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Paper prepared for
The First International Conference of Indonesian Forestry Researchers (INAFOR)
Bogor, 5 – 7 December 2011

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ABSTRACT

Forests provide a number of ecosystems services to human life-support. The most important are as climate regulation which is close relationship with carbon sequestration and watershed function. However, forest conversion and degradation occurred in the large area in Indonesia due to economic reason. Involving community on managing degraded forest through agro-forestry systems is an alternative option to enhance carbon stock, biodiversity, maintaining watershed function and generate income for community. Assessment of carbon stock, watershed and livelihood condition was conducted in buffer area of Sesaot protected forest, West Lombok, Nusa Tenggara Barat. Rapid carbon stock appraisal (RaCSA) and participatory landscape appraisal (PaLA) developed by ICRAF was applied to assess carbon stock and watershed condition. Amount of 30 plots were set up in for land use systems namely secondary forest and agroforest which differentiate based on land status (private land, management permitted, non permitted). Household survey was conducted for 120 respondents across three land status. Carbon stock in agroforestry system is affected by type of planted trees as well as land status. Higher carbon stock was found in agroforestry of private land (72 ton/ha) compared to forest land (42 ton/ha). More timber trees were grown in private land rather than in forest land, both in management permitted or non-permitted. Water quality and quantity in this area is relatively good. There is no high fluctuation of discharge between wet and dry season. Dependence of local community to forest land in is quite high, because 33-59% of total income come from agroforestry systems in the buffer area of protected forest and play an important role in poverty alleviation through narrowing inequity income.

Keywords: Carbon stock, community forestry, Flow Persistence, income and equity

1. INTRODUCTION

Protected forest of Sesaot in West Lombok District, East Nusa Tenggara Province is an important area as providing ecosystem regulation. This forest is located in the upper part of Dodokan and Jangkok watershed which plays an important role in the water supply to Mataram city, as well as Central and East Lombok District. However, forest degradation and conversion to other land use systems such as agriculture and agro-forestry occurred in this area. It will impact to loss of forest function particularly carbon dioxide sequestration and hydrological function, even though potentially on increasing local income.

Local community in the buffer area of protected forest had practiced agro-forestry systems mostly coffee and cocoa mixed with other trees such as timber, fruit trees, shading trees as well as some annual crops for a couple of decades. However, tree composition growth in the systems is varied depend on the land status. So far, there are three types of land status across the buffer area are private land, permitted managing forest called community forestry and non permitted.

Community forestry (Hutan Kemasyarakatan/HKm) is one of mechanism strategy to improve degraded forest through involving community on managing forest area (Suyanto *et al.*,

2004). Of course, rule of forest management, for example, prescribing of tree and crop proportion in the certain land use should be implemented to maintain forest function. Practicing agro-forestry system through integrating tree species, perennial crop and annual crop will provide both ecological and economical function. Tree species, for example, timber and fruits mainly provide ecosystem services as a micro climate regulation and hydrological function through carbon dioxide sequestration and controlling run-off. Perennial and annual crop are mostly as sources of income for community.

Even though, community forest (HKm) mechanism is being discussed and sometime still in debate, particularly in the conservation or protected forest area due to some government regulation. However, some evidence indicates that involving community on managing degraded forest give better environment condition (Suyanto, *et al.*, 2007). The aim of this study is to know the impact of community forest program to social economic condition and the conditionality to environmental condition. We used carbon stock and watershed functions as an environmental indicator.

2. METHODS

2.1 Study Area

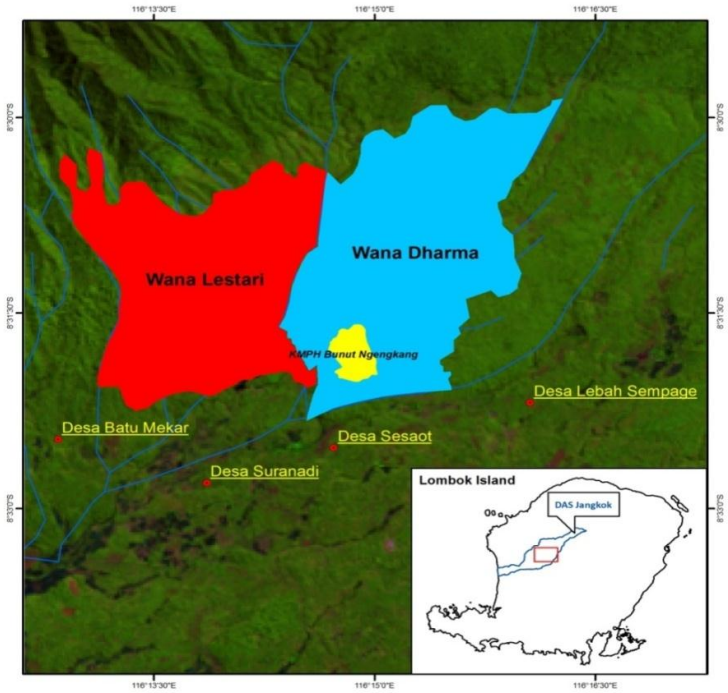

Figure 1: Location of study

This research was conducted in protected forest of Sesaot, West Lombok about 5950.18 ha under two farmer groups namely Wana Lestari and Wana Dharma (Figure 1). Both of those farmers group currently is in process to promote community forestry permit (HKm pertmit). Part of Wana Dharma area there is about 21 ha managed by KMPH (Kelompok Masyarakat Pengelola Hutan Bunut Ngengkang) had been stated as HKm permit area since 2008 from West Lombok local government.

Carbon stock measurement was conducted through set up 30 plots of 20 m x 100 m which are distributed in secondary forest (3 plots), tree-based agro-forestry system in community forestry program (HKm program 6 plots and proposed HKm program, 12 plots), private land (6

plots) and mahoni plantation (3 plots) following RaCSA method (Hairiah *et al.*, 2011). Diameter at breast height (dbh) of all trees more than 5 cm diameter in the plot were measured and identified base on local species name. Carbon stock in each land use was estimated with allometric equation developed by Ketterings *et al.*, 2001). Litter, understorey and soil were collected in 0.5 m x 0.5 m, 3 replications in each plot.

Discharge data time series of Jangkok river from 2000 – 2008 was collected from public work department as data input for running Flow Persistence model. Data of Jangkok river was selected in this analysis because the water come from the forest as well as flows through the forest. The FlowPer.xls model provides a parsimonious null-model, that is based on temporal autocorrelation or an empirical 'flow persistence' in the river flow data (Van Noordwijk *et al.*, 2011). Assessment for landscape condition using PaLA (Participatory Landscape Assessment), the method developed from Participatory Rural Appraisal (PRA) or Rapid Rural Appraisal (RRA) method.

Household survey was conducted to get socioeconomic data, particularly for quantitative data. Amount of 120 respondents consist of 40 respondents in HKm permit area, 40 in HKm non permit area and 40 in Non HKm (private land) was randomly selected from the larger sample to be interviewed. Both husband and wife were interviewed to collect information on family characteristics, such as the number of family members; age and education; history of land use; plot size for all crops; costs and revenue of land-use types, such as mixed gardens (agro-forestry), rice field and other. Poverty level of respondents was generated from household income.

3. RESULT AND DISCUSSION

3.1 Plant Species Composition in Agro-forestry System of Sesaot

Community forest management raise based on forestry minister's regulation and it is potential mechanism to improve forest function in degraded area through agro-forestry systems. Local government sees the potential benefits of handing over forest area to local community (Murdiyarso and Skutch, 2006). The local communities are allowed to manage degraded forest with an agreement. Under community forest management scheme, local communities get the formal and legal rights to use and get profit from forest products (Murdiyarso and Skutch, 2006). The legal right on managing degraded forest will encourage local communities to grow perennial tree species such as slow growing timber, fruits trees and perennial crop, instead of annual crop due to land security reason.

Identification of trees group grown by local community in agro-forestry system of Sesaot was done during the survey as Multipurpose tree species (MPTs) consist of shading trees for such as *Erythrina* sp., *Gliricidia sepium* as well as fruit trees such as candlenut, durian, avocado, petai etc; perennial crop (coffee and cocoa), annual crop (banana) and timber species.

The survey result indicates that in the area with HKm permit, more MTPs and timber trees grown by local community compared to non HKm permit (Figure 2). In opposite, more perennial crop grow in non HKm permit. Issue of eviction as the main reason why they are not interesting to grow timber species, instead of there is no regulation and agreement in non HKm area. However, there is indication that high percentage of perennial crop in non HKm area occurred due to dependence of land resource for generate income from crop. Extremely, different with in private land that is dominated by MPTs and timber species (more than 80%), because of more secure than HKm.

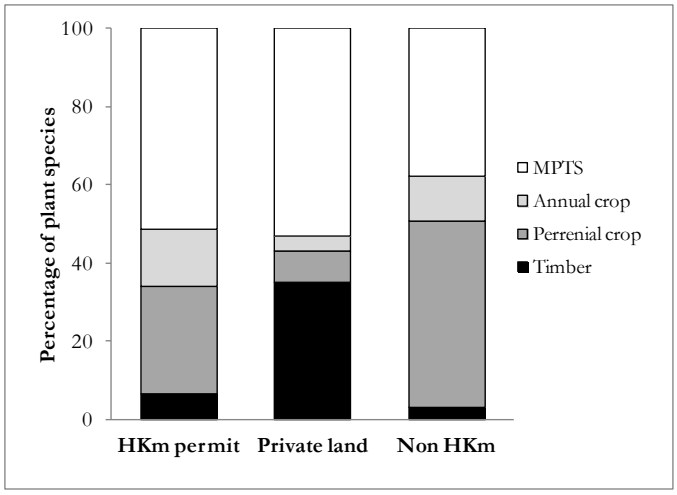

Figure 2: Percentage of plant species in various land status of agro-forestry system in protected forest of Sesaot

3.2 Carbon Stock in Agro-forestry of Sesaot

Multipurpose trees species in agro-forestry systems of community forestry area highly potential as carbon sequester, since the biomass will stay for longer time. Only fruits are extracted from MPTs. Even, coffee and cocoa just contributed about 20 – 30 ton carbon stock per hectare, but MPTs which are integrated in this land will increase the total of carbon stock per unit area.

The average of total aboveground carbon stock in agro-forestry system of Sesaot is about 46 ton/ha in HKm non permit and 33 ton/ha in HKm permit (Figure 3). There is different land history among them. HKm non permit had been developed since about 1970 from logged-over area and mahoni plantation initiated by government. HKm permit just established since 1999 from Imperata grassland after abandoned from logged-over forest. Compared with secondary forest (119 ton/ha) and private land (72 ton/ha), total aboveground carbon stock in agro-forestry system of Sesaot both in HKm non permit and HKm permit is lower. Tree species composition and age of managed land is the main factor on carbon stock contribution. Zahabu (2006), stated that in full community forest management, have resulted in significant reductions in degradation together with significant increases in sequestration of carbon.

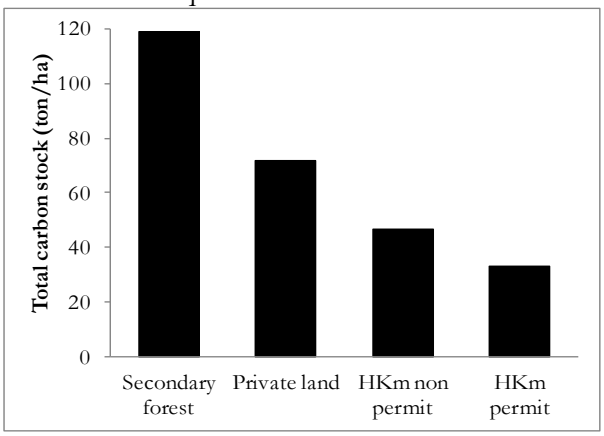

Figure 3: Total aboveground carbon stock in various land status of agro-forestry system in protected forest of Sesaot

3.3 Watershed Condition

The Flow Persistence (FlowPer) model provides a parsimonious null-model, that is based on temporal autocorrelation or an empirical 'flow persistence' in the river flow data (Van Noordwijk *et al.*, 2011). The basic form is a recursive relationship between river flows Q at subsequent days:

$Q_{t+1} = fp\ Qt + Q_{add}$

where: Q_t and Q_{t+1} represent the river flow on subsequent days, fp is the flow persistence factor ([0< fp <1]) and Q_{add} is a random variate that reflects inputs from recent rainfall.

Q_{add} and fp are related, as $\Sigma\ Q_{add\ i} = (1 - fp)\ \Sigma Q$. Thus, if fp = 1, $Q_{add} = 0$ and river flow is constant, regardless of rainfall (the ideally buffered system). If fp = 0 there is no relation between river flow on subsequent days and the river is extremely 'flashy', alternating between high and low flows without temporal predictability within the frequency distribution of Q_{add}.
Water discharge data used for this model comes from the station Jangkok Dam year period from 2000 to 2008. Previously carried out analysis of the quality of the data, after which discharge data were then tested with the Flow Persistence model. FlowPer average value of 0.86 (Table 1) this means that discharge still relatively good condition, or discharge during wet months and dry months is still persistent.

Table 1. Flow Persistance value per year of Jangkok river

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average
FlowPer value	0.79	0.69	0.85	0.87	0.90	0.88	0.90	0.86	0.92	0.86

Figure 4 shows that trend of FlowPer value tends to rise. This is in harmony with the history that forest of Sesaot is getting better due to initiation program of community forest management. FlowPer smallest value was occurred in 2001 due to land degradation, encroachment and logging triggered by the publication of West Lombok Regent Decree No. 522.21/457/prov/2000 on utilization of wood waste. Encroachment and logging increased runoff and reduce water absorption into the soil, because during the rainfall, water flows directly into the river and only very small part of water go into the soil and resulting large water discharge in the river. While in the dry season discharge of water per day decreased. Higher fluctuations pattern of discharge per day resulted smaller value of fp.

Otherwise, land cover condition has improved due to increasing community awareness. They plant perennial crop such as coffee and cacao with shagging trees than ultimately affects to the river flow stability.

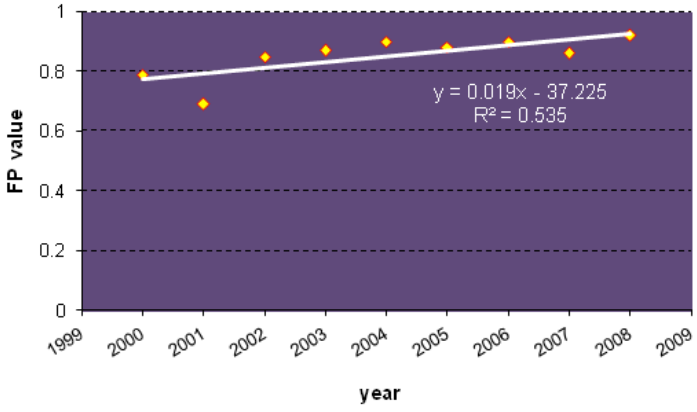

Figure 4: Trendline of FlowPer of Jangkok river

Participatory landscape assessment which was conducted in 2010 indicates that bio-physical problems, such as encroachment, logging, landslide and spring exploitation in Sesaot area haven't give impact to water quality, but it will be a potential threat if there is no controlling. Most of the soils type in the study area is regosol with high content of sand that prone to erosion and landslide. However, the effort of communities to plant fast growing tree such as 'sengon' (*Paraserianthes falcataria*) and keeping old stand such as 'durian pecing' and mahogany around spring seemly can maintain watershed function in the area. In addition, local community also takes the initiative on protecting forest through doing the patrol and coordination with forestry officer.

In the other hand, bio-physical problem in this area occurred due to lack of knowledge, coordination, communication, law enforcement and limited sources of funding for farmer group on managing forest.

3.4 Livelihood

3.4.1 Land holdings

Compared to non HKm area (0.42 ha) and HKm permit (0.39 ha), land holding per household in HKm non permit is the largest (0.64 ha) (Figure 5). Different land holding occurred due to different rule on getting land. In HKm non permit they opened land by themselves from secondary forest, but in HKm permit they got from local government through farmer group. Survey results indicate that actually, dependence of local community to land in protected forest is very high. It reached 95% in HKm permit area and 89% in HKm non permit. In term of management system, all respondents (100%) in HKm non permit area and 98% in HKm permit area applied agro-forestry systems. All of local community (100%) applied agro-forest system in private land.

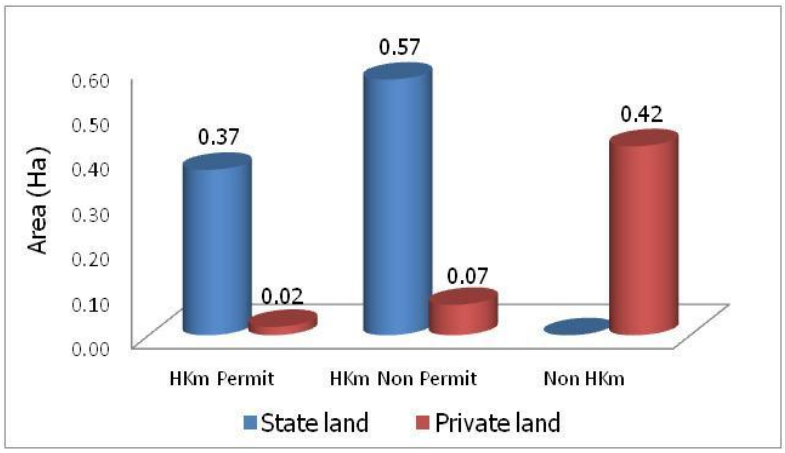

Figure 5: Average Land Holding per household

3.4.2 Quantitative analysis for Poverty

Household income which is calculated based on the consumed commodities used as a quantitative indicator for poverty. However, most of income came from cash crops. Daily income per capita in HKm permit is similar with HKm non permit, IDR 12 654 (USD 1.4)[1] and IDR 11 679 (USD 1.2), but higher income occurred in Non HKm IDR 14 748 (USD 1.6) (Figure 6). It is indicates that farmers in HKm permit as well as HKm non permit are less prosperous than the farmers non HKm. Even the daily income per capita of HKm non permit is slightly lower than in HKm permit, but they have perception that HKm permit will improve their

[1] Exchange rate in 2009 averaged at USD 1 = IDR Rp 9,300

livelihoods and they hope that their incomes will further increase if they continue to manage the forest.

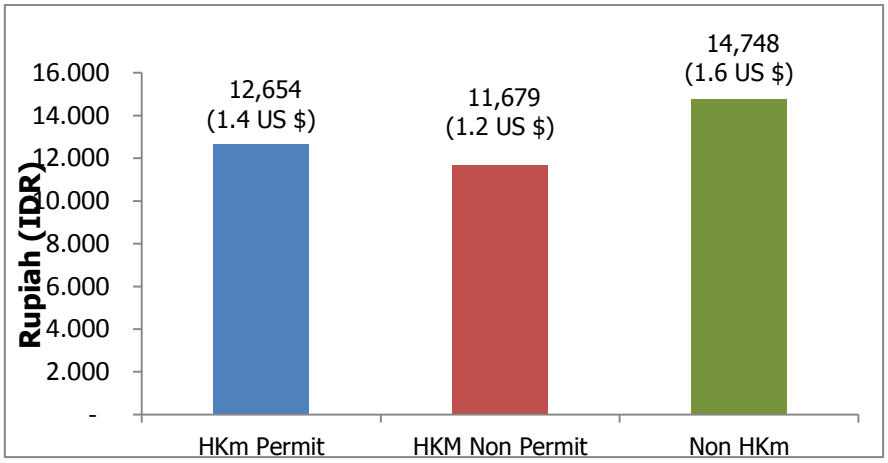

Figure 6: Income per capita per day

Even the average of total income per year per household in Non HKm are slightly higher than in HKm permit areas and HKm non permit, but the composition of income source are different. Agriculture (agro-forestry) is the major source of income in the HKm permit, HKm non permit and Non HKm areas, but the status of land was different.

Income from the agricultural sector of mixed gardens (agro-forestry) on state land area was contributed to poverty reduction. It is seen from the large proportion of the income of farmers in HKm permit and HKm non permit from state land area. The proportion of income in HKm permit from the state land area was reached 33% of total revenue. In HKm non permit, the proportion of income derived from state land area is about 59%. While the farmers non HKm, the largest proportion of revenue that comes from a mixed gardens (agro-forestry) in the private land is 38% (Figure 7). The higher proportion income from the state land proved that communities who live in the forest land of Sesaot need the land as their main source of livelihood, in particular for farmers in HKm non permit.

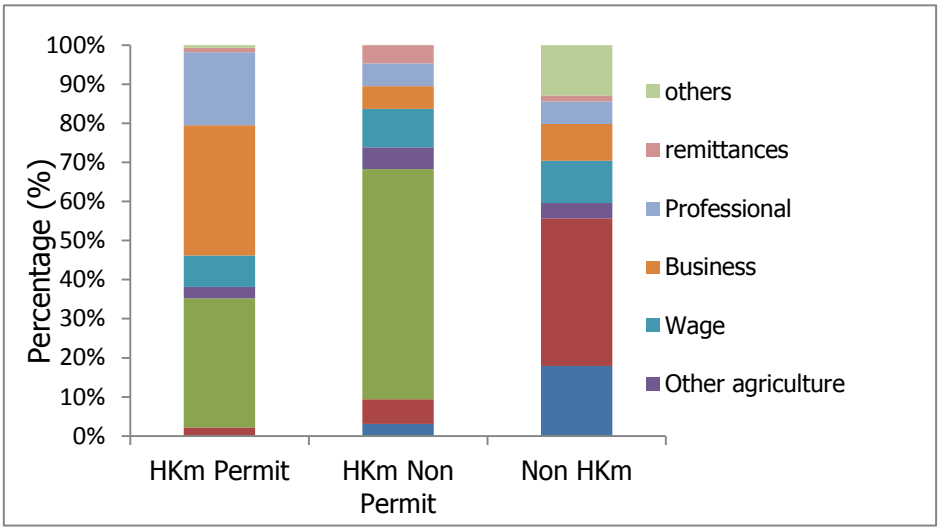

Figure 7: Household income by activity type (%)

In the HKm permit areas, the main source of income was came from agroforestry in state land (33%) and business activities (33%), followed by professional (19%), wage (8%%), other agriculture (3%), agroforestry in private land, remittances and others were very low (2%), (1%) and (1%).

In the HKm non permit areas, highest source of income came from agroforestry in state land (59%) followed by wage (10%), agroforestry in private land, professional, other agriculture, business activities were the same (6%), remittances (5%) and rice field were very low (3%). In the Non HKm areas, highest source of income came from agroforestry in private land (38%), following by rice field (18%), others (13%), wage (11%), business activities (9%), professional (6%), other agriculture (4%) and remittances (2%).

3.4.3 Equity analysis

In order to analyze the equity of income, a decomposition analysis was applied using the Gini coefficient that ranges from 0 (equal distribution of income) to 1 (total concentration of income). Gini decomposition is commonly applied in economic analysis (Alderman and Garcia, 1993) using the Gini decomposition formula that was developed by Fei, Ranis, and Kuo (1978) and Pyatt, Chen, and Fei (1980).

The computation results of the decomposed Gini ratios of income for farmers in HKm permit and HKm non permit area relatively small (0.26-0.38). This indicated that income at both sites was equally distributed. The assessment of income inequity is using the concentration coefficient. A source of income is influential in improving income equity if it has a concentration coefficient of less than 1. On the contrary, if the concentration coefficient is higher than 1, the source of income is influential in causing income inequity.

Income from agriculture (agroforestry) on state land reduced the overall inequity of income distribution at the Sesaot area, because the concentration coefficients were less than unity (Figure 8). This suggests that the income from agriculture (agroforestry) grown on state land is relatively equally distributed, making this income important to reducing poverty and increasing income equity. On the other hand, Income from agriculture (agroforestry) on private land leads to unequal income distribution in the Sesaot area. Wealthy farmers often extend their private land through of inheritance or purchasing, which seems to have concentrated income from private land in the hands of fewer people. In contrast, it state land area income from agriculture (agroforestry) on state land reduced inequity of income, since state areas (protection areas) were more available.

The HKm area has made land more accessible, particularly for poor farmers who do not own land. Through HKm area, poor farmers can have access to land without having to pay. On the other hand, private land ownership has caused land to be distributed unevenly as only the rice will have access to land.

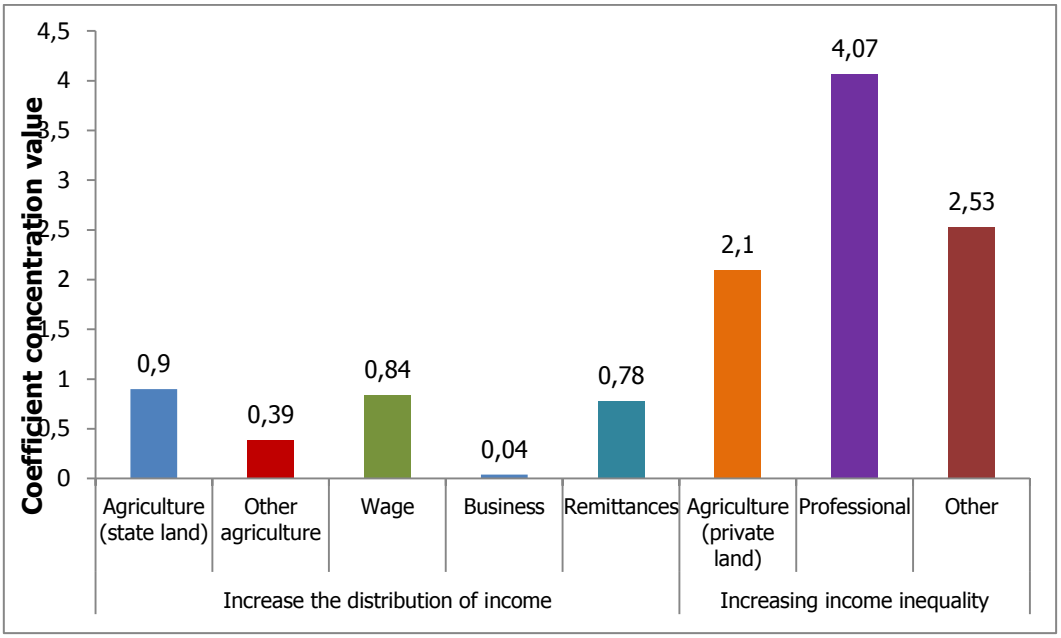

Figure 8: Coefficient concentration in Sesaot Lombok

From three components study (carbon stock, water and livelihood), indicates that three of them have close relationship. Through community forestry mechanism (HKm), local community in protected forest of Sesaot willing to growth tree species instead of annual crop among coffee or cacao tree due to land security. Increasing number of tree species in their agro-forestry systems increasing carbon stock in each unit area as well as increasing canopy covers. Tree root systems, canopy covers and soil covers has an important role in water regulation. In addition, land security in protected forest of Sesaot triggered of local community on management improvement and will potentially impact to household income.

4. CONCLUSION

- Community forest management stimulate community to manage forest area and will provide environmental services particularly for carbon sequester. Carbon stock in community forest management is about 54% of private land.
- FlowPer model shows the condition of watersheds which persistence (0.86), it means that landscape still perform its function in the system of hydrology.
- Bio-physical problems as potential trigger to the environmental damage in the future, particularly for water quality.
- Income from agroforestry systems in the buffer area managed by the local community ranged 33-59% of total income and plays an important role in poverty alleviation.
- Income from state land (under community forestry program) in the agroforestry narrowing the income inequity.
- Legal permission for managing land is an incentive for the local community and will improve land management.

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