestock breeds	Rank 1	Rank 2	Rank 3	Index
Cattle	47	11	3	0.43
Sheep	14	42	6	0.34
Goat	0	3	6	0.03
Chicken	1	6	19	0.09
Donkey	0	3	9	0.04
Horses	0	0	0	0
Mule	0	0	0	0
Camel	1	0	0	0.01
Beehives	3	0	5	0.04
Others	0	0	7	0.02
Total	66	65	55	1

Table 4. Major crops and their importance

Item	Rank 1	Rank 2	Rank 3	Index
Bean	0	3	7	0.03
Barley	1	2	4	0.03
Sorghum	12	5	12	0.14
Milt	13	9	2	0.14
Teff	37	18	16	0.38
Maize	16	19	17	0.24
Wheat	0	9	2	0.05
Total	79	65	60	1

Culling reasons for sheep

Livestock keepers need to evaluate each animal and decide whether that animal is productive or not, with increasing production costs. Nonproductive ewes and rams should not be maintained in the flock.

The best way to increase the efficiency of the sheep breeds is culling. Culling criteria for ewe and ram in Tahtay Maychew District with corresponding index values are presented in Table 6. Most of the respondents cull their breeding rams in which body conformation (index = 0.17) and body condition (index=0.17) were the most important ram culling criteria followed by color (index = 0.16) and the next culling criteria were temperament and poor fertility with an index value of 0.14 and 0.13, respectively. And again most of the respondents cull their breeding ewes in which poor fertility (index = 0.25) and body size (index=0.18) were the most important ewe culling criteria followed by body conformation (index = 0.16) and the next culling criteria were body condition and color with an index value of 0.13 and 0.10, respectively.

As the study showed, the respondents cull their sheep mostly through sale and slaughter. As reported by Taye et al. (2010) sale of sheep at an early age is common in other areas too. This, the sale of young animals negatively influenced flock productivity that fast-growing and good-looking lambs could be removed out from the flock before reaching breeding age and replacing themselves (Taye et al. 2010), and therefore drains the genetic pool of the flock. However, the practice can be taken as an efficient method of culling less productive and unselected animals out of the system, if properly managed. Therefore, care should be taken to maintain the productivity of animals while removing those with unwanted traits.

Selection of breeding animals and trait preferences

The most common way of selecting sheep as parents for the coming generations is to use the offspring of a chosen parent (ewe/ram). A linear index is the best strategy for selecting replacements in the livestock industries (Chawala et al. 2019). The selection criteria for ewe and ram in Tahtay Maychew District with corresponding index values are presented in Table 7. Most of the respondents select their breeding ewes and rams in which body size (index = 0.27) was the most important ewe and ram selection trait followed by body conformation (index = 0.26) and the next selection criteria that the respondents prefer were growth performance and color with an index value of 0.24 and 0.18, respectively. Therefore, this study is not in line with Haile et al. (2015) who reported that Basonawerena farmers do not include an appearance as a primary criterion for selecting breeding ewes. Instead, they ranked twining ability (index=0.26) as first, followed by age at first sexual maturity (index=0.19) and appearance (index=0.14).

Table 5. Purposes of keeping sheep

Item	Rank 1	Rank 2	Rank 3	Index
Meat	7	10	21	0.1
Milk	0	0	0	0
Breeding	27	23	8	0.21
Manure	36	15	5	0.23
Blood	3	0	0	0
Hide	0	0	0	0.01
Hair	0	0	0	0
Income generation	72	12	18	0.41
Ceremonies	1	5	9	0.03
Others	0	1	0	0
Total	146	66	61	1

Table 7. Ranked selection criteria for breeding males and females

Item	Rank 1	Rank 2	Rank 3	Index
Size	26	9	16	0.27
Conformation	12	31	10	0.26
Color	4	17	29	0.18
Temperament	3	4	1	0.04
Growth performance	25	8	9	0.24
Others	1	0	0	0.01
Total	71	69	65	1.00

Table 6. The culling reason for male and female sheep in Tahtay Maychew District

Item	Male				Female			
	Rank 1	Rank 2	Rank 3	Index	Rank 1	Rank 2	Rank 3	Index
Size	2	4	4	0.05	14	7	6	0.18
Conformation	9	16	4	0.17	9	13	4	0.16
Color	6	14	12	0.16	2	8	14	0.10
Temperament	11	6	5	0.14	3	1	3	0.04
Health problem	3	4	7	0.07	3	10	3	0.09
Body condition	15	6	5	0.17	3	13	10	0.13
Old age	1	5	7	0.05	1	4	6	0.05
Poor fertility	9	6	7	0.13	21	8	7	0.25
Others	0	0	26	0.07	0	0	0	0
Total	56	61	77	1	56	64	53	1

Table 8. Major disease in the study area

Type of disease	Rank 1	Rank 2	Rank 3	Index
Stomach ache	5	0	0	0.07
Diarrhea	19	1	1	0.29
Mucus discharge	9	3	0	0.16
Dermal disease	2	11	7	0.17
Loss of appetite	11	6	8	0.26
Weight loss	1	0	6	0.04
Total	47	21	22	1

Table 9. Reproductive performances of Tigray sheep in Tahtay Maychew District

Reproduction parameters	N=70 (Mean ± SEM)
Average sexual maturity of male (month)	6.76±0.20
Average sexual maturity of female (month)	7.86±0.32
Age at first lambing (month)	12.09±0.35
Lambing interval (month)	7.26±0.31
Average market age of male (month)	6.86±0.29
Average market age of female (month)	7.66±0.30

Table 10. Major sheep production constraint in Tahtay Maychew District

Constraints	Rank 1	Rank 2	Rank 3	Index
Lack of water	1	0	0	0.01
Disease	30	9	0	0.34
Lack of drug	1	0	0	0.01
Lack of improved breed	0	0	4	0.01
Lack of grazing	11	13	2	0.19
Feed	17	7	0	0.21
Animal stole	0	0	1	0
Lack of vet	0	6	0	0.04
Lack of housing	7	3	0	0.09
Predator	2	11	4	0.1
Lack of proper management	0	0	0	0
Total	69	40	11	1

Disease of sheep in the study area

The major sheep health problems mentioned by the respondents are presented in Table 8. In the study area, the most important sheep health problems mentioned by the respondents were diarrhea (0.29), loss of appetite (0.26), dermal disease (0.17), mucus discharge (0.16), stomach ache (0.07), and weight loss (0.04) (Table 8). As reported by Edea (2012) in Adillo Kaka, the most important sheep health problems were pasteurellosis, coenurosis, diarrhea, and lungworm. Edea (2012) also reported lungworm, liver fluke (fasciolosis), and coenurosis were mentioned as important health problems of Horro sheep producers, which is not in agreement with reports of this finding.

Sheep breeding and reproduction performance

Average sexual maturity of male and female sheep

The average age at sexual maturity for male and female sheep varies from breed to breed. Reproductive performances of Tigray sheep are summarized in Table 9. The average reported age at sexual maturity for Tigray sheep breeds were 6.76±0.20 and 7.86±0.32 months for male and females, respectively. The age at sexual maturity in this study is shorter than the finding of Edea et al. (2012) who reported that the average sexual maturity of Horro and Bonga sheep was 7.5 ± 2.1 and 9.3 ± 2.2 months for male and female sheep, respectively. Therefore, the age at sexual maturity in this study is not in agreement with Edea et al. (2012) who reported that average sexual maturity was 7.5 ± 2.1 and 9.3 ± 2.2 months for males and females, respectively.

Age at first lambing (AFL)

The average AFL of the study area was 12.09±0.35 months. The average age at first lambing for Tigray sheep breeds was shorter than 13.3 and 14.9 months reported by Edea et al. (2012) for Horro and Bonga sheep, respectively. Feed shortage and disease can also lead to delayed age at first lambing through limiting early animal growth. Year of lambing and season of birth, influence age at first lambing through their effect on feed supply and quality. The type of birth of the ewe/lamb significantly affects the age at which the ewe/lamb first lambed. The good performance of Tigray sheep breeds has an opportunity for genetic improvement as a greater population turnover and more rapid genetic progress.

Lambing interval (LI)

The average lambing interval of Tigray sheep was 7.26±0.31 months (Table 9). It appears that this value is shorter than 8.9 and 7.8 months reported by Edea et al. (2102) for Bonga and Horro sheep, respectively. Tigray sheep breeds, under traditional management production systems, lamb three times in two years. This is in agreement with the literature (Mengistu 2020) who indicated that through the provision of better nutrition and management in organized farms of tropics it is practically possible to attain three lambings in two years. This kind of breeding schedule would permit the exploitation of the full reproductive potential, while at the same manner avoiding overly stressing females. To achieve such optimum reproductive performances from the Tigray sheep breeds, the prevailing feeding system needs to be adequate throughout the year.

Market age

The average market age of Tigray sheep in both sexes is not fixed. The market age of Tigray sheep is summarized in Table 9. The average reported market age for Tigray sheep breeds were 6.76±0.20 and 7.86±0.32 months for males and females, respectively.

Major constraints of sheep production

The major constraints of sheep production in the study area as mentioned by the households were disease, feed shortage and lack of grazing land, predator, and lack of housing (decreased in both size and productivity (Table 10).

Discussion

The result showed that the majority of the small ruminants owning households were male-headed (93.2%) while only small proportions (6.8%) were headed by females. This finding is in line with Beyene (2018) that households were predominantly headed by males and that most livestock farmers are old aged are common phenomena in most developing countries. The current study described and documented Tigray sheep production systems in the traditional sector of Tahtay Maychew as an essential step towards the development of a sustainable breed improvement program.

Livestock farming was identified as the second activity in the study area; farmers had alternative means to source income. Similarly, farm produce alone could not sustain the household upkeep. Adem et al. (2018) attributed this to unreliable food crop yield in the province. 'Even in good years', the result showed that, 'crop cultivation is not enough to guarantee the respondents sufficient food and income for one year'. Hence, other sources of income (salary and others like labor work, selling wood and manure) reported in the current study, seemed to serve as supplements to farming income. This phenomenon presents an opportunity for sustainable utilization of indigenous livestock; which can withstand drought and can produce under conditions of low input and low-level management, thus requiring less input and availing farmers time to conduct other activities.

As the result showed, both female and male sheep are maintained mainly for income generation followed by manure and breeding. This builds financial capital and allows the sale of animals for cash that can be used for other agricultural enterprises, school fees, and medical bills, etc. Functions like hiding and hair received a lower ranking among sheep breeders. The purpose of keeping sheep for milk is zero, due to the culture of the society restricts not to drink sheep milk. As Mengistu (2020) reports, sheep milk is not used for drink and it is not also supplied to the market due to culture in acceptance of the society. Diverse functions are particularly important under the subsistence production system. The importance of diverse values of indigenous livestock breeds under low input system were well documented (Wurzinger et al. 2011)

The culling of rams for sale or family consumption is another possible factor contributing to the high proportion of ewes per flock in this study. One aim of this study was to document information that would be useful in the future when formulating a breeding program for Tigray sheep. As the result showed sheep were commonly used as a family income, manure, breeding, and source of meat. The other use mentioned by respondents was hiding. Only 15 farmers, in the Tahtay Maychew District, used sheep for ceremonies (Table 5). Teklebrhan (2012) mentioned that fibers, hides, skins, and pelts of indigenous sheep breeds are better than the crossbreeds. These could be possible opportunities that farmers can exploit to better utilize their indigenous sheep.

As the result showed most of the respondents' major cause of loss of sheep identified in this study was a disease with an index value of 0.34. This concurred with findings by Weldemariam et al. (2014) that diarrhea and pneumonia are most commonly associated with an endemic condition in Ebinat and he ensured that poor health is the key limiting factor to productivity of sheep raised by most rural farmers in the study area. As reported by Weldemariam et al. (2014) most farmers interviewed depended on drug suppliers for veterinary help; this raises some doubts on the accuracy of the diagnosis of diseases. Maximum productivity in a given system of production emerges when disease control is optimal (Edea 2012). Thus, healthcare is an important problem to consider before the genetic program can be seriously contemplated. Community-based animal health programs may be one way forward and wider utilization of indigenous breeds tolerant to disease another (Mirkena et al. 2012). Feed shortage was identified as the second constraint for the sheep producers in the study area. Causes of feed shortage were due to human population growth, and frequent occurrence of drought, the low genetic potential of the breed, and lack of drug were ranked lowly in the study area. This might be due to a lack of awareness of sheep owners about genotype. Woldemariam et al. (2014) reported that pneumonia and diarrhea are the major cause of sheep mortality in the Ebinat district. Wendimu et al. (2016) also reported that the lack of strong animal health services and recurrent drought was mentioned as the main cause of sheep mortality. Another constraint for the sheep producers was the lack of grazing land. Other constraints such as lack of improved breed, lack of veterinary service, and drug identified in the present study were less significant (Table 10).

In conclusion, this study provides insight into agricultural production systems, breeding practices, and major production constraints encountered in sheep farming in the study area, which are preconditions in developing breeding programs. Livestock production is the main means of livelihood of the Maychew community in the study area. Cattle and sheep have a great role in the livelihoods of the community. Tigray sheep breeds are the most promising for their better adaptability under low input extensive production environments where scarcity of feed and grazing land are the two major constraints. Sheep are highly valued animals by the Tigrian people next to cattle and reared to fulfill diverse socio-cultural needs. Body size and growth performance are given high priority in selecting breeding males among his mates. Similarly for breeding female body size, body conformation and growth performance are among the most considered criteria for selection. Disease, feed shortage, and predators are the major constraints of sheep production in the study area.

To avoid early disposal of breeding males, strong extension service is required to convince farmers and to develop an interest in the benefits of better genotypes or incentives that might be provided for those keeping their best males for breeding purposes. Owing to the small flock size in the study area, reasonable genetic gain demands the formation of breeders' groups or co-operatives, which in turn require full participation and long-term commitment of sheep keepers and other livestock development actors. To realize the full benefits of breeding programs, approaches

should be holistic, and a concurrent improvement in the non-genetic factors (disease and feed) is central.

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The landlords, the peasant, and the retention basin: Local political ecology of water management in the small island of Semau, Kupang, Indonesia

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Abstract. *Kuswardono PT, Mudita IW, Pandie DBW. 2021. The landlords, the peasant, and the retention basin: Local political ecology of water management in the small island of Semau, Kupang, Indonesia. Intl J Trop Drylands 5: 12-19.* Freshwater is the most fundamental issue in small islands because of very small catchment area and low water retention capacity. To ensure water availability for domestic and agriculture purposes, the Government of Indonesia (GoI) has built hundreds of retention basins in all islands in East Nusa Tenggara Province from 1985 until recent times. In the small island of Semau where the study is undertaken, the availability of more than 24 retention basins did not solve freshwater problem. Inequality of distribution and usage of water from retention basin has become latent issues for more than 20 years. Under water provision program of GoI, all small retention basin management has been handed over to local community to become common pool resources (CPR). However, retention basin as CPR is not happening as expected. Using the Social-Ecological System Framework (SESF), the study found that one of the Governance components of SESF, i.e. property rights, is the key problem in achieving CPR. Informants from 5 villages interviewed and involved in focused group discussions consistently mentioned the word landlord in stories of water conflict, sabotage, and exclusion of access to water. The word landlord implied a tenurial or property rights system. A landlord had the traditional rights as a land custodian of the retention basin and all resources on his lands. The findings suggested that further investigation of the tenurial system and its transformation is needed whenever a vital construction such as retention basins would occur. In the past, the landlord would wisely distribute land and water as social goods so each person living in his ancestral land would not suffer from hunger. The construction of new retention basins could transform the roles of a landlord from a land custodian into a land owner and transform common-pool resources into private goods.

Keywords: Commons, common-pool, political-ecology, social-ecological system, tenurial

INTRODUCTION

The importance of studying small islands is not merely because of their vulnerability to climate change particularly in regard to sea-level rise which might cause them to be sinking (Solomon 2007). Instead, there is another eminent problem regarding fresh-water availability which has actually been recognized since early nineties. Some small islands have or limited fresh-water supply because of their geological formation, shape and small catchment area (Falkland and Custodio 1991). Since they cannot depend on the natural hydrological cycle, water catchment infrastructure needs to be built to address freshwater challenges. Alternatively, advanced technologies, such as seawater desalination installation, need to be placed to provide freshwater for its dweller (Falkland dan Custodio 1991).

According to Falkland (1991), a small island is a land with an area of fewer than 2000 km^2 (200,000 ha) or has a wide distance between one side to another side is less than 10 km (Falkland and Custodio 1991; UU no 1 Year 2014, n.d.). As a consequence, small island has a limited water catchment area, a very small basin and a short drainage system (Falkland and Custodio 1991). Therefore, water retention times of small island is very short. Rainwater can easily flow to the sea without infiltrating or dwelling on the land.

In Indonesia, particularly in East Nusa Tenggara (Nusa Tenggara Timur, NTT) Province, the Government of Indonesia (GoI) has been implementing freshwater provision program by developing rainwater retention basins in the areas where freshwater is limited. From 1985 until 2014 in all over the province, GoI has built 832 retention basins including in small islands such as Rote, Sabu, Lomblen, Pantar, and Semau (Balai Wilayah Sungai Nusa Tenggara II, n.d.). Even though hundreds of retention basins have been built, the numbers are inadequate to fulfill the need for freshwater of whole island. In 2017, Senator Ibrahim Agustinus Medah asked central government to spare 10% of 30,000 national programs on retention basins to be built in ENT Province alone (Kompas Cybermedia 2017). Not so long before Medah, Member of Parliament, Fary Francis, also encouraged central government to develop retention basins to increase freshwater reserve both for domestic use, agriculture, and cattle raising (Kompas 2017).

Although the development of retention basins is considered a solution to increase freshwater reserve, several studies on sustainability of retention basins showed that retention basins are not effective (Bunganaen 2013; Notoatmojo and Rivai 2001; Pradhan et al. 2011; Triastono

and Lidjang 2007). For example, Triastono and Lidjang (2007) and Bunganaen (2013) explained that water volume of retention basins in Timor was only 40-60% of its capacity on average. Most of the retention basins studied have high sedimentation because of lack of management at catchment areas. Both studies concluded that there is no governance at micro basin to prevent sedimentation of each retention basin.

Another problem related to underperformance of retention basins is operation and maintenance (O&P). A study by Bunganaen (2013) and Triastono and Lidjang (2007) showed that O&P is the worst aspect in the management of retention basin. All retention basins studied don't have organizations or institutions responsible for maintaining the basin performance to provide optimum services. Whereas, after a retention basin is built, the government transfers the basin management to the local community. It was expected that a self-governing system could be emerged and be established to sustainably manage the basin (Pradhan et al. 2011; Triastono and Lidjang 2007).

Aside from technical and institutional problems, conflicts among communities also emerge in many retention basins. Ratumakin (2016) mentioned that tensions and conflicts related to water resources occurred in 15 sub-district in Kupang District. Ratumakin (2016) recorded the tensions and conflicts among those who claim on ancestral land (landlords) and commoners. The landlords usually use customary rights of land to exclude commoners when accessing water from retention basins built for public. Occurrence of tensions and conflicts on access to water particularly from built infrastructure is likely to be common in East Nusa Tenggara. And most of the findings involve actors such as landlords. Regarding indication that the conflicts over water resources are likely to involve landlords and commoners, it raised question of whether customary control over land is the prominent factor of the conflict? It is also interesting to Ratumakin (2016) findings that natural water resources, such as springs or old wells, are less likely to become the center of conflicts and tensions. Most of the tensions happened inbuilt infrastructure such as retention basin. The study aimed to understand the difference between power and values of landlords regarding water resources. The research questions are: to what extent the landlords would play their roles and power to water resources? Is there an evolution of roles, powers, and values of local actors over water resources? The last question is the impact of these power games on the sustainability of retention basin in terms of stability of water reserve and equity of access.

MATERIALS AND METHODS

Study area

The study area is located in Semau Island, Kupang District, East Nusa Tenggara Province, Indonesia, a small island with an extent of 26,750 ha. Semau Island is a semi-arid island according to Schmidt and Oldeman climate classification (Type E and F) (Kaho 2019). Semau has rainfall of less than 1100 mm per year, lesser than western part of Indonesia (Kaho 2019). The population of the island in 2018 is 12,776 inhabitants. Most of the inhabitants are dryland farmers planting maize, paddy, and horticulture. Shallots and chili are the main agricultural crops, making Semau the largest producer of shallots (BPS Kabupaten Kupang 2019). Demand for water for shallots planting in dry season is high. Community mostly use retaining basins. The small island also consists of more than 9000 cows (*Bos javanicus*) owned by the island inhabitants (BPS Kabupaten Kupang 2019).

Figure 1. Map of the study area in Semau Island, Kupang District, East Nusa Tenggara Province, Indonesia

Semau Island has more than 34 retention basins built since 1985 to 2016 (Balai Wilayah Sungai Nusa Tenggara II, n.d.). The development of retention basins is still going on now. According to the design, all of the retention basins in Semau are multipurpose basins. They provide water for domestic use, agriculture, and cattle raising. Villages in north of Semau have more retention basins from the south. Twenty-six retention basins were built from 1985 until 2016 in the northern part of the island.

The study was undertaken in 4 villages, namely Hansisi, Uiasa, Huilelot, and Batuinan, where most of the retention basins were built since 1985. There were two reasons for the study undertaken in these 4 villages. First, the villages represent the age of retention basins. Uiasa and Hansisi villages have the oldest retention basins built before regional autonomy was placed in 2000. While Batuinan and Huilelot represent newer basins that were built after regional autonomy era in 2000.

Secondly, the 4 villages have different sub-ethnic groups with different kinds of tenurial systems. Hansisi represents a fully Rotenese sub-ethnic, Huilelot represents two cultures of Rotenese and Helong, while Batuinan and Uiasa represent a fully Helonese sub-ethnics.

Conceptual framework

Retention basin is one of the oldest infrastructures to harvest rainwater in the world (Boers 1986). It is also the easiest infrastructure to build on small islands (Falkland dan Custodio 1991). Retention basins can also be an indicator regarding sustainable management of micro-basins because the sustainability of retention basins depends on their water catchment areas (land cover). A high rate of sedimentation of retention basins indicates that the upper area of the basin is disturbed (Ali et al. 2010; Kerr 2007).

A retention basin is socio-ecological system. Berkes and Folke (1994) explain that SES is an approach to studying multi-level system of essential services such as food, fiber, energy, and water. Social-ecological system consists of resource system component, resource unit component, governance component, user component, and the action situation resulting from the dynamics of other components (McGinnis and Ostrom 2014). Socio-Ecological System is a complex system where human systems, economic systems, and natural systems intertwine and influence each other (Berkes and Folke 1994; Holling 2001). Previous research by Triastono and Lidjang (2007), Bunganen (2013), and Ratumakin et al. (2016) indicated that the complexity of water resource management is a problem of Socio-Ecological System.

Ostrom and McGinnis (2014) explained that SESF is designed to identify the works and critical relationships among components of SES. Ostrom and McGinnis defined five components or sub-system to explain SES: (i) Resource system, a biophysical subsystem that we want to study, for instance, lake, dams, forest, or habitat of fish, (ii). Resource unit, a subsystem explaining the flow of a resource, for instance, water discharge, trees harvested in a period. A resource unit explains amount of resource that flows or is used or extracted for a certain period, (iii). Governance system is a sub-system related to property rights, rules, regulations, and sanctions, (iv). Actors as subsystems explain people involved in such SES include each actor's attributes and how they interact with each other, (v). Action-situation is the result of interaction among components. Action situations can be positive, indicating the improvement of the systems, or negatives indicating deterioration of the system such as conflicts, in-justice, etc.

Using the SESF, the study tries to answer questions about the influence of tenurial system on SES performance. Performance here is related to sustainability of resource flow and equity of resource usage. We started by studying action-situation components (conflicts, tensions, sabotage of system) of retention basin. We also include access to groups of community, who are excluded from the system, and who gets access to water in a retention basin.

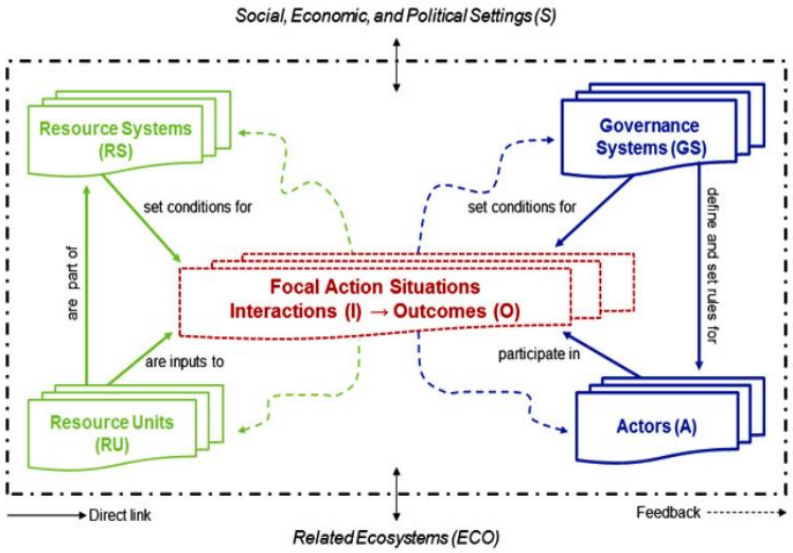

Figure 2. Social ecological framework (McGinnis and Ostrom 2014)

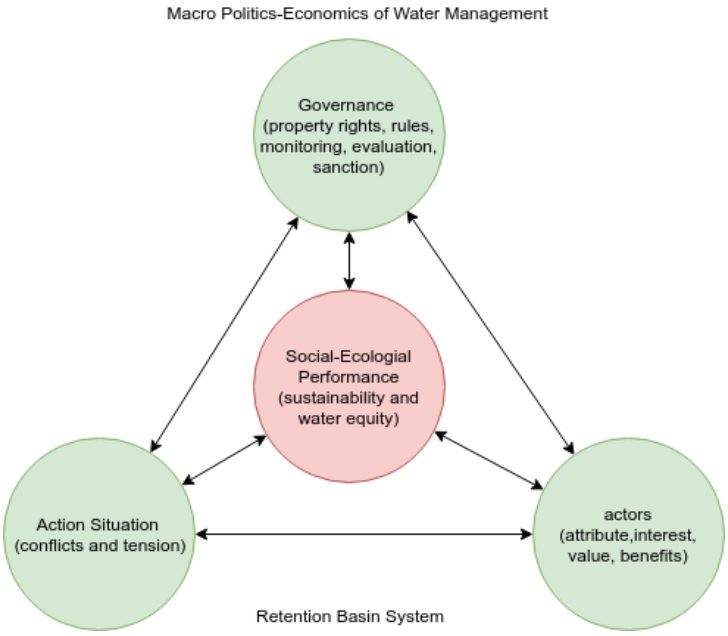

Figure 3. Conceptual framework of the study, adopted from McGinnis and Ostrom (2014)

Table 1. Summary of data collection techniques

Type of data	Topics	Data collecting techniques	Instrument	Source/resource persons
Primary	Action situation (conflicts, tensions, sabotage, vandalism)	FGD	Semi-structured questionnaire guidelines	Village government officials, female and male farmers, customary leaders
	History of retention basins	FGD on history of village	Semi-structured questionnaire guidelines	Customary leaders, village government officials
	Land use	Village sketch and aerial photos	Semi-structured guidelines, aerial maps	Male and female farmers
	Land ownership	Village sketch and aerial photos	Semi-structured guidelines, aerial maps	Customary leaders, male and female farmers
	Perception on socio-ecological performance	Seasonal calendars	Calendar tables, Semi-structured guidelines	Male and female farmers
	Perception on governance of retention basins	FGD	Semi-structured guidelines	Village government officials, female and male farmers, customary leaders

After studying the action situation, the next step is to gain information related to governance which includes tenurial system, rules, and behavior of actors involved in action-situation. The third step is to study actors involved in conflicts, those who gain benefits, social attributes of each actor, and power relationships among actors. The fourth step of the study is analyzing the overall socio-ecological performance of the SES. There are two themes studied under socio-ecological performance, sustainable flow of resources, and equity of access. We modified the framework for practical reasons in the study as in Figure 3.

Procedure

The study is a mixed-methods applying conversion mixed data analysis (Teddlie and Tashakkori 2009). The methods quantify qualitative data and then analyze descriptive statistics and network analysis to find the most significant themes raised by resource persons (Teddlie and Tashakkori 2009). Data was gathered from 8 focused group discussions separating male and female participants in 4 villages. Total participants of 8 different FGDs are 50 people consisting of 21 females and 29 males which are farmers and part of customary leadership in the villages. We also interviewed eight customary leaders, and six male and female village government officials.

We employed Participatory Rural Appraisal such as village history, land use, land ownership, seasonal calendar, and village sketch to dig deeper information from resource persons during discussion. Using participatory rural appraisal instruments we can see the dynamics of discussion, when they agree on some issues, or when they do not agree on some issues. The PRA also can be used to

build consensus of information among participants (Narayanasamy 2009). To systematize the process during FGD, we divided the discussions of SES into 6 topics or themes, namely conflicts over water, the history of retention basins, land use, land ownership, perception on socio-ecological performance emphasizing on sustainability of water availability and equity of access, and governance of retention basins emphasizing the roles of actors, rules, institutions, and confirmation of land ownership basin retentions SES. All the information gathered is documented in transcripts, sketch maps, a list of participants, and tables of seasonal calendars.

Analytical methods

We used mixed conversion data methods to analyze significant themes from transcripts. Mixed conversion data analysis is a quantifying-qualitative analysis (Hesse-Biber 2010; Teddlie and Tashakkori 2009). The quantitative technique was by counting frequencies of themes from an interview, dialogue, speech, or text. Hesse-Biber (2010) and Teddlie et al. (2009) explain that quantitative analysis of themes or categories can give significant themes that need to be analyzed further. Both Hesse-Bieber (2010) and Teddlie (2009) suggest an iterative analysis from codified and quantified themes with interpretation of texts in the transcripts.

We employed the process from grounded theory approach using coding technique of themes, sub-themes, and category, or profile data from transcripts as suggested by Creswell (1998). We used open-source software R-QDA (R-Qualitative Data Analysis) to help categorize and code themes from the transcript. We also used spreadsheet Libreoffice Calc to help quantitative analysis of themes (Bree and Galagher 2016).

The procedure of analysis is following procedures suggested by Creswell (1998) as follows: (i) *Open coding*. In this step, we categorized information by segmenting information. In each category, we looked for a phenomenon related to the SES framework. We look at the whole transcript and code every paragraph and sentence into open categories or code. Similar property (characteristics) or statements will be coded under the code. Extreme phenomenon or statements is categorized under different code. (ii) *Categorizing codes*. With RQDA categorizing bigger themes can be done after or before open coding is completed. We did categorize codes into 6 themes (conflicts, SES performance, land use, land ownership, governance, history) after we did the open coding process. (iii) *Axial coding* is a process to link relevant codes contribute or as a result of a central phenomenon. Here, we used logical diagram and tabulate the codes with adjacency matrix (1 to 1 matrix) to find the cause and the result of a central phenomenon.

Then, we went to the next step to identify stories of phenomenon of water conflicts and their impact. To ensure that the stories composed from data analysis are consistent with the transcript, we compared the stories with the transcript of FGDs and find the text that proves the theory constructed from coding process.

RESULTS AND DISCUSSION

Center phenomenon

The focus group discussions and interviews were undertaken from June 2018 to September 2019. There was 17 transcripts of code analyzed in this study. The 17 transcripts were coded into 38 thematic codes, and there have been 412 individual paragraphs and statements coded. The second step is to categorize the 38 codes and counting frequencies of each theme and cluster them into 6 categories. Table 2 showed the frequencies of themes mentioned by participants of FGD and interviews.

Qualitative analysis of transcripts resulted in the most frequent themes from FGD and interviews for each category. Under category of resources system, the participants described diverse systems of water resources in the villages. Water sources consist of low wells, deep wells, springs mostly in the cave, and retention basins. The infrastructure of water system is also varied. Some springs and deep wells have piping distribution systems mostly to public taps. But not all wells and springs are equipped with distribution pipes and pumps. Community-built wells usually are not equipped with infrastructures such as pumps or piping. If there are community-built wells equipped with such infrastructure, that is the owner of the wells who buy all the equipment and flow the water to his/her house. In government-built wells, usually equipped with pumps and piping to public tap. However, the infrastructure is not always maintained. Some of the infrastructures such as piping were damaged, and no one cared to repair them. In all villages, most governments built wells do not have institutions or organizations ensuring sustainability of the infrastructure.

Retention basins are the most discussed water system under the category of resource system. All of the retention basins mentioned by participants are under conflicts or tensions. The accessories of the retention basins such as piping are usually damaged or sabotaged by some people to water their own crop gardens or cattle. None of the retention basins have an institution to manage the basin system. After the government at national, provincial, or district level transferred the basins to the village or community, government expected community to self-govern the basin. The only role of government at national, provincial, or district level is providing maintenance budget for some years (usually 2 or 3 years) to repair the accessories of the basin.

In category of action, conflicts in many forms are the most frequent themes exposed during discussion and interview. In category of actors, landlords are the most frequently spoken by participants as influential figures and perpetrators of water conflicts. Landlords with their affiliates members usually sabotage the piping system to benefit their groups or families. Open conflicts did not occur, sabotage, damaging pipe, or breaking pipe, was the common action by certain groups in the community. Most of the participants suggested that landlords and their affiliates are the perpetrators of sabotage to exclude larger groups to access the water. In governance category, clan ownership is the most issue told by participants. Clan

ownership is influential and has a strong relation with community-managed resources, ineffective water institutions, and conflicting village government control over retention basins.

The last category analyzed in the study was the socio-ecological performance of retention basins. In this category, basin condition issues mean sedimentation is the most frequent topic discussed by participants and interviewees. The next theme that came up from the discussion is retention basin water availability. Retention basins are mainly used for agriculture and cattle raising. Only when getting freshwater is very limited, inhabitants in 4 villages fetch water from retention basins. The issues are also related to the distribution challenges themes and equity of access. Not all inhabitants get the same opportunity to access water even in a sub-village. In-equity of water access relates to the conflicts.

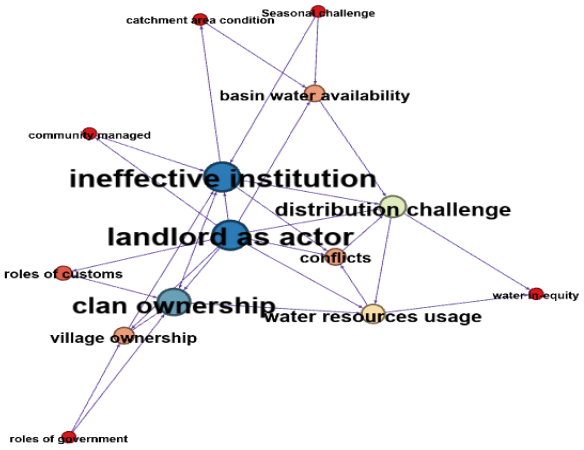

Figure 4. Relationship among selected themes

Table 2. Thematic coding and categorizing results

Category	Code	Batuinan	Hansisi	Huilelot	Uiasa	Total result
Action situation	Colonial forest border	1				1
	Conflicts	4	7	1	8	20
	Land and forest conflicts	1			1	2
Actors	Landlord[1]	16	4	2	3	25
	Roles of government		3	2	1	6
Gender	Female participation	1	5	2	4	12
	Male domination	1			2	3
Governance	Clan ownership	11	6	7	10	34
	Community managed	5		2	6	13
	Customary rules on natural resources			6	5	11
	Ineffective institution	2	11	3	5	21
	Land ownership	1			1	2
	Roles of churches	1	1			2
	Roles of customs	1				1
	Village ownership	5	1	1	6	13
Resource system	Climate and weather condition	2	1	1	3	7
	Population number	1				1
	Retention basin	12	8	5	10	35
	Spring	1	3	2	6	12
	Unfit technology			1		1
	Users	7	1	2		10
	Water consumption	1	3			4
	Water cost	5	5	1	7	18
	Water fetch technology	2	2			4
	Water resource usage	16	24	5	18	63
	Water tank	2	1	1		4
	Well	6	2	2	4	14
SE-performance	Basin condition	1	9	5	10	25
	Basin water availability	3	2	2	3	10
	Catchment area condition	1			1	2
	Distribution challenge	1	4	3	3	11
	Negative impact of water system		2	3	1	6
	Seasonal calendar			1		1
	Spring condition			6	1	7
	Water equity	2		1		3
	Well condition	4	1	1	2	8
Total result		117	106	68	121	412

Note: [1]Landlords or *tuan tanah* in Bahasa Indonesia and local dialects could mean the owner of the land. In customary terms, *tuan tanah* is sometimes associated with the heir of customary or ancestral land. The landlords or *tuan tanah* usually control large parcel of land and can give use rights to relatives or those who needs land to plant food crops. In other custom for instance in Timor, in the *Atoni pah Meto* (Timorese) customs and tenurial system, a landlord is not the land owner. The land belongs to his ancestor, and the landlord play the roles as the custodian or steward of the land (Ataupah, 1994). Explanation of the terms is explained in the Discussion section.

Table 3. Relational matrix of selected themes

		Results													
	Cause	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**
A	Conflicts												1			
B	Landlord	1			1	1	1		1	1	1		1			1
C	Roles of government				1					1						
D	Clan ownership						1		1							1
E	Community managed						1									
F	Ineffective institution	1			1								1			
G	Roles of churches															
H	Roles of customs				1											
I	Village ownership				1		1									
J	Basin water availability												1			
K	Catchment area condition										1					
L	Distribution challenge														1	
M	Seasonal calendar										1					
N	Water in-equity															
O	Water resources usage														1	

Selective themes and their relations

After finding the central phenomenon from the open code and categorization, we look back to the transcript and find the logic of the stories described in each transcript. We found 15 themes relevant to central phenomenon and created an adjacency matrix to relate the direct cause and result of each theme as presented in Table 3.

We then create visualization with Gephi 0.9.2, software for social network analysis where the visualization is presented in Figure. 4. In Figure 4 we can see the landlord as actor, ineffective institution, and clan ownership as the center of themes network. It means the three themes are the most influential factors of the dynamics of retention basin socio-ecological system.

Discussion

It is likely that the socio-ecological performance in terms of sustainability of water flow and equity of water access is influenced by landlords' roles. In all retention basins development, land was given by landowner or landlords through written agreement. Some landlords even got compensation for the land, even he still control the land. The retention basins usually only used some part of landlords' land, yet the landlord still has control over the storage and piping facilities of a retention basin. By controlling these facilities, landlords are able to exclude other users for his benefits.

The use of claim of ancestral land by landlords to exercise his power to control natural resources and infrastructure probably is the opposite of the original values of custodianship or stewardship of land and resources. Ataupah (1995) explains that in Timor, a landlord is a father of his community. As a good father, a landlord who is the descent of the first dweller, has the moral obligation to ensure the life of its community. Landlord would give lands to those who hunger, thirsty, and cold. By giving parcels of land, he protects all the people living in his domain. However, giving land to produce food, build a house, or access to water, doesn't mean that the landlord transfers ownership to his people. The landlord still has control of the land, because land is social goods, not private goods. If one does not need land, they should give back the land to the landlords so the landlord can give the land to others who need it.

In Semau, we found that the value of natural resources as social or public goods still exists in the old water resources such as the spring, spring in the cave, and old wells where in the past people fetch water manually. However, new built resources such as retention basins, constructed deep well equipped with pump and piping systems become a contested arena between landlord and commoners. In the report written by Hormat et al. (2015), in the past, similar values and roles of the landlords have similarities as Ataupah (1995) explain in the context of Timor where the landlords have moral obligation to ensure the subsistence of their people. We suggest that it might have been changed in values and roles of landlords in Semau.

It is also quite obvious that whenever water resource is used for domestic subsistence use (drinking, washing) the conflict over water resources is much lower or does not exist. Conflict or tension occurred only when water resources are used for commercial agriculture. Retention basins are mostly used for agriculture. These findings are similar to the study done by Jocom (2016) in Timor and Ratumakin (2016) in Timor and Alor that conflict on water resources rarely happens where water resources is natural and traditionally used for domestic purposes.

This might be in line with the explanation of Blaikie in Ribot and Peluso (2003) that technology, capital, markets, knowledge, authority, social identities, and social relations can shape or influence access. And also, the tendency of government to uniform approach of community-based resources management might be influential in changing the behavior and values of traditional institutions that are landlords authority, claim over ancestral land, roles and values. Blaikie (2006) has critical view on the uniformity of government's community-based natural resources management program. Blaikie (2006) explains that government program tends to simplify or even hide the

complexity within communities. Hiding and simplifying the complexity could have an implication to more marginalization of already marginalized groups and enforcing the already have power (Blaikie 2006).

The phenomenon of conflicts on water from retention basins can also be explained under hydro-social territorialization concepts introduced by Swyngedouw (2009) and Boelens (2016). Boelens (2016) defined hydro-social territory as: "the contested imaginary and socio-environmental materialization of a spatially bound multi-scalar network in which humans, water flows, ecological relations, hydraulic infrastructure, financial means, legal-administrative arrangements, and cultural institutions and practices are interactively defined, aligned and mobilized through epistemological belief systems, political hierarchies and naturalizing discourses."

This article explains the first finding of our study. Further investigation will be needed to understand the relation of external and internal factors enforcing the dynamics of social-ecological system as suggested by Armitage (2005), Ostrom and McGinnis (2014), and Boelens (2016). Socio-ecological System particularly the governance of water changes when water infrastructures are built in an area. The external factors and the process of territorialization need to be investigated further in the political-economic context in terms of policy, program influencing the SES of retention basin in Semau Island.

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Detection of *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) in maize field in East Flores District, East Nusa Tenggara Province, Indonesia

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Abstract. *Mukkun L, Kleden YL, Simamora AV. 2021. Detection of* Spodoptera frugiperda *(J.E. Smith) (Lepidoptera: Noctuidae) in maize field in East Flores District, East Nusa Tenggara Province, Indonesia. Intl J Trop Drylands 5: 20-26.* Fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), is a pest originating from America and rapidly spread to various parts of the world, including Indonesia. In January 2020, armyworm attacks appeared on maize plantations in several districts in East Nusa Tenggara Province, Indonesia one of which is in East Flores District. This study aimed to identify *S. frugiperda* occurrence in East Flores District and to determine the damage intensity of *S. frugiperda* and the population of larvae on the maize plant. The maize fields were surveyed, and purposive sampling technique was used to assess the maize plants damaged by armyworm. Observations were made on the symptoms of the damage, identification of armyworm species, percentage of attacked corn plants, the intensity of the infestation, and maize cultivars planted by farmers. The results showed that *S. frugiperda* caused severe damage of 85 to 100% of the cultivated maize plants with damage intensity on a scale of 6 to 9. The larval population was relatively high, ranging from 1 to 28 per plant with an average of 6.65 in West Solor Subdistrict, while in Ile Mandiri Subdistrict, it ranged from 1 to 7 larvae per plant with an average of 2.55 per plant on heads.

Keywords: Control, fall armyworm, identification, monitoring, pesticides, *Spodoptera frugiperda*

INTRODUCTION

Fall Armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith), is a pest originating from America, but it is rapidly widespread to various parts globally. In January 2016, FAW was first discovered in West Africa (Nigeria and Ghana) and spread to almost all sub-Saharan Africa countries (Brévault et al. 2018). In May 2018, FAW was discovered in Karnataka in southwest India, and by late 2018 FAW outbreaks had been found in additional southeastern Asia countries, such as Bangladesh, Myanmar, and Thailand (Sun et al. 2019). *S. frugiperda* is a transboundary destructive pest that will continue to spread because it has unique biological characteristics supported by the high volume of trade in goods between countries.

This pest attacks the plant's growing points, making plant failing to form shoot/young leaves. Fall armyworm larvae are reported to attack more than 80 plant species, including maize, rice, sorghum, barley, sugarcane, vegetables, and cotton. FAW larvae can damage almost all parts of corn plants (roots, leaves, male flowers, female flowers, and cobs) (Nonci et al., 2019). According to Assefa & Ayalew (2019), armyworms that attack maize in the mid and late stages of corn growth can cause yield losses ranging from 15 to 73%, with a range of the number of plants affected by 55 - 100%. The reported losses vary depending on the age of the maize affected, the variety, and cultivation techniques used. Due to this pest attack on maize crops in Africa, the losses incurred are between 8.3 and 20.6 million tons per year, with an economic loss value of between US $ 2.5-6.2 billion per year (FAO & CABI 2019).

Because of its wide range of hosts, *S. frugiperda* is one of the most destructive pests threatening annual crops in tropical regions (da Silva et al. 2017). *S. frugiperda* needs to be controlled because of its invasive nature with a short life cycle, i.e. adult female insects can produce 900-1200 eggs; thus, the population increases rapidly and threatens cultivated plants in the tropics. Control with insecticides is reported to be less effective, and in Africa, it is reported that armyworm has been increasingly resistant to many groups of insecticides (Subiono 2020; Gutirrez-Moreno et al. 2019; Prasanna et al. 2018)

In early 2019, this pest was found in Indonesia, i.e. in maize plants in West Pasaman District, West Sumatra (Maharani et al. 2019). FAW was reported to have damaged maize crops with a high-intensity attack rate, and larvae population was between 2-10 per plant. In Lampung, this pest attack on maize has also been reported. It has also been reported that in June 2019, FAW was identified in maize plantations in Bandung District (Soreang), Garut District (Leles, Banyuresmi, and Sucinaraja), and in Sumedang District (Jatinangor) with low to high populations (Maharani et al., 2019). In January 2020, an armyworm attack appeared on maize plantations in several districts in East Nusa Tenggara Province, one of which is in East Flores District. The area of the maize crop attacked was 4,585 ha out of a total planted area of 12,072 ha spread

over 19 sub-districts (Data from The Ofice of Agriculture and Food Security, East Flores District). However, there has been no scientific study of the species and levels of the attack on maize crops in East Flores. Therefore, it is necessary to do early detection to identify pest species, determine the level of attack, and develop appropriate control strategies both in the short and long term. This study aims to identify *S. frugiperda* attack in East Flores District, determine the intensity of pest attacks, and determine the larval population that attacks maize.

MATERIALS AND METHODS

Study area and period

This research was carried out at the maize plantations that have been attacked by armyworms, including in the West Solor Sub-district and Ile Mandiri Sub-district, East Flores District, East Nusa Tenggara Province, Indonesia, in February 2020.

Research methods

The research was conducted using a survey method, including interview techniques and direct observation. Interviews were conducted with officers from the Office of Agriculture and Food Security, East Flores District, to determine the location and whereabouts of maize plantations that were attacked by *S. frugiperda*, as well as maize farmers. Direct observations were made on pests' morphology, including egg, larvae, pupae, and imago, to identify the species of armyworm, attack symptoms, attack intensity, and the percentage of plants affected. Determination of the sampling location was carried out purposively in villages and gardens that armyworm pests had attacked.

Sampling

Each planting area was sampled by taking 200 maize plants which were determined systematically. A sampling of larvae was carried out directly using a soft brush or tweezers on maize plants that showed signs of damage. The samples taken were larvae of the Lepidoptera group. The samples obtained were put into a plastic bag to be identified, and the morphological data of insects were obtained in a new state. The plastic bags were labeled containing location name, date of collection, and varieties of corn. The samples obtained were identified morphologically at the Plant Pest Laboratory, Faculty of Agriculture, Nusa Cendana University.

Observation

Morphological data, including shape, color, the pattern of the head, the shape of the spines on the body, and the number of pinacula, were recorded visually. Sampling 100 plants was conducted to determine the number of larvae per plant. The leaf whorl of plants showing signs of an attack was opened, and the number of larvae per plant was counted. The percentage of damaged plants was estimated by counting the number of clumps of plants showing symptoms of an attack on 100 sample clumps of plants. The damage intensity was carried out using a scoring system of 1 to 9 (Table 1) (FAO and CABI, 2019). Data on temperature, humidity, and daily rainfall were sourced from the Kupang Meteorological, Climatology, and Geophysical Agency as secondary data.

Data analysis

The data collected were qualitative and quantitative, subsequently tabulated and analyzed. Symptoms of damage were described in narrative form and pictures. Meanwhile, the number of larvae per clump, the percentage of crop damage, and the damage intensity were analyzed and presented in tables and graphs.

Table 1. Scale of attack of armyworms on leaves

Scale	Damage definitions
0	No damage
1	A speck of the borehole
2	Several points of holes and circles of small holes on the leaves
3	Small holes, small circular lesions, multiple lesions extending to more than 1.3 cm across the entire leaf surface
4	Some of the lesions extend about 1.3 to 2 cm across the leaf surface
5	Some lesions display more than 2.5 cm in size on some leaves, and/or several holes are small to medium in size, with a uniform or irregular shape due to consumption by caterpillars
6	Multiple large elongated lesions on several leaflets with no size
7	Many large elongated lesions on several leaves of irregular or irregular shape
8	Many lesions on almost all leaf surfaces with large holes because some of the leaf surface is eaten by caterpillars
9	Almost all the leaves are damaged/destroyed

RESULTS AND DISCUSSION

Distribution and extent of *S. frugiperda* infestation

Based on data from the Office of Agriculture and Food Security of East Flores District (Table 2) showed that *S. frugiperda* had attacked maize plantations in 18 of the 19 sub-districts. Of the total planted area of 12072 ha in 2020, about 4,585 ha (37.98%) of the total area was affected. The armyworms infestation was also not evenly distributed across sub-district (Figure 1).

The incidence of *S. frugiperda* was recorded in almost all sub-districts after 3-4 weeks of maize planting. Several sub-districts experienced severe damage to maize crops, including West Solor (100%), Titehena (95%), Waiotan Ulumado (92.75%), Ile Bura (82.56%), East Adonara (70.16%), and Tanjung Bunga (52.07%). *S. frugiperda* is reported as a highly destructive pest, which can fly hundreds of kilometers overnight with the help of wind (Bagariang 2019; Westbrook et al. 2016). In addition, these pests can also be carried through seeds and also with the help of human transportation inadvertently (Sisay et al. 2019). The existence of a certain type of pest is strongly

influenced by ecological factors, especially insects that cause damage to crops (Baskauf 2003) such as *S. frugiperda*. The laboratory studies in Ghana reported that one life cycle of *S. frugiperda* could be completed for 30 days at 25ºC; in one year, 12 generations are produced (Nboyine et al. 2020). Tropical climatic conditions and their polyphagous nature can cause an exponential increase in population over a period of time (Harrison et al. 2019; Du Plessis et al. 2020). Control measures against the *S. frugiperda* pest are carried out chemically by spraying with various types of insecticides. However, the control is not comprehensive and is applied only during severe attacks to not suppress the pest population.

Spodoptera frugiperda identification

Identification of the *S. frugiperda* was carried out by using morphological characters which differentiate it from other species.

Larva

There are distinct four characteristics of *S. frugiperda* larvae that are not shared by other species, such as (1) the presence of an inverted Y letter on the head (Figure 2A), (2) 4 points (pinacula) forming a rectangle on the abdomen of the segment 8 (Figure 2B), (3) a thick line like a ribbon on the lateral part of the body, and (4) a pinacula with a single seta (Jeger et al. 2017; Jacobs et al. 2018).

The larvae characteristics observed in the present study are the same as the morphological descriptions of *S. frugiperda* larvae (Ganiger et al. 2018; Bagariang 2019). The larvae found at the time of observation varied in number and size. One to 10 larvae were found in each maize clump, with larval stages varying from 1 to 6 instar larvae. This indicates that there have been overlapping generations of the pest that has developed more than one life cycle. Generally, 3 to 6 larvae were found in feeding on leaf whorl and damaging the growing point by scrapping the young leaves and boring the stems. If the leaflets that are still rolled are opened, medium to large larvae was found, while younger larvae found scrapping on the leaf surface (Figure 3).

Table 2. Infestation of *Spodoptera frugiperda* on maize field in East Flores District, East Nusa Tenggara Province

Sub-district	Planted area (ha)	Damaged area (ha)	Insecticide used
Adonara Timur	124	87	Decis
Ile Boleng	1246	102	Decis, Siklon
Witihama	2009	540	Foker
Adonara	250	22	Sidametrin, Buldox
Waiotan	193	179	Sidametrin, Arivo,
Ulumado			Super Max, Decis
Tanjung bunga	916	477	Sidametrin, Arivo, Decis
Larantuka	172	84	Decis, Panser
Ile Mandiri	603	201	Decis
Demon Pagong	119	32	Decis, Arivo, Amabas
Lewolema	305	61	Arivo, Supermax,
			Baycarb, Decis
Titehena	640	608	Decis, Siklon
Wulanggitang	999	50	Foker
Ile Bura	585	483	Arivo, Panser
Solor Barat	1012	1012	Sidametrin, Arivo, Decis
Solor Selatan	971	273	Arivo, Amabas, Decis
Solor Timur	1324	361	Decis, Sidametrin, Arivo
Adonara Barat	454	9	Cypermax
Klubagolit	124	40	-
Adonara Tengah	66	0	-
Total	12.072	4.585	

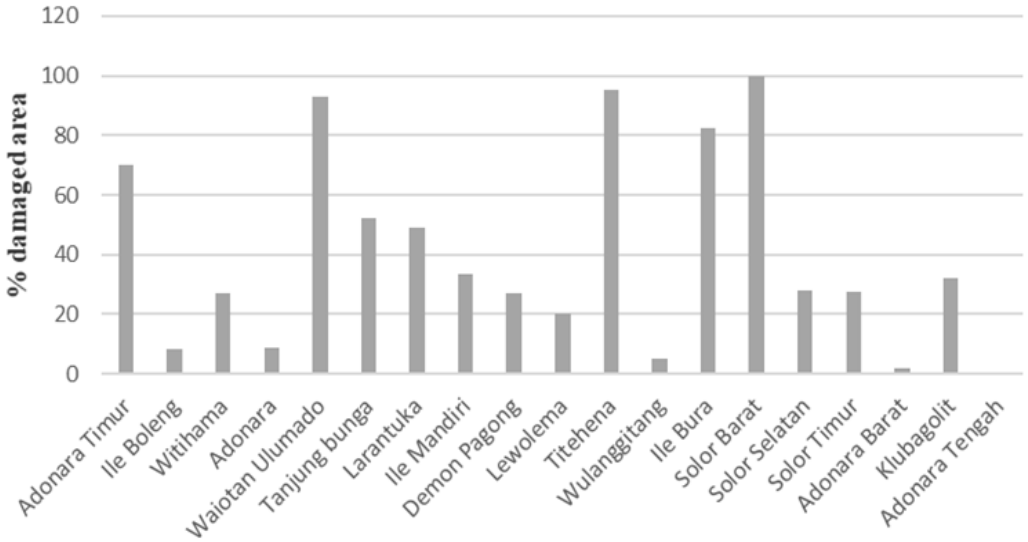


Figure 1. Distribution and percentage of planted areas affected by *Spodoptera frugiperda* in East Flores District, Indonesia

Figure 2. A. Inverted Y letter on head, B. 4 rectangular panicula in segment 8 abdomen, C. thick line on the lateral part of the body, D. *panicula* with a single seta

Damage symptoms

The attack symptoms of *S. frugiperda* are also very distinctive so that they can be easily distinguished from that of other armyworm species. The frost around the maize leaves indicates a heavy attack of larvae on the leaves caused by the instar larvae (Figure 4). In a mild attack, tiny larvae feed on the leaf bark's surface, making it appear transparent (Figure 4A). In a further attack, the leaves' larvae boreholes to show holes or torn leaves (Figure 4B). Damage to plants is usually marked by frost on the leaf surface and around the shoots after larval feeding (Figure 4 C, D). The initial symptoms of a FAW attack are similar to those of other pests on maize. If the larvae damage shoots, young leaves, or growing points of the plant, they can kill the plant. In African countries, the loss of maize crop due to FAW attacks is between 4 and 8 million tons per year, with a nominal loss of between the US $ 1-4.6 million per year. In Nicaragua, insecticide application can save yields of about 33% (Nonci et al. 2019). The reported losses vary depending on the age of the maize affected. In addition, yield losses also depend on the variety and cultivation techniques used.

Imago

Imago or adult insects were found to have the following characteristics: *S. frugiperda* imago wingspan ranges from 32 to 40 mm. Male imago size is slightly smaller than female imago. On the forewings of *S. frugiperda* male imago, there is a striking whitish mark on the tip and center. Meanwhile, the forewing of female *S. frugiperda* imago is slightly darker than male imago and has a pale complexion, ranging from grayish brown to gray and light brown patches. The hind wings of both sexes of *S. frugiperda* imago are silver-whitish with dark stripes on the edges.

Based on the characteristics of larvae, imago, and attack symptoms compared with the literature (Nboyine et al. 2020; FAO & CABI, 2019), it can be concluded that the species of armyworm that attacks maize crops in East Flores District, East Nusa Tenggara Province is *Spodoptera frugiperda* (JE Smith).

Percentage of affected planting area and plants, damage intensity and number of S. *frugiperda* larvae per plant

The percentage of maize area affected, the percentage of plant damage, the damage intensity, and the number of larvae attacking maize in three sub-districts in East Flores District are presented in Table 3. Almost all maize crops in East Flores District have been attacked (on average 80 to 100%) by *S. frugiperda*, and 45 to 100% of the plants were damaged. The damage intensity was ranged from 4 to 8 on a 0 - 9 scale. The damaged lesions on the leaf surface were 1.3 to 2 cm due to larval feeding, and even in some instances, the whole plant was destroyed by mature larvae. The number of larvae present in each plant determines the severity of this armyworm attack. The invasive armyworm *S. frugiperda* is a very destructive pest with a high-speed spreading ability. The previous research results showed that this pest could damage and spread ten times higher than other species of armyworm pests (Hruska 2019; Sisay et al. 2019).

Controls of this pest were carried out by spraying insecticides on maize crops, but this method did not show encouraging results due to the higher larval population of *S. frugiperda*. These results were probably due to several things, including (i) incomplete spraying of insecticides due to limited human resources, tools, and insecticides available, (ii) inappropriate insecticides used, (iii) low rainfall; thus, maize plants experience slow growth. Besides, the ability to move quickly causes these pests to move to other fields; therefore, their spread occurs quickly. Hruska (2019) stated that an insecticide application is usually not economical for control of the fall armyworm. However, it may be necessary if the infestation is extremely severe and the plants are under stress.

In Table 4, it can be seen that the intensity of monthly rainfall in East Flores during the rainy season (November 2019 - May 2020) was very low, ranging from 0.04 to 11.4

mm. Meanwhile, the humidity (RH) was high, especially when the farmers started planting maize, ranging from 76.74 to 84.54%. The average temperature was also in the range of 27ºC to 30ºC and is the optimum temperature range for developing this insect pest. Nurzannah et al. (2020) demonstrated that the optimum temperature for larval development is 28ºC, while the pupa and imago require lower temperatures. Larvae are the destructive stage of the *S. frugiperda* pest, with a high larval development rate, the intensity of the damage caused can also be high. The optimum temperature will also affect the pest population because in a short time (less than 30 days), a new generation will be formed. In a year, it will produce a minimum of 12 generations if the host is available (Du Plessis et al. 2020).

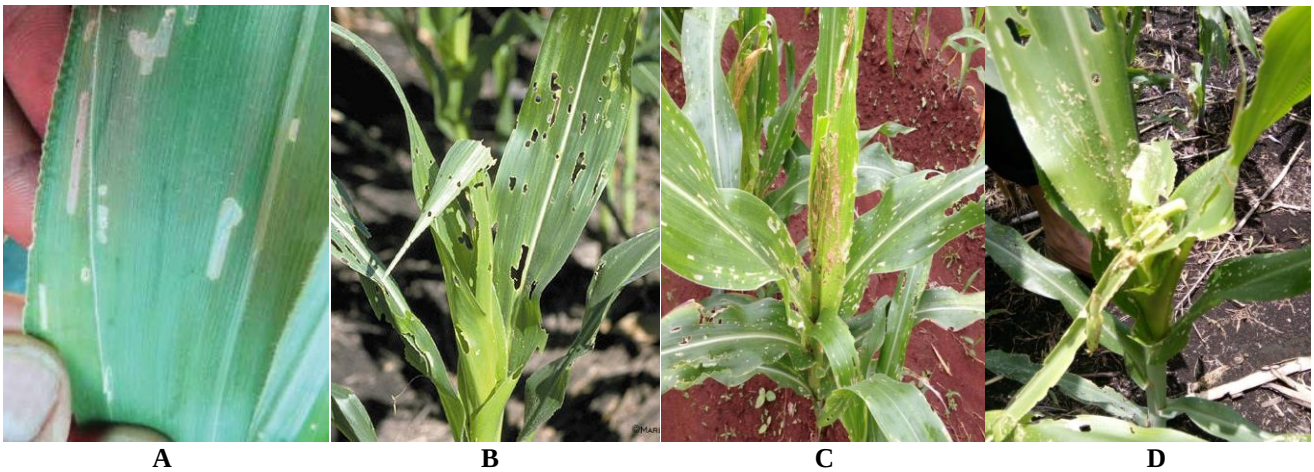
Low rainfall conditions also increase the ability to develop shorter reproductive cycles and higher distribution capabilities of *S. frugiperda*. However, if the rainfall increases, the pest population decreases due to pests being washed or carried away by rainwater, and plant development improves (Nurzannah et al. 2020; Jaramillo-Barrios et al. 2019).

Table 3. Average percentage of planting area and maize plants affected, intensity of damage and number of *Spodoptera frugiperda* larvae in maize in East Flores District, Indonesia

Sub-district	Village	% infected field	% infected plant	Scale of attack on leaves (1-9)	Number of larvae/ plant
West Solor	Kalelu	100	100	8	6.60
	Ritaebang	85	68	6	6.45
Ile Mandiri	Riangkemie	100	50	5	2.40
	Lewohala	80	45	4	2.20
Tanjung Bunga	Waiklibang	85	85	8	5.20
	Kolaka	65	50	6	3.55

A **B** **C** **D**

Figure 3. A. Larvae of various sizes (instar), B. Instar 3 and 5 larvae in one maize clump, C. Third instar larvae, D. Affected maize plants



A **B** **C** **D**

Figure 4. Symptoms of attack on maize leaves, A. Small spots caused by early instar larvae, B. More leaf holes, caused by 3-4 instar larvae, C. Almost all leaves are damaged, D. Damaged plants to the point of growing

Table 4. Average temperature, humidity and monthly rainfall in East Flores District, Indonesia

Month/year	Temperature (ºC)	RH (%)	Rainfall (mm)
October/2019	29.24	71.93	0
November/2019	30.30	69.86	0.04
December/2019	29.84	76.74	2.58
January/2020	27.93	84.54	11.14
February/2020	28.75	81.81	8.23
March/2020	28.26	82.65	5.52
April/2020	28.56	79.03	4.61
May/2020	28.54	77.77	7.83
June/2020	28.11	71.75	0
July/2020	27.61	68.03	0
August/2020	27.35	71.35	0
September/2020	28.43	70.20	0

Note: *) data processed from http://dataonline.bmkg.go.id/data_iklim, accessed 19/11/2020

In conclusion, based on the morphological characteristics of eggs, larvae, imago, and the damage symptoms, and subsequently, compared with the existing literature, it can be ascertained that the insect pests that attack maize plantations in East Flores were *Spodoptera frugiperda*. The damage caused by the S. *frugiperda* pest was highly severe, much heavier than the damage caused by other types of armyworms. Almost all maize fields (85 to 100 percent) have been attacked by FAW, most of which occurred in the early vegetative phase, making it challenging to recover. The damage intensity was classified as heavy with a scale ranging from 6 to 9. The larvae population per plant was high, ranging from 1 to 28 individuals plant^{-1} with an average of 6.65 larvae plant^{-1} in West Solor sub-district, while in Ile Mandiri it ranged from 1 to 7 per plant with an average of 2.55 larvae plant^{-1}. Low rainfall and humidity, and high temperature are thought to be factors that influence population development and the intensity of damage caused by S. *frugiperda*. Rain intensity in Ile Mandiri subdistrict was more frequent than that in West Solor subdistrict; therefore, it is assumed that the rainfall factor plays an essential role in the development and damage caused by this FAW. Chemical control carried out on some fields was not effective because not all fields were uniformly sprayed with insecticides, and the insecticides used were not suitable for this FAW in maize.

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Reviews: Komodo National Park as a conservation area for the komodo species (*Varanus komodoensis*) and sustainable ecotourism

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Abstract. *Hidyarko AIF, Gayatri AC, Rifa VA, Astuti A, Kusumaningrum L, Mau YS, Rudiharto H, Setyawan AD. 2021. Komodo National Park as a conservation area for the komodo species* (Varanus komodoensis) *and sustainable ecotourism. Intl J Trop Drylands 5: 27-40.* Komodo National Park (East Nusa Tenggara Province, Indonesia) is a biodiversity conservation area with the main aim to protect the original habitat and remaining population of Komodo dragon species (*Varanus komodoensis* Ouwens, 1912). Nonetheless, the area also has great potential as one of the objects of tourist attraction. The purpose of this study is to see the sustainable function of conservation and tourism in Komodo National Park. Komodo National Park covers land area of more than 603 square kilometers and 1214 square kilometers of marine habitat. The land habitats have 277 species of animals while the marine habitats have 253 species of corals, more than 1,000 species of fish, and 25 species of whales and dolphins. One of the main attractions of the Komodo National Park area is the ancient giant reptile of the Komodo dragon (*Varanus komodoensis*). The tourism management of Komodo National Park (KNP) is currently done through an ecotourism approach. The tourism zone is determined based on part of the Komodo National Park which has the potential for land and marine tourism with a diversity of flora and fauna. The participation of communities living around KNP in the ecotourism business can increase local economics and conservation awareness; as well as their participation in conservation. Meanwhile, the factors that hinder community participation in tourism development are limited budget, apathy and low public awareness, fluctuations in tourist visits, and difficulties in marketing ecotourism products.

Keywords: Ecotourism, Komodo National Park, protected areas, tourism zone

INTRODUCTION

Komodo Island is one of the islands in the East Nusa Tenggara Province, Indonesia. This island is the habitat of the Komodo dragon (*Varanus komodoensis* Ouwens, 1912) (Figure 1) (Kurniawati and Ratunnisa 2016). The island is named as Komodo Island (Pulau Komodo) after the animal was discovered in 1910. Komodo is an endangered animal with a population of less than 4000 in the wild. As an effort to protect Komodo dragons, in 1980 a conservation area was established on Komodo island which is now known as the Komodo National Park (Situmeang 2012). Komodo National Park is located in Komodo Sub-district, West Manggarai District, East Nusa Tenggara Province, Indonesia (Figure 2) (Gibson et al. 2020).

The determination of the Komodo National Park Conservation Area was based on the Decree of the Minister of Forestry No. 172/Kpts-II/2000 dated June 29, 2000 with a total area of 173,300 ha, of which the water area is 114,801 Ha and the land area is 58,499 Ha. The zoning of Komodo National Park was approved based on the Decree of the Director-General of Forest Protection and Nature Conservation No. SK.21/IV-SET/2012 concerning Zoning of Komodo National Park (Ministry of Forestry 2012). Komodo National Park consists of several small and medium islands.

The Komodo National Park area is divided into several zones, including the core zone (34311 ha), jungle zone (66921.08 ha), marine protection zone (36308 ha), land tourism utilization zone (824 ha), marine tourism utilization zone (1584 ha), land traditional use zone (879 ha), marine traditional use zone (17308 ha), pelagic special use zone (59601 ha), special zone for traditional community settlement (298 ha) (Figures 2 and 3). The division of the zone is based on land function, land use and land potential. For example, tourism zones are defined based on the part of the national park that has land and sea tourism potential (Walpole et al. 2008). Nonetheless, there is one potential zone that is not yet designated, namely the community business potential zone. This zone becomes

important for community development to support tourism if the Komodo National Park area develops rapidly to become a tourism center (Adil 2018).

The Indonesian tourism industry continues to experience rapid industrial development. Tourism is one of the potential sectors that influence economic development such as job creation for local residents, infrastructure development, and as a medium in understanding the culture of an area (Sokhanvar et al. 2018). In order to achieve maximum sustainability and tourism goals, the management of tourism is an important thing to pay attention to (Gabur and Sukana 2020). Ecotourism is one part or sub-sector of the tourism industry which attracts many domestic and foreign tourists (Yilma et al. 2016). The concept of ecotourism is to combine environmental aspects with sustainable tourism. Ecotourism aims to maintain the use and conservation of natural resources, especially biodiversity (Imran 2012). Ecotourism is a responsible concept for protecting the environment and the living things that live around protected areas (Safaradabi 2016). Ecotourism can act as a model for sustainable development for local governments and local communities that have economic, social and ecological benefits (Nurinsiyah et al. 2015). Ecotourism will create a stable situation by following a philosophy of life based on intrinsic and inner values (Safaradabi 2016). Ecotourism creates an environmental management tool for local governments while providing an alternative source of income for local residents and avoiding unsustainable land use (Koens et al. 2009). Ecotourism is related to local government policies to preserve the environment and culture of protected areas (Seifi and Ghobadi 2017). There are several criteria to make an area into an ecotourism area, namely: (i) the area must have a special uniqueness and cannot be found anywhere else; (ii) the readiness of the local community to participate; (iii) the legal status of the area should be clear; (iv) accommodation and other supporting facilities are available (Pratiwi et al. 2017). In the concept of ecotourism, attraction is one of the important things. Attraction is the main factor that influences tourists to get pleasure and experience in visiting tourism (Ramadhan 2016).

Figure 1. Komodo (*Varanus komodoensis*) in Komodo National Park, Indonesia (KSDAE 2021)

The Komodo National Park area consists of three large islands, namely Komodo Island, Rinca Island and Padar Island (Jamu 2014). Padar Island is the third-largest island and located between Rinca Island and Komodo Island (Komodo National Park Hall 2018). Each island has its own attractiveness (Parta 2019). Komodo Island has tourist attractions in the form of Loh Liang, Rinca Island with Loh Buaya and Padar Island with South Padar and Long Beach located in the western part of Padar Island and several small islands around it. Nonetheless, the main attraction of ecotourism of Komodo National Park is the Komodo dragon itself, spread across several islands, including Komodo Island, Rinca Island, and Padar Island. Considering that Komodo dragon is an endangered animal, the tourism management of Komodo National Park is currently using an ecotourism approach. The resource management strategy used in the implementation of tourism on Komodo Island should refer to conservation principles, so that the preservation of Komodo can be maintained and tourism activities can be carried out in a sustainable manner (Suryani et al. 2016).

The ecotourism potential in Komodo National Park is in fact very competitive at global level by bringing more than 50,000 people per year with 85% of them are foreign tourists (Iriyono et al. 2013). The high level of tourism activities in this national park seems to affect the existence of Komodo dragon population (Ardiantiono et al. 2018). This is evidenced by the declining distribution and population of Komodo dragons in the last three decades. For example, data from the Komodo National Park office (2018) showed that the population of Komodo dragons on Padar Island remains seven. In addition to tourism, population decline of deer as the main prey has also been another factor causing the decline in the Komodo dragon population (Jessop et al. 2007). With this population decline, special attention and conservation efforts are needed for Komodo dragons.

PROTECTED AREA - KOMODO NATIONAL PARK

Act No. 26 of 2007 concerning Spatial Planning, which was followed up by Government Regulation No. 26 of 2008 concerning National Spatial Planning, stated that protected area is an area designated with the main function of protecting environmental sustainability which includes natural resources and artificial resources, as well as the historical and cultural values of the nation, in the interest of sustainable development. A protected ecosystem conserves potential germplasms which can be developed to meet human needs in the future (Anshori 2005). Protected areas consist of national parks, wildlife sanctuaries, nature reserves, nature conservations and cultural heritages, areas prone to natural disasters, geological protected areas, and other areas (Mokodongan et al. 2014). Based on the IUCN there are several categories of protected areas, namely: 1) strictly protected areas for nature protection; 1a) protected areas for research; 1b) protected area for nature conservation, 2) protected area for ecosystem protection and recreation, 3) protected area for conservation, 4)

protected area for conservation management, 5) for tourism and landscape, 6) preservation of natural resources for ecosystem sustainability. Protected area might serve as attraction for tourism, but without disturbing the function and environmental sustainability. The development of attractions in protected area can be in the form of green open spaces (Darsiharjo et al. 2016). The Komodo National Park area as a form of national park functions to protect the ecosystem and biodiversity while to some extent it might be utilized for tourism purposes.

The Komodo National Park area and its surroundings are one of the areas designated as national strategic areas (Kawasan Strategis Nasional/KSN) as stated in Government Regulation No. 13 of 2017 concerning National Spatial Planning. The determination of this area is because the Komodo National Park and its surrounding areas located on Flores Island and Sumbawa Island have the potential and strategic importance to be developed as a driver of the national economy and protection of biodiversity. The development of the area, an agglomeration of natural and socio-cultural wealth located in West Manggarai and Bima districts, is expected to provide important resources as part of Integrated Coastal Area Management. The National Strategic and Important Values that have been outlined in the National Strategic Area Zoning Plan (RZ KSN) of Komodo National Park are also expected to provide sufficient water resources and legal certainty to minimize problems/conflicts on the use of water areas in the Komodo National Park Area KSN and its surroundings. Conservation Areas and Protected Biota Conservation areas within the Komodo National Park include: (i) Banta Island Regional Water Conservation Area which has been established by the Decree of the Governor of NTB No 523-505 dated 25 May 2016; (ii) Reserve for the Coconut Island Regional Water Conservation Area that has been allocated in the Perda RZ WP3K NTB document; (iii) Reserve for Longos Island Regional Water Conservation Area that has been allocated in the Perda RZ WP3K NTT document; (iv) Komodo National Park which has been established by the Decree of the Minister of Forestry and Plantations No. 172/KPTS-II/2000 (Suraji et al. 2020).

Protected areas that are used as tourist areas such as Komodo National Park must be able to maintain and accommodate the things that become criteria of protected areas. Nonetheless, non-conservation and tourism uses are also allowed to some extent particularly if there is an enclave area with historical use by indigenous communities. For example, Papagaran Island is one of the small islands located within the Komodo National Park area, and as a traditional use zone in accordance with the 25 years management plan initiated by the Government of the Republic of Indonesia through the Komodo National Park Center (BTNK). More than 280 fishermen households depend on coastal resources around the small island (Sudaryanto and Herdiansyah 2018).

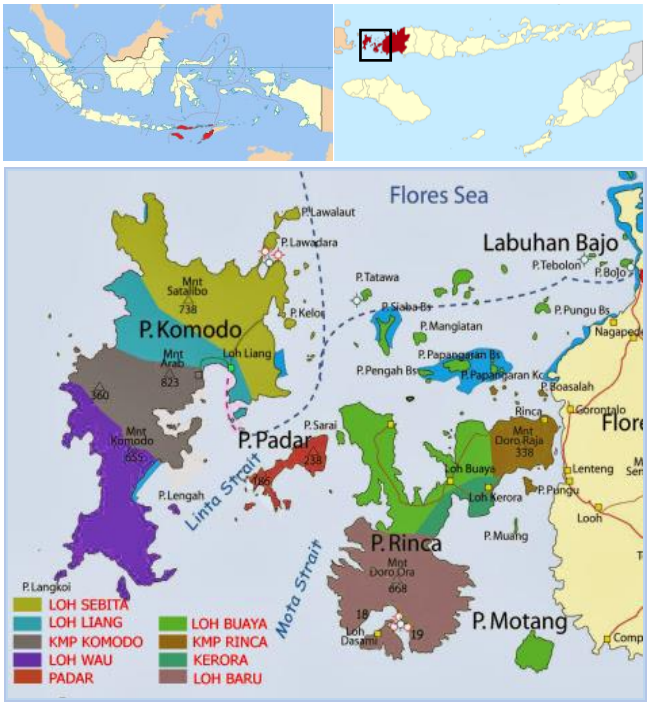

Figure 2. Map of the Komodo National Park area, Indonesia. Source: pariwisata-tourisme-flores.blogspot.com

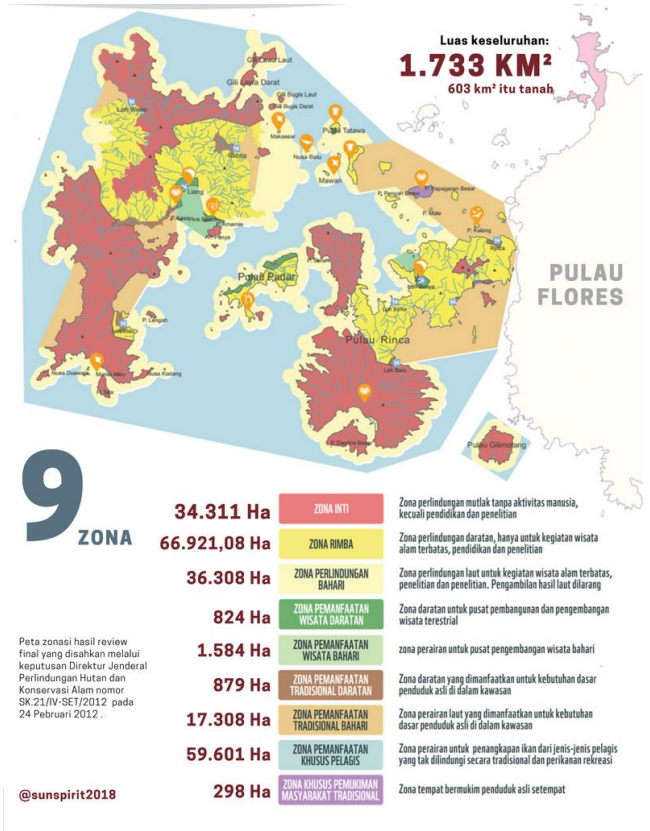

Figure 3. Komodo National Park zoning, Indonesia. Source: sunspiritforjusticeandpeace.org

In accordance with the mandate of the Law of the Republic of Indonesia No. 32 of 2014 concerning Marine Affairs Article 42, as well as maritime and marine policy directions and listed in the 2015-2019 RPJMN, considering that the Komodo National Park area is one of the national strategic areas, it is necessary to prepare a Presidential Regulation on Komodo National Park KSN Zoning Plan (Suraji et al. 2020). Regulations regarding zoning are provisions that regulate the use of space and elements of control that are prepared for each designation zone to conform to its designation (Budhianti 2019).

As stated above, Komodo National Park is divided into 9 zones, with each zoning has a different area function. The core zone is a zone that focuses on area conservation (Oktaviani et al. 2021). There should be no human activities in the core zone, except activities related to research and education. The jungle zone is a protection zone, this zone can be used for limited nature tourism activities, research and education. The marine protection zone is a zone that focuses on marine/water conservation, in this zone limited natural tourism activities are allowed, but no marine product collection activities are allowed. Land tourism utilization zone is an area used for a mainland natural tourism center. Marine tourism utilization zone is an area that is used as a center for marine natural tourism. There is a favorite destination for scuba divers or snorkeling in this zone because it has tourist attractions such as coral reefs, sharks, and various other marine biotas (Kusnanto et al. 2018). Traditional land and maritime use zones, zones used for accommodation activities for the basic needs of indigenous people with special utilization rights permitted by the Head of the National Park Authority. In the traditional marine use zone, marine products can be harvested using environmentally friendly tools (fishing rods, huhate, and umbrellas). The special pelagic zone is a zone in which fishing activities and other unprotected marine products can be taken as well as tourism/recreational activities. Furthermore, the special settlement zone, the zone used to settle the natives.

These zones are spread over 3 major islands, namely Komodo Island, Rinca Island and Padar Island. Komodo Island is the largest island, this island is mostly a core zone and a jungle zone. The second largest island in the Komodo National Park area is Rinca Island. This island has a beauty that is no less interesting than Komodo Island. In addition, Rinca Island has several species of animals that are not found on Komodo Island such as the Rinca rat (*Rattus rintjanus*), Wild horse (*Equus caballus*) and Long-tailed macaque (*Macaca fascicularis*). Rinca Island has also a savanna area which is the habitat of various wild animals such as deer, buffalo, horses, all of which are a source of food for the Komodo dragon. Limiting the distribution of settlements in the savanna area is an action to maintain the survival of the Komodo dragon (Adil et al. 2017). The mainland of Padar Island is divided into 3 core zones, namely the core zone in the small Padar and Batubilah island, the jungle zone at several points in the south and west of Padar Island, and the northern, eastern and southern land tourism utilization zones. The waters in the Padar Island area as a whole are included in the marine protection zone.

TOURIST ATTRACTION

Tourism potential is the most important component for developing tourist areas and maintaining tourism resources (Rijal et al. 2020). The ecological carrying capacity aspect is the ability of the environment to provide a tourist attraction (Butarbutar and Soemarno 2013). Tourist attraction is everything that has uniqueness, beauty and value in the form of a diversity of natural, cultural and man-made wealth that is the target or purpose of visiting tourists (Susila and Pramono 2020). Komodo National Park has two kinds of attractions, namely marine tourism attractions and mainland tourist attractions. Marine tourism attractions include snorkeling, diving, canoeing, and others. Meanwhile, activities on the land include animal watching, hiking and camping. Animal watching is a form of tourist attraction that comes from the diversity of natural wealth in the form of fauna or endangered animals used as objects that can attract visitors. The animal watching tourist attraction is distinct from other attractions because it includes various species in different locations and pays attention to the typology of visiting tourists (Tapper 2006). Animal watching pays attention to typology to maintain animal quality and protect animals in vulnerable areas. Animal watching tourism product is a tourism product that is used to distinguish the animals watched from their natural habitat. Tourism products can be interpreted as interrelated components and support tourism activities (Gabur and Sukana 2020).

There are several tourist attractions in Komodo National Park, especially in Loh Liang, Loh Buaya and Pandar Island (Figures 4-6) as described below.

Loh Liang on Komodo Island

One of the tourist destinations that are the mainstay of Komodo Island is Loh Liang. Loh Liang is the main welcoming area for tourism activities (Mayasari 2006). Loh Liang is dominated by savanna ecosystem consisting of 5 valleys, including two broad valleys, namely the Banunggulung valley and the Poreng valley (Muslich and Priyono 2005). At this location, visitors can see directly the Komodo dragons and local plants that grow in the area (Ahmad and Yunita 2019). Besides being able to see Komodo dragons directly, visitors can also observe deer, wild boars, and birds as well as climbing. In Loh Liang there is also mangrove area where tourists can watch sea birds (Butchart et al. 1996).

Loh Buaya on Rinca Island

Loh Buaya is one of the tourist areas in KNP. Loh Buaya has the main attraction because of its authenticity and natural beauty, especially the savanna ecosystem and underwater panorama. Savanna is the dominant ecosystem in Loh Buaya. In this ecosystem, tourists can directly observe Komodo dragons, deer (*Cervus timorensis*), Long-tailed macaque (*Macaca fascicularis*), Wild horses (*Equus caballus*) and buffalo (*Bubalus bubalis*) (Garsetiasih 2001). The attractions of marine tourism in Loh Buaya are fishing, snorkeling, diving and canoeing (Lun 2016). In addition,

tourism activities that can be carried out are observing wildlife and observing bats (Kodir et al. 2019).

Padar Island

Padar Island is a small island located between Komodo Island and Rinca Island. Padar Island has two main attractions, namely South Padar and Long Beach, located west of Padar Island. Padar Island is the third largest island after Komodo Island and Rinca Island (Leha et al. 2021). Padar Island has become an UNESCO world heritage because it is part of the Komodo National Park (Narulita et al. 2012). Padar Island is included in the jungle zone and the tourism activities are limited. The basis of the attractions of Padar Island is the beauty of the natural scenery both on land and at the sea. Tourism activities in Padar Island are divided into two parts, in South Padar in the form of trekking, adventure and bird watching. Meanwhile, in Padar Barat, tourism activities include snorkeling and swimming at Long Beach.

KOMODO NATIONAL PARK BIODIVERSITY

Komodo National Park applies ecotourism-based tourism management (Liestiandre et al. 2019). Apart from tourism, other activities carried out in the Komodo National Park area are related to the conservation of the Komodo dragon and other biodiversities (Ziku 2015). Komodo dragon is an ancient reptile that has high conservation value and is included in the flagship species of KNP. The Komodo dragon is the largest lizard in the world with prominent conservation value as a species that protects the ecosystems of southeastern Indonesia (Ariefiandy et al. 2015). Species with limited distribution will decline rapidly because they are very sensitive to global change processes (Ariefiandy et al. 2013; Davis et al. 2016). Komodo dragons are also top predators and have isolated island distributions, making them very sensitive to environmental changes (Ariefiandy et al. 2021). The Komodo dragon has small home range with isolated populations with only about 80 km^2 of potential Komodo dragon habitat is protected and conserved (Jones et al. 2020). The limited range of Komodo dragons causes the Komodo dragon to be categorized as "Vulnerable" by the World Conservation Union (IUCN 2014). Given the high risk of extinction this species faces, a multidisciplinary approach is needed in the conservation program that addresses the species itself and its habitat (Estoque et al. 2012).

The Komodo dragon is also included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is a regulation that deals with issues such as exploitation of wild organisms for profit; trade-in illegal goods; killing or capturing wild animals; and the use of animals for purposes deemed repugnant. Certain species included in the appendix to the CITES are those vulnerable to extinction. It is necessary to conserve and apply trade restrictions as a contribution to international conservation (Hutton and Dickson 2000). The Komodo dragon is included in Appendix I due to its demographic decline and limited distribution. The Komodo dragon sales are about 0.0010% of the global sales percentage (Pernetta 2009). The level of sales of live Komodo dragons tends to be higher than the trade of komodo skins (Murphy et al. 2002).

Figure 4. Loh Liang in Komodo National Park, Indonesia. Source: www.getlostsafely.com

Figure 5. Loh Buaya in Komodo National Park, Indonesia. Source: portal.manggaraibaratkab.go.id

Figure 6. Iconic scenes of Padar Island in Komodo National Park, Indonesia. Source: www.cnnindonesia.com

The Komodo dragon is endemic to five small islands in eastern Indonesia, with four populations in Komodo National Park and several fragmented populations on the larger Flores Island (Ariefiandy et al. 2013). Komodo dragon is top predator with the dominant prey species include deer, wild boar, and buffalo (Bull et al. 2010). Anthropogenic activities such as poaching can reduce the Komodo dragon population outside and inside the Komodo National Park area. Ecotourism is deemed the right solution to protect endangered species that will become extinct (Portia and Ulfah 2019).

In addition to Komodo as a flagship species, the Komodo National Park area that is dominated by grassland (savanna) also has other diverse fauna species. There are 277 species of animals found that currently living inside the park. Those animals are believed to be a mix of Asian and Australian biodiversity. Among those numbers, there are 32 species of mammals, 128 species of birds, and 37 species of reptiles. The marine habitats found in the park are mangrove forests, seagrasses, and coral reefs ecosystem. There are 253 species of corals that have been successfully identified. More than 1,000 species of fish live in that ecosystem (KSDAE 2021) and 25 species of whales and dolphins (Putra and Parno 2018). Some interesting animals are shown in Figures 7-11.

Mammals that are relatively abundant in the Komodo National Park area are Long-tailed macaque (*Macaca fascicularis*) and Asian palm civet (*Paradoxurus hermaphroditus*) (Jessop et al. 2006). The long-tailed monkey is a semi-arboreal, omnivorous species and is distributed throughout the islands of Southeast Asia to mainland Asia (Supriatna and Wahyono 2000). Other mammal species such as Javan rusa (*Cervus timorensis*), Wild boar (*Sus scrofa*), Rinca rat (*Rattus rintjanus*), Water buffalo (*Bubalus bubalis*) and Wild horse (*Equus caballus*) and Asian wild dog (*Cuon alpinus*) (Djuanda 2009). Komodo National Park found about 18 species of herpetofauna. Among them were 2 species of amphibians, namely *Fejervarya cancrivora* and *Kaloula baleata* (Kennedi et al. 2020) and 16 species of reptiles, including Indian cobra (*Naja naja*), Russell snakes (*Viperia russeli*), White-lipped pit viper (*Trimeresurus albolabris*), pythons (*Python* sp.), sea snake (*Laticauda colubrina*), gecko (*Gekko* sp.), Hawksbill turtle (*Eretmochelys imbricata*), Green turtle (*Chelonia mydas*) and lizards (Scincidae, Dibamidae, Varanidae). There are also several species of birds including, Christmas frigatebird (*Fregata andrewsi*), Eurasian whimbrel (*Numenius phaeopus*), Red-backed buttonquail (*Turnix maculosa*), Zebra dove (*Geopelia striata*), Rainbow pitta (*Pitta australis*), Pied bush chat (*Saxicola caprata*), Helmeted friarbird (*Philemon buceroides*), Black-naped oriole (*Oriolus chinensis*), Orange-footed scrubfowl (*Megapodius reinwardt*), Blue-tailed bee-eater (*Merops philippinus*), Yellow-crested cockatoo (*Cacatua sulphurea*) and Green junglefowl (*Gallus varius*). The most common species encountered is Large-billed crow (*Corvus macrorhynchos*). Crows are vultures that have an important role in maintaining the balance of the ecosystem. Based on estimates, more than 1000 small yellow-crested cockatoos were found on Komodo Island (Reuleaux et al. 2020). There are also 5 species of eagles found in the Komodo National Park area, namely White-bellied sea eagle (*Haliaeetus leucogaster*), Brahminy kite (*Haliastur indus*), Black-winged kite (*Elanus caeruleus*), Bonelli's eagle (*Hieraaetus fasciatus*) and Spotted kestrel (*Falco moluccensis*).

Meanwhile, the species of fish found in the waters of Komodo National Park include *Cheilinus fasciatus, Scarus flavipectoralis, Ctenochaetus striatus, Scolopsis margaritifera, Hemigymnus melapterus, Mobula birostris, Scarus dimidiatus, Ctenochaetus binotatus, Pentapodus trivittatus, Parupenetic Zebrasoma scopas* (Indrawati et al. 2020). In addition, the diversity of fauna such as reef fish is also abundant. The existence of coral reefs in the waters of Komodo National Park is very useful for increasing the sustainability of marine ecosystems. Coral reefs provide ecosystem services in the form of habitats for breeding, shelter and large wave barriers. In addition to ecological functions, coral reefs are a tourism attraction so that they will have an economic impact on the community (Witomo et al. 2020). Among the fauna species found above, there are 4 protected fauna species, namely, Komodo dragon (*Varanus komodoensis*), Manta rays (*Mobula birostris*), Great white shark (*Carcharodon carcharias*), and Green sea turtle (*Chelonia mydas*).

The diverse ecosystem of Komodo National Park, including savanna (predominantly, 80%), upland forest, monsoon forest and mangrove forest is one of the factors contributing to its high potential for biodiversity (Borchers 2008). Savannahs and savanna grasslands occupy drier areas. Savanna is a grassland that is used by Komodo dragons (Sutomo 2020). The palm tree (*Borassus flabellifer)* is the most dominant and distinctive species in the savanna ecosystem. In addition, there are four species of grass in the savanna, namely *Themeda arguens, T. frondosa, T. intermedia* and *T. gigantea*. In addition to the 4 dominant grass species in the savanna of Komodo National Park, there are several other grass species, such as *Setaria adhaerens, Chloris barbata* and *Heteropogon contortus*. However, the dominant species is the *Themeda arguens* which account for 80% of the savanna cover. Several other plants in Komodo National Park include rattan (*Calamus* sp.), bamboo (Bambuseae), tamarind (*Tamarindus indica*), Java olive tree (*Sterculia foetida*) and jujube red date (*Ziziphus jujuba*) (Aqualdo and Malantino 2014).

Another area that dominates is the tropical monsoon forest which is located 500-700 m asl. Some tropical community activities depend on the wet-dry season, especially in the Asian monsoon climate (Opaev et al. 2021). Monsoon forests have an important role in maintaining the microclimate, especially during the dry season in regard to fluctuations in rainfall and fires (Hamilton et al. 2020). The species of plants found in the monsoon forest include Kusum tree (*Schleichera oleosa*), Jujube red date (*Ziziphus jujuba*), banyan tree (*Ficus* sp.), noni (*Morinda citrifolia*), gebang palm (*Corypha utan*) and luwi (*Alstonia scholaris*). Komodo National Park also has highland forests. The forest, which is located above 700 m

asl, has flora such as *Calophyllum spectabile*, *Colona kostermansiana*, *Glycosmis pentaphylla*, Purple aril mischocarp (*Mischocarpus sundaicus*), Mountain teak (*Podocarpus neriifolius*), Mengge (*Terminalia zollingeri*), Torres Strait scambler (*Uvaria rufa*), rattans (*Calamus* sp.), bamboo (Bambuseae). In addition, in Komodo National Park there are also about 30 species of orchids. The most dominant type of orchid is the *Dendrobium* orchid with white and orange flowers. Orchids in mountain forests usually live as epiphytes, but in Komodo National Park, two species of amoeboid orchids are found, namely *Nervilia aragona* and *Nervilia* sp. which has a tuber-like part under the ground and during the rainy season will release dormant leaves (Witomo et al. 2020). In Komodo National Park, the diversity of mangrove species found in bays protected by waves is also very diverse. Several species of vegetation, namely *Rhizophora* sp., *Rhizophora mucronata* and *Lumnitzera racemosa* which are the 3 dominant species of mangrove vegetation. In addition, other species of mangrove vegetation such as *Avicennia marina*, *Bruguiera* sp., *Capparis sepiaria*, *Ceriops tagal* and *Sonneratia alba* (Got 2013).

PARTIES INVOLVED IN KOMODO NATIONAL PARK

The communities living in the Komodo National Park area and its surroundings act as first-time occupants along with their origin history (Naufal 2019). During the early stages of determining the Komodo National Park as a protected area, the Ministry of Forestry and international institutions did not properly disseminate information to village communities in the area (Hironimus et al. 2019). In fact, the community here is an important component in supporting protected areas because the people whose livelihoods depend on the area are not expected to damage or even threaten the fauna in the area, including Komodo dragons. There are currently three villages located within Komodo National Park; (i) Pasir Panjang Village (Kampung Rinca and Kampung Kerora), (ii) Komodo Village (Kampung Komodo), and (iii) Papagarang Village (Kampung Papagarang). The people have been living inside the park for centuries and have been preserving the environment of the dragons' habitat (KSDAE 2021).

Komodo National Park is responsible for the management of the protected areas since the determination of the KNP area in 1980 through the UPT (Technical Implementation Unit) for Natural Resources Conservation. All aspects regarding the national park are managed by the national park authority, even if there are other parties such as the private sector or investors. Temporary permit (contract permit) might be issued to private sectors to participate in the management of the KNP area through the enactment of government regulation No. 36 of 2010 concerning the Natural Tourism Concession Permit (IPPA).

Komodo National Park in its area has tourist destinations that are integrated into selected tour packages by tour operators in order to become an attraction for tourists from abroad and domestic. This is inseparable from the role of the West Manggarai Tourism and Culture Office which coordinates tourism on the West Manggarai District to manage tourism within the Komodo National Park area to accommodate the increasing number of tours and tourists. Thus, the Komodo National Park tourism programs are only related to increasing tourists and collecting data on tourist destinations within the Komodo National Park area (Lukita and Sunarto 2018).

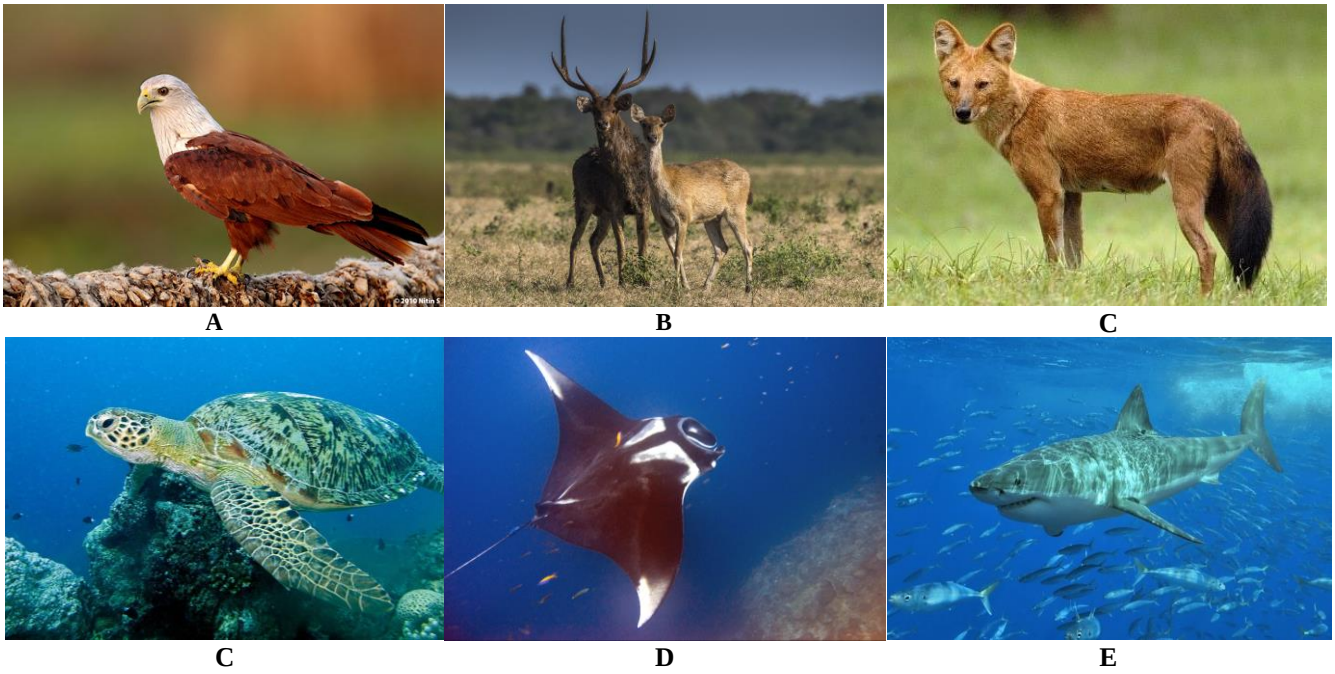

Figure 7. Some impressive fauna of Komodo National Park, Indonesia. A. *Haliastur indus*, B. *Cervus timorensis*, C. *Cuon Alpinus*, D. *Chelonia mydas*, E. *Mobula birostris*, F. *Carcharodon carcharias* (Photos from many sources)

Figure 11. Some plant species of Komodo National Park, Indonesia. A. *Borassus flabellifer*. B. *Ziziphus jujuba,* C. *Uvaria rufa*, D. *Rhizophora mucronata,* E. *Avicennia marina,* F. *Lumnitzera racemosa*

The phenomenon of changes in the livelihoods of the Komodo Island community cannot be separated from the intentional element of the government that regulates and supervises the KNP area into a resource based on natural tourism (Kiwang and Arif 2020). For example, when the existing resources have been used as objects of tourism attraction, then the people of Pasir Panjang Village are involved in gaining access to tourism resources such as Bat islands and Strawberry islands around the Pasir Panjang Village area. Thus, community involvement in the area has the ability to gain access to the benefits of tourism resources at the village scale (Michael 2009).

By regulation, natural resource management at the village scale must be managed professionally by establishing legal institutions recognized by the State through Village-Owned Enterprises (BUMDes) (Sembiring 2017). The prevailing regulations regarding village-scale resource management are implemented by village communities in the Komodo National Park area. The community is aware of the potential of natural resources owned by the village and the willingness of the community to take resource management by forming institutions through BUMDes. The village community in the Komodo National Park area deeply regrets the BUMDes institution which is expected to improve the welfare of the community but always conflicts with the rules of the Komodo National Park. One of them is an effort to maintain access to village tourism resources for the welfare of the community through BUMDes. On the other hand, there is awareness from village youth in Komodo Village and Pasir Panjang Village to form a tourism-aware community. This tourism-aware community wants to be better sheltered by BUMDes, a village tourism business division, both from the community in the area and the private sector with regard to maintaining access to village-scale resources. The ability to maintain access is carried out through the BUMDes institution by the community in the area. The role of community actors in the area is trying to maintain the usefulness of tourism resources through legal regulations in accordance with the law applicable to village laws (Puspitasari 2016).

There are useful suggestions for the development of ecotourism in Komodo National Park in Komodo Village, including the following: (i) To the managers of the National Park Authority to continue carrying out more vigorous promotions about the natural charm of Komodo National Park, improve the quality of information services about KNP and develop the existing tourism potential. In addition, for its preservation, attention must be paid to its impact on the economic growth of the Komodo Village community, in this case, the community can benefit directly from the development of ecotourism itself. (ii) To the government to continue to improve and develop infrastructure and tourism supporting facilities in the KNP area and in Labuan Bajo as the main entrance to Komodo National Park (Putra and Parno 2018).

BARRIERS OF KOMODO NATIONAL PARK

Indonesia is an archipelagic country and located in the equator, between two oceans and two continents so that it has a diversity of rainfall, temperature, humidity and wind direction (Kasa and Gunam 2019). The Komodo National Park ecosystem is influenced by the climate resulting from

a long dry season, high air temperatures and low rainfall. In addition, Komodo National Park is located in a transitional zone between Asian and Australian flora and fauna (Wallacea Zone) (Fisher et al. 2020). Its aquatic ecosystem is affected by the El-Nino/La Nina impact, resulting in warming of the surrounding seawater and frequent strong ocean currents. The various types of ecosystems and habitats that Indonesia has created an amazing diversity of species and endemism (Keong 2015). However, the rapid and extensive loss of habitat, together with climate change become threats and create significant risks to biodiversity (Purwandana et al. 2014).

Increased tourist visits can also be a threat to the sustainability and diversity of the Komodo National Park area resources (Lasso and Dahles 2020), especially marine resources, so it is necessary to arrange the allocation of marine space to protect marine resources and ecosystems, as well as to utilize the potential marine resources in the Komodo National Park KSN. The presence of human settlements in the Komodo dragon's habitat has led to increased interactions between the two which can be negative. Negative interactions or commonly referred to as conflicts are interactions that are detrimental to one or both of the interacting parties. Conflict can occur because of competition between the two parties in utilizing the same resources and space (Luo 2007). Human-komodo conflicts are found in various areas within KNP and Flores Island, especially in areas with high populations of humans and Komodo dragons. Human-komodo conflicts that occur include Komodo attacks on humans, Komodo dragon attacks on livestock, and human attacks on Komodo dragons (Endo 2013). Wild animal attacks on livestock are one of the most common types of human-wildlife conflict (Karanth et al. 2012). The case of attacks by Komodo dragons has become a concern and has sparked concern among villagers in KNP and Flores. The existence of Komodo dragons in the village is often considered a threat and cases of attacks by Komodo dragons are often the reason for villagers to expel, capture, or even kill Komodo dragons (Sudibyo 2019). Komodo dragons are hunted by residents using dogs, caught with traps and bait, and even killed by poisoning (Gustaman 2020). However, since KNP was established in 1980 as a conservation area and the Komodo dragon was designated as a protected animal, cases of hunting, catching and killing of Komodo dragons are no longer found in KNP areas as reported by KNP Office in the statistics on types of disturbance in KNP areas during 2007-2012 (BTNK 2013). The expulsion of the Komodo dragon is still being carried out. Villagers used to use wooden sticks and pelt stones to repel Komodo dragons that entered the village (Sunkar et al. 2020).

Another obstacle factor in the development of ecotourism in Komodo National Park is the lack of community participation in tourism development (Benu et al. 2020). Minimal public participation can occur due to limited budgets, apathy and low public awareness, fluctuations in tourist visits, and difficulties in marketing ecotourism products. In an effort to overcome these barriers, communication between park managers and local communities is essential (Ormsby and Kaplin 2005). Communication has 3 main indicators, namely: transmission, clarity of communication and consistency of communication. The communication transmission in question is the process of distributing information about a matter from the Head of the Tourism Office to the head of the tourism section and to the community. Clarity of information plays an important role in supporting the smooth flow of information between the Head of the Tourism Office as a policymaker and its parts and the community as policy implementers. Communication consistency will help the communication delivered by the Tourism Office so that the public can easily understand it. The recipients of communication, namely the community, can also understand the intent and purpose being discussed. The consistency of communication can prevent confusion from the Tourism Office in the field. Based on the observations of researchers, the information submitted by the Department of Tourism and Culture is one form of tourism object development coupled with support from local governments, stakeholders and related agencies, which are very influential in the activities carried out. Forms of support from the West Manggarai District government is evident in the construction of conference halls, boat bridges, and infrastructure improvements (Idris and Destari 2019).

COMMUNITY-BASED TOURISM DEVELOPMENT STRATEGY

The sustainability of ecotourism in protected areas needs to be considered in its development. Several factors that influence the development of ecotourism in protected areas including tourism potential maintained by the community can empower the surrounding community to manage tourist areas, and ecotourism activities that do not negatively impact the environment (Wulandari and Sunarto 2013). These negative impacts can be in the forms of pollution, damage to the physical environment, exploitation of resources and construction of facilities without considering the environmental conditions (Hijriati and Mardiana 2014). The development of ecotourism in protected areas must pay attention to the condition of the protected area. The pattern of spatial use that will be applied must be adapted to the conditions of the protected area (Zambrano 2010). In addition, the accessibility and safety of ecotourism development for protected areas must also be considered. The use and development of ecotourism in protected areas must pay attention to the activities that will be carried out by tourists (Hearne and Santos 2005). Thus, it can minimize the impact caused by these activities. Protected areas as ecotourism areas are permitted because protected forests are high in biodiversity, beautiful, and have diverse landscapes that can become tourist attractions and protect the protected areas (Lelloltery et al. 2020).

The current management of tourism in Komodo National Park (KNP) is through an ecotourism approach. KNP tourism activity is an ecotourism activity related to the Komodo dragon species and its biodiversity (Sulaeman et al. 2019). Good tourism management applies when the

tourism sector can provide benefits to the whole community. This can be seen when small businesses in the community are involved in the tourism industry. Ecotourism was born as a form of protest against the model of mass tourism development with an emphasis on environmental conservation, cultural preservation, community participation, economic benefits, and empowerment of vulnerable groups (Cobbinah 2015). Ecotourism has the characteristics of managing landscapes and endangered species directed to resource conservation, community cultural management is directed to community welfare, and conservation activities are directed to efforts to maintain the continuity of resource use for the present and the future (Yustinaningrum 2017). Community participation is important in order to benefit from ecotourism development (Damanik 2013; Moscardo et al. 2017). Ecotourism development must be led by the local government which is part of the development vision. However, it does not rule out the possibility of conflict from the government and local communities, strict regulations, and environmental degradation (Lee and son 2017). Conflicts usually occur when services and facilities do not make local people and tourists comfortable (Ogucha et al. 2016). The involvement of local communities should start from planning to providing facilities and implementing ecotourism properly (Koens et al. 2009) in the end by forming good institutions that will produce sustainable tourism.

The community of Komodo Village is currently participating in the development of ecotourism in Komodo Island. The participation of the Komodo Village community in the development of ecotourism on Komodo Island cannot be separated from various factors that affect the Komodo Village community itself. Various forms of community participation in Komodo Village in the development of ecotourism in Komodo Island provide various benefits to the people of Komodo Village (Umar 2016). The participation of the Komodo Village community in the ecotourism business, for example as a dragon sculpture craftsman, selling souvenirs, naturalist guides, managing homestays, and renting motorboats. The participation of the Komodo Village community in conservation, namely by being involved in the Forestry Police Partner Community group and Conservation Cadre. Community-based tourism is an important component in the development of sustainable tourism (Asriyani and Verheijen 2020). One of the important elements in sustainable tourism development is careful and effective management of tourism destinations. In ensuring the sustainability of community-based tourism and its tourist attraction in the form of daily social and cultural activities from the community, ideally, it is also supported by safe and comfortable tourism destinations (Sin and Minca 2014). A tourism destination is a stage for the performance of all tourism resources that provide final value for tourist satisfaction. Therefore, the management of tourism destinations will determine the following three elementary things; a) the advantages and attractiveness of a destination for the tourist market; b) the level of benefits ecologically, economically, socially and culturally for the region; c) its competitiveness among international tourism destination markets (Damanik 2013).

The Komodo National Park tourism development strategy is carried out with community-based tourism (CBT). This approach will place the community as the main actor in tourism development that can minimize the negative impact of tourism development that relies on outside parties (Baksh et al. 2012; Hidrawati et al. 2019). Zoning provides guidance on the implementation of conservation strategies in Komodo National Park. As a conservation area, Komodo National Park is only occupied by officers from the Komodo National Park Office. Since it was opened for tourism activities, interactions that may be carried out in Komodo National Park are only limited to tourists buying souvenirs made by local people (Gabur and Sukana 2020). Another strategy implemented in Komodo National Park is holding tourism awareness counseling to the community to increase public understanding of the importance of conservation, then increasing supervision of illegal fishing. In addition, the Komodo National Park community can create distinctive products, collaborate with various competent parties in tourism, such as travel agents, tourism organizations, NGOs and the government (Sanjaya 2018).

Tourism has an impact on foreign exchange earnings, government revenues, prices, distribution of benefits, employment opportunities, ownership and control (Mbaiwa 2003). As the results of the study of the positive impact of the "hot spring" tourist attraction in Marobo with tourism activities, employment opportunities for the surrounding community are also created which can benefit local communities, development in general, and community income (Pieda and Anom 2019). This impact becomes an idea to create a flow of tourism development in an area. Tourism development must be carried out through: (i) Promotion, which is the implementation of marketing efforts that must be carried out in an integrated manner both at home and abroad; (ii) Accessibility, is one of the important supporting aspects because it involves cross-sectoral development; c) Tourism area. These three will be a solution in developing aspects of tourism in Indonesia.

The development of community-based tourism in Komodo National Park has various potentials that are ideal for maximizing it in the form of an action plan, including several obstacles to formulating appropriate and effective strategies. Strategy is a process of determining the value of choices and making decisions in the use of resources that creates a commitment for the organization concerned to actions that lead to the future (Kanom and Zazilah 2019). Strategy can also be interpreted as an integrative general plan designed to empower tourism organizations to achieve their goals through the proper use of resources despite encountering many obstacles from competitors. Development is a process, method, act of making something better, advanced, perfect and useful. Development is a process/activity to promote something that is considered necessary to be arranged in such a way by rejuvenating or maintaining what has been developed to become more attractive and developing (dos Anjos and Kennell 2019). One of the most important things in

developing an area into a tourism destination is analyzing and assessing internal and external environmental conditions, which include strengths, weaknesses, opportunities and threats (SWOT analysis). By knowing these conditions development can be carried out properly (Kanom 2015). SWOT analysis can be used as a model in analyzing a profit-oriented and non-profit-oriented organization with the main objective of knowing the state of the organization more comprehensively (Fahmi and Yunus 2013).

Participation of ecotourism actors in conservation efforts

When ecotourism development in Komodo National Park is implemented, it is considered to be a threat to the site. Pressures on the area such as garbage, pollution, collection of biological resources by visitors, vandalism and so on often accompany tourism development (Nepal 2000). Heny et al. (2013) stated that community participation in development is important because basically, the community knows best what is needed. In principle, community participation, especially in the development of tourist villages, is participation in managing resources in their environment (Batt 2009). One example is participating in keeping the environment clean or the cleanliness of the river means having participated in the preservation of wildlife. Keeping the natural environment clean is the same as maintaining the natural habitat of the wild animals themselves (Zulfa 2015). The existence of local communities has positively impacted forest sustainability (Badola et al. 2012). Local communities have understood the importance of the existence of forests for the lives of surrounding communities, so that community dependence, especially in collecting forest resources, is low and can be controlled (Ginting et al. 2010). Community participation can provide a strong impetus for resource protection in tourism areas (Wang and Tong 2009).

The participation of the people of Komodo Village in the development of ecotourism on Komodo Island has a positive impact on the maintenance of land and marine ecosystems around Komodo Island. The Komodo Village community actively participates in environmental conservation efforts by being involved in the Forestry Police Partner Community and Conservation Cadre (Ziku 2015). The definition of MMP as summarized in the Regulation of the Minister of Forestry of the Republic of Indonesia concerning Community Forestry Police Partners, Chapter I, Article 1 paragraph 4, is a community group around the forest that assists the Forestry Police in implementing forest protection under the coordination, guidance and supervision of the supervisory agency. Generally, communities empowered as MMPs are people living around forests or protected areas (Irfan 2018). The task of the Komodo Village MMP is to carry out land and sea security and provide understanding for the community both inside and outside the area related to zoning. A conservation cadre is a person who has been given education or who has been designated as the successor of natural resources conservation efforts who have awareness and knowledge of natural resources, and is voluntary, willing and able to convey conservation messages to the surrounding community. Through the Komodo National Park, the government empowers the people of Komodo Village as Conservation Cadres. KNP establishes and provides guidance related to environmental conservation to Conservation Cadres on a regular basis. Increasing community participation needs to be encouraged through several strategies including community capacity building, regional planning, financing, infrastructure development, institutional development and marketing (Kurniasari et al. 2013).

In conclusion, Komodo National Park covers land area of more than 603 square kilometers and 1214 square kilometers of marine habitat with high diversity. The land habitats have 277 species of animals, including 32 species of mammals, 128 birds, and 37 species of reptiles. The marine habitats have 253 species of corals, more than 1,000 species of fish, and 25 species of whales and dolphins. One of the main attractions of the Komodo National Park area is the ancient giant reptile of the Komodo dragon (*Varanus komodoensis*). Komodo dragon is top predator with the dominant prey species such as deer, wild boar and buffalo. Anthropogenic activities such as poaching can reduce the Komodo dragon population outside and inside the Komodo National Park area. Ecotourism is the right solution to protect endangered species that will become extinct. The participation of the people of Komodo Village in the ecotourism business, namely as craftsmen of Komodo statues, selling souvenirs, naturalist guides, managing homestays, and renting motorboats, can increase local economics and conservation awareness; as well as the participation of the Komodo Village community in conservation, such as being involved in the Forestry Police Partner Community group and Conservation Cadre. Meanwhile, the factors that hinder community participation in tourism development are limited budget, apathy and low public awareness, fluctuations in tourist visits, and difficulties in marketing ecotourism products.

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