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Incidence of forest income in reducing poverty and inequalities:
Evidence from forest dependent households in managed forests' areas in Burkina Faso.

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Incidence des revenus forestiers sur la réduction de la pauvreté et des inégalités : le cas des ménages riverains des zones forestières aménagées du Burkina Faso.

Résumé

Cet article vise à analyser de près le rôle et l'incidence des revenus forestiers sur la réduction de la pauvreté et des inégalités de revenus parmi les ménages riverains des zones forestières aménagées du Burkina Faso. Les indices FGT de pauvreté (Foster et al., 1984) et le coefficient de Gini sont utilisées pour examiner comment la gestion participative ou communautaire des forêts peut réduire la pauvreté et les inégalités de revenus dans les chantiers d'aménagement forestier. En outre, une première tentative d'analyse des 2 interactions entre la richesse et les ressources environnementales est discutée à travers la notion d'inégalités écologiques. Une variable environnementale spécifique, la pluviométrie, est introduite dans l'étude pour simuler la relation qui peut exister entre le bien-être des exploitants forestiers (ménages riverains) et la quantité d'eau de pluie recueillie à l'intérieur de ces chantiers forestiers. Les résultats de l'étude révèlent une dépendance élevée des ménages aux ressources forestières et montrent combien les revenus tirés de la forêt contribuent de manière importante à la réduction de la pauvreté et des inégalités de revenu parmi ces ménages. De plus, la variabilité des précipitations dans ces villages affecte de manière significative les deux sources de revenus forestiers (positivement) et le niveau de pauvreté de ces ménages (négativement).

Mots-clés : gestion participative des forêts, pauvreté, inégalités de revenu, inégalités écologiques.

Incidence of forest income in reducing poverty and inequalities: Evidence from forest dependent households in managed forests' areas in Burkina Faso.

Abstract

This paper aims to analyse closely the role and the incidence of forest income on reducing poverty and income inequalities among forest fringe households who are located in joint forest management (JFM) areas in Burkina Faso. Poverty indexes (Foster et al., 1984) and Gini coefficient are used to examine how forestry can reduce poverty and income inequalities in these JFM sites. Furthermore, a first attempt to analyse interactions between wealth and environmental resources is discussed through the ecological inequality concept. A specific environmental variable, "rainfall", is introduced into the analysis to simulate the relationship that may exist between forest households' well-being and rainwater collected in these JFM sites. The study outcomes show a higher dependency of forest fringe households to forest resources and how forest incomes have a great contribution to poverty and income inequalities reduction among these households. Moreover, rainfall variability in these JFM villages affects significantly both forest income sources (positively) and these households' poverty level (negatively).

Keywords: joint forest management, poverty, income inequalities, ecological inequalities.

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1. Introduction

Forest is an essential source of earnings for the forest fringe households mainly through their extraction of wood (timber and firewood) and non-wood (non-timber) forest products. Many studies pointed that plants and animals from natural forests, woodlands and planted trees provide ecological services and are used by rural Africans for food, energy, medicine, animal feed, construction, furniture, agricultural implements and utensils, allowing livelihood diversification (Belem et al., 2007; Kristensen and Balslev, 2003; Kristensen and Lykke, 2003; Mamo et al., 2007; Shackleton et al., 2007; Taïta, 2003). According to FAO[1] (2006), "In most debates on forestry and development taking place in international forums, one of the main questions was to identify ways of integrating forests and forestry in the objectives of the Millennium Development Goals of the United Nations to halve poverty and food insecurity by 2015".

Thus, forests offer large potential for poverty alleviation and reduction of income inequality among forest dependent households as some studies have recently emphazised (Das, 2010; Babulo et al., 2009; Druckman and Jackson, 2008; Ouedraogo, 2009; Fisher, 2004; Pattanayak et al, 2004; Kumar, 2002; World Bank, 2001; Wunder, 2001; Kumar et al., 2000; Cavendish, 1999; Reddy and Chakravarty, 1999; Adams, 1994; Chinn, 1979; Shand, 1987). Druckman and Jackson (2008) dedicated their paper on highlighting area-based resource inequalities measurements (concepts and methodology). All these studies use the Gini coefficient and adapt it to their methodology to understand income and resources inequalities (Das, 2010; Druckman and Jaxkson, 2008; Jaganathan and Pramodhkumar, 2003). On the analysis of poverty, they essentially use the poverty indices of Foster, Greer and Thorbecke (1984).

In this context, this paper, far from obscuring the impact of forest management on these forest resources' sustainability, aims to study how joint forest management (JFM) could reduce both poverty and income inequalities among forest fringe households in Burkina Faso. In addition, the impact of agro-climatic differences between these JFM sites on poverty and income inequalities is analysed by using the variable "rainfall" to simulate the relationship that may exist between forest households' different sources of income and the volume of rainwater collected in these JFM sites. This analysis led us to introduce the key concept of ecological inequalities for a better explanation of this socio-ecological aspect of the study.

The relevance of the ecological inequality approach comes from two complementary aspects associated with ecological inequalities. First, we analyze the interactions between forestry in JFM sites and forest fringe households' well-being (analysis in terms of poverty). Second, we analyze interactions between the level of forestry and rainfall variable by highlighting its evidence on households' poverty in these JFM sites. We assume that they are differences in agro-climatic potentialities of these JFM sites that could be captured by rainfall levels in these particular sites.

Thus, ecological inequalities are used to analyse interactions between well-being and environmental resources access. When access is defined as "the ability to benefit from things including material objects, persons, institutions, and symbols" (Ribot and Pelsuo, 2003), it encompasses both entering into a defined physical property and obtaining products of a resource, in terms of access and withdrawal (Schlager and Ostrom, 1992). Then, we ask through this study the following specific issues: does joint forest management (JFM) in Burkina Faso improve forest fringe households' economic position (poor, very poor or rich) in these JFM sites? Does households' income from forestry (TFPs and NTFPs) contribute to reduce income inequalities in Joint Forest Management

[1] http://www.fao.org/forestry 2006

(JFM) sites in Burkina Faso? And, finally, does rainfall level in JFM villages affect forest fringe households' income and poverty level? These questions lead us to examine more closely the role and the incidence of forest income on reducing poverty and income inequalities among forest fringe households in JFM areas in Burkina Faso.

We proceed as follows. Section 2 presents the context of forest policy in Burkina Faso and the dataset used for our study. Section 3 deals with the contribution of forest to aggregate income by analysing the structure of forest fringe household's income. Section 4 put a special emphasize on the incidence of forest income on reducing poverty and income inequalities among forest fringe households. Section 5 analyses the relationship between the environmental variable "rainfall" and the poverty in JFM areas. Section 6 concludes.

2. Forest management policies in Burkina Faso: background and dataset

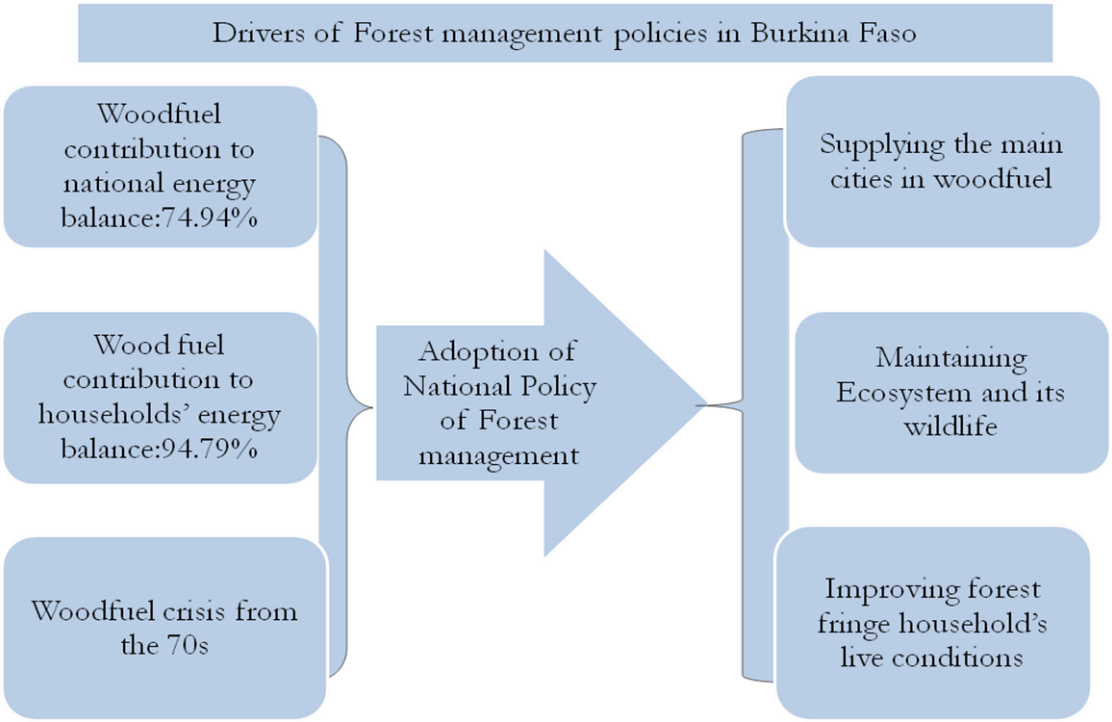
2.1. The coming up of a participatory forest management: an outline

Forest policies in Burkina Faso has been subject to two different regimes that can be related to some specific drivers.

The period of the 60s (country's independence) has been characterized by forest policy inherited from colonization. Conservation policies were enacted by the State setting most of populations living areas set aside, while the management of harvested areas was planned centrally (Ribot, 1999). Those centralized forest policy and law enforcement have quickly revealed their shortcomings with respect to the protection and the unregulated exploitation of forest resources. Local communities whose livelihood were clearly affected by planned interventions were neither consulted nor informed, but requisitioned to meet the needs of labour for forest management (Delnooz, 2003).

Those failures in forest resources management were exacerbated by the crisis of wood energy in Ouagadougou the nation's capital at the end of 70s. They led the government to rethink forest policy. Since 1983, the national policy of forest management refocused the role of local people in planning and managing forest resources. Thus, public authorities have adopted a new approach based on active sociocultural and voluntary participation of local populations who were recognized as a key factor for starting a sustained logging of these resources. This period is characterized by a participatory forest management or joint forest management (JFM) that has been implemented in 1986 as a pilot project named "Natural Forest Management" to supply populations in wood energy and to safeguard the environment (Kabore, 2004).

The diagram below shows some selected driving factors of Forest Management Policies in Burkina Faso.



Logging in JFM sites is done with respect to forestry standards. According to the experience of forest management in Burkina Faso, loggers are trained in forestry techniques, including cutting techniques, and are surrounded by a forest engineer -named Technical Director- who provides technical management of sustainable use of the forest. The management model adopted is participatory management. It can be considered as a partnership where two or more parties negotiate together, agree and execute functions, benefits and responsibilities associated with a particular territory or set of natural resources Gray (1998). Joint management of protected forest areas allows managing the forest area and its periphery to maintain the ecosystem and its wildlife. Doing so, it can ensure the welfare of local people by legal and institutional mechanisms and guarantee an equal partnership between these communities and government agencies (Kothari et al., 1996).

In JFM sites, the local partners (forest fringe households) are organized into Village Forest Management Groups (VFMG) trained in forestry, which are responsible for the forest resources management and for the promotion of local development. These VFMG are associative or cooperative groups. They are also responsible for the protection of Forest Management Units (FMU) against any form of occupation which non comply with forestry rules and with forest resources sustainability. For increasing credibility, VFMG have set up umbrella organizations called Unions of Village Forest Management Groups (UVFMG). The State remains the owner of the land and allows to UVFMG the autonomy of management of these forest areas recorded in a particular specification.

The JFM program in Burkina Faso currently spans over 10 provinces and covers more than 667 600 hectares of forest protected areas. Around 50% of those managed forest areas are autonomous and run by more than 10 Unions of Forest Management officially recognized which represents more than 400 village forest management groups. The Unions of Forest Management are grouped around a national federation of unions which rules on forest management guidelines for forest management. Table 1 below gives the main JFM sites supplying Ouagadougou in wood-energy.

Table 1: Characteristics of selected managed forest areas

Forest Lands (JFM)	Forest land (ha)	Start Dates	Average prod./year (steres)	Number of VFMG	Number of members	Distance from capital city	Statute
Bougnounou	24 914	1993	12 000	30	1860	135	Autonomous
Cassou	29 515	1990	23 000	24	960	150	Autonomous
Nakambé	21 424	1998	17 000	20	336	45	Autonomous
Nazinon	24 899	1987	51 000	30	919	70	Autonomous
Sapouy-Biéha	21 000	1996	54 850	31	937	100	Autonomous
Silly-Pouni-Zawara	52 000	1993	58 933	50	1 706	125	Autonomous
Sud Ouest Sissili	55 964	2001	58 930	55	1 100	165	Autonomous
Total/Average(*)	**229 717**		**39 387.57(*)**	**240**	**7 818**	**112.86**	

Source: CIFOR-Burkina Forestry Surveys (2005), Environment Ministry (2004)

These 7 JFM sites covers 230 000 hectares with an average annual timber production of 39 387.57 steres. A total of 240 village forest management groups working in these forest managed areas, count altogether 8000 members or lumberjacks. The average distance of each of these JFM sites from Ouagadougou is 113 km.

2.2. Dataset of the study

The paper is a part of research study on the effects of joint forest management on fringe forest households' life conditions in Burkina Faso. The required data have been collected through a large surveys developed and implemented with funding from USAID and technical assistance from the International Center for Forestry Research (CIFOR) in May-June 2005 on the main JFM sites in Burkina Faso. These surveys covered 23 villages located between 45 km and 250 km from Ouagadougou, the country's capital city. The sample size of those studies is n = 300 forest fringes households whose are woodcutters, charcoal burners and non timber forest products, logging forest resources. Table n° 2 below draws the distribution of households by JFM sites and administrative located province.

Table n° 2: Distribution of households by JFM sites and administrative provinces

JFM sites	Administrative provinces of JFM				
	Ziro	Sissili	Sanguié	Bazega	Total
Cassou	25	0	0	0	25
Silly-Pouni-Zawara	0	30	31	0	61
Sud Ouest sissili	0	65	0	0	65
Sapoui Bieha	45	0	0	0	45
Nazinon	34	0	0	0	34
Nakambé	0	0	0	32	32
Bougnounou	0	38	0	0	38
Total	**104**	**133**	**31**	**32**	**300**

Source: Analysis of survey data (May-June 2005).

The main variables captured by these surveys are:

- *Loggers' socioeconomic characteristics* (age, gender, education, ethnic groups, main and secondary activity...).

- *Loggers' income sources* (timber forest products (TFPs), non timber forest products (NTFPs) and farm income.

In a next step, those surveys data will be combined with rainfall data collected in each of the 23 villages of the surveyed JFM sites in 2005 for analysing the impact of different environmental conditions between the JFM sites on poverty and income inequalities. In order to explain the impact of agro-climatic differences between these JFM sites on poverty and income inequalities, we use the variable "rainfall" to simulate the relationship that may exist between forest households' different sources of income and the volume of rainwater collected in these JFM sites in Burkina Faso.

3. Forest contribution to aggregate income

Using household production framework, the aggregate income accounts in monetary unit may be assessed by using total income of forest fringe rural households on two earning sources, namely forest income (NTFPs and TFPs) and non forest income (farm) in net real terms.

3.1. Assessing forest fringe rural households' income in JFM villages

Forest source of revenue is generated from the sale of timber (firewood and charcoal) and from the sale of non-timber forest products like wild fruits (pulp Shea, almond Shea, grape, honey, etc.). Non-forest revenues on the other hand arise with the sale of agricultural products from farm crops, from non forest wage labour (mainly from agricultural farm labour) and others (self-employed business activities).

Under this section, we make a statistical study of loggers' sources of income in joint forest management (JFM) sites in Burkina Faso (Table 3). The main objective here is to assess the importance of forest revenues in fringe forest households' total income in JFM sites. Table No. 3 gives the JFM sites and by type of activity, the total revenue.

Table 3: The structure of forest fringe household's incomes of in Burkina (FCFA[2]), 2004.

JFM areas	Villages	Forest income		Farm income	Total income
		TFPs	NTFPs		
Cassou	Pro	49,769	19,077	56,754	125,600
	Oupon	47,200	18,850	0	66,050
	Ouayou	20,000	3,500	0	23,500
Silly-Pouni-Zawara	Kouri	127,667	5,467	10,000	143,133
	Baporo	149,063	0	21,875	170,938
	Ladio	68,467	10,317	0	78,783
	Niminlaye	122,333	10,000	0	132,333
Sud Ouest sissili	Ly	168,333	13,292	89,167	270,792
	Korobou	137,667	62,267	66,000	265,933
	Ti	294,750	2,250	161,250	458,250
	Bourra	281,944	1,333	63,556	346,833

[2] FCFA = Monetary Unit of African Financial Community
1 Euro = 655.957 FCFA

Sapoui Bieha	Dianzoé	117,727	5,767	0	123,493
	Tiagao	150,733	32,320	0	183,053
	Nébrou	208,400	4,927	0	213,327
	Sayaro	10,000	80,000	0	90,000
Nazinon	Bawiga	18,769	3,692	2,231	24,692
	Nadonon	11,167	0	4,083	15,250
	Gallo	14,000	0	1,667	15,667
Nakambé	Silkouka	112,250	0	0	112,250
	Kalwiga	186,875	0	2,813	189,688
Bougnounou	Loro	63,214	3,357	3,571	70,143
	Nago	119,333	4,667	1,667	125,667
	Aziga	82,778	1,222	7,222	91,222
All JFM village	**Average**	**130,395**	**9,614**	**26,395**	**166,404**
	Average (%)	**78%**	**6%**	**16%**	**100%**
	Sum	**39 248,900**	**2 893,950**	**7 944,800**	**50 087,650**

Source: Analysis of survey data (May-June 2005).

The average loggers' income of 300 producers of wood energy in the seven major JFM areas in Burkina Faso in 2004 -which preceded the investigation period (2005)- was 166 276 FCFA per logger, all activities being combined.

This income is mainly composed by an average income of:

⇒ 89,176 FCFA per logger from wood harvesting;

⇒ 40,223 FCFA per charcoal producer from charcoal burning ;

⇒ 27,483 FCFA per producer from farming;

⇒ 9,614 FCFA per logger from the collection of non-timber forest products (almond Shea, beekeeping (honey), production of nursery).

There is a wide dispersion in the average incomes of farmers between JFM sites for forest fringe households. The overall standard deviation of average total gives a coefficient of variation of the order of 179.30% between the sites. This shows a great income disparity of producers of wood energy between the sites. This large disparity in incomes is due to the observed differences of these JFM sites' agro-climatic potentialities that offer different economic opportunities in these forest sites (farming of cash crops, beekeeping, collection of almond shea and locust, nursery production, etc. ...).

Moreover, the charcoal's production is effective in two specific JFM sites: Silly-Pouni-Zawara and the South West Sissili. The forest fringe households' annual average income in those sites are higher than in other sites, and are respectively estimated at 179 308 FCFA and 347 573 FCFA. Similarly, in these two sites, farm incomes and those from non-timber forest products are the most high as well: this is explained by the importance of agro-climatic potentialities in these two sites.

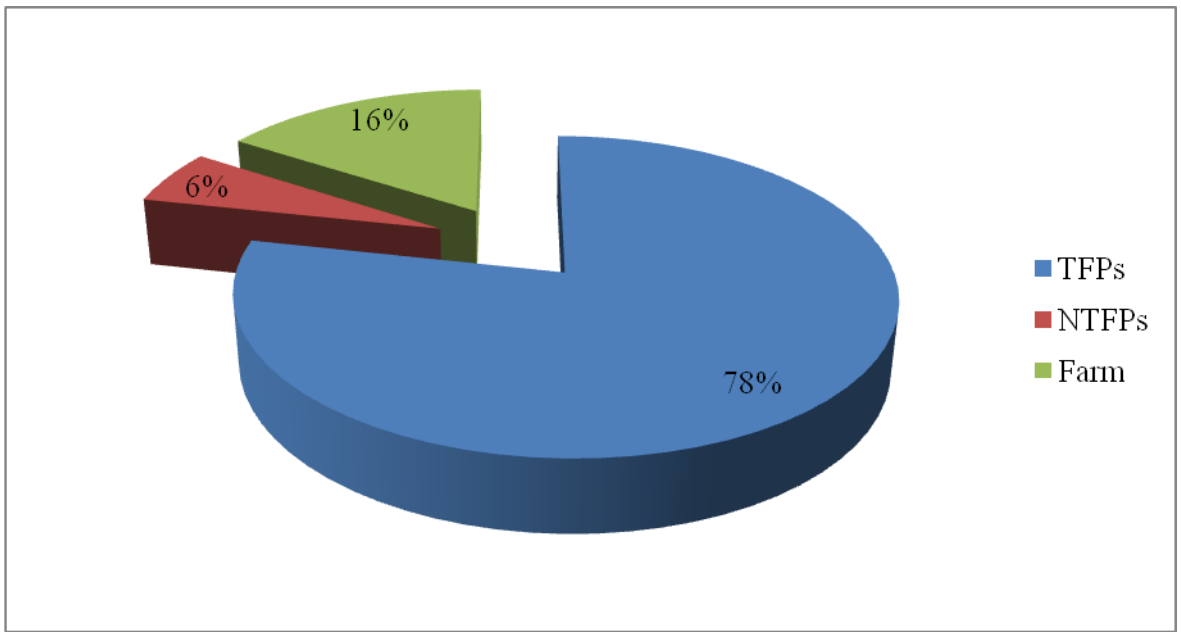
In all surveyed JFM sites, the loggers' average total income is composed of 70.47% from timber harvesting, 12.81% from charcoal production, 6.97% from non-timber forest products and 9.73% from farming. There is a wide disparity of loggers' income distribution between joint forest management areas. Depending on whether the household is a woodcutter or a charcoal producer, revenue structure is different, but for the JFM site of Silly-Pouni-Zawara, cutting wood contribute at

average 57.86% in total income, 29.15% for charcoal production, 8.33% for agriculture and 4.6% for non-timber forest products. In the South, West Sissili site, the composition of the income structure is more or less balanced between positions respectively giving an average contribution of 33.27% for cutting wood, 30.98% for charcoal, 26.71% for agriculture and 9.03% for non-timber forest products. Those two forest areas provide greater economic opportunities than the other forest areas for three main reasons. First, because they are the most distant JFM sites from the city of Ouagadougou, they were allowed3 to produce charcoal, even if the production process associated has a low energy efficiency. Second, these two JFM sites are also important agricultural areas (mainly cotton). Finally, those areas offer opportunities for collection and production of NTFPs such as almond Shea and honey.

3.2. Households dependence on forest income

The figure 1 illustrates the magnitude of income of forest source in total income. It shows that households participating in joint forest management in Burkina benefit mainly from this activity.

Figure 1 : Households income sources in joint forest management areas



For those forest fringe households, timber forest products (firewood and charcoal) remain their main income source while farming appears to be the second pecuniary activity. When forest income represents 84% of these households total income, farming contributes to their total income of 16%.

All these households are strongly dependent on forest activities for survival. Within this context, forest remains for them their main coping strategies. Such a situation is very common in other developing countries. According to Reddy and Chakravarty (1999, page 1142): "The households' dependence on forests in the North region in India is for fuelwood, fodder and auxiliary non-timber forest products (NTFPs), with the major proportion of dependence contributed by fuelwood and fodder." Consequently, forest activities have to be managed with sustainable rules for ensuring basic needs of households and giving them opportunities to face poverty.

[3] Governments prohibit the production of charcoal in the forest areas at a distance less than 100 km from the city of Ouagadougou. This prohibition is related to the fact that the production of charcoal using carbonization technique has very low yield. As a consequence, it does not allow a sustainable use of the forest.

4. Role of forest income in inequality and poverty

4.1. Methods of inequality assessment

Mesured income inequality decomposed by income source provides meaningful estimate of source-wise income to total inequality as quantified by the Gini coefficient (Babulo et al., 2009; Fisher, 2004; Jaganathan and Pramodhkumar, 2003; Reddy and Chakarvarty, 1999). This measure enables us to look at the direction of change in enquality du to the change from a source. Once a quantitative estimate of different sources of income is given, the Gini coefficient for a particular source of income, I, may be defined as:

$$G(i) = 1 + \frac{1}{n} + \frac{2}{n^2 \overline{w_i}}(w_{i1} + 2w_{i2} + ... + nw_{in}) \quad (1)$$

Where n is the number of households. Then, the decomposition of above mentioned inequality for a particular source, i, is given by equation 2:

$$G_i = w_i + r(i) \times G(i) \quad (2)$$

Where wi=share of ith source of total income ($w_i = \overline{w_i} / \overline{w}$) and r(i) = correlation between ith source of income i.e., r[wi, W]= {cov(wi,R(W))}/{cov(wi,R(W)}, here R(W) and R(wi) are ranks of ith households in total income respectively.

Hence the total income inequality after decomposition of different sources of income is defined as G=∑ Gi.

To assess wether a given source of income reduces or increases income inequality, we use the relative marginal effect as defined by the difference between proportional contribution of a source to inequality and its share in total income (Jaganathan and Pramodhkumar, 2003:511). With this measure we find out the marginal impact of each source of income on overall inequality of income. The marginal change has a sensitive economic interpretation since it gives us the responsiveness of inequality subject to a change in any source of income. And typically it is captured to a partial derivative of the aggregate Gini with respect to a change in income of a source. While the magnitude of relative marginal effect gives the degree of change in income source to total inequality on the margin, its direction say negative sign of the source income indicates a decrease in total inequality due to an increase in income from this source.

4.2. Pragmatic investigation of income inequalities in JFM villages

The decomposition of income inequality by various income sources allows us to find out whether forest source plays any important role to improve income distributional pattern among these forest fringe households. The decomposition of income inequality by income source is given by table 4 and figure 3.

Table 4: Decomposition of income inequality by income source

Indicators	Joint forest management villages		
	Forest source		Non forest source
	TFPs	NTFPs	Farm
% of households having access in income source	100.00	29.90	21.26
Share in total income	0.78	0.06	0.16
Source income Gini coefficient	0.44	0.88	0.89
Share in Gini	-0.65	-0.16	0.33
Relative inequality	-0.51	-0.01	0.05
Relative marginal effects	-1.30	-0.07	-0.11
Aggregate Gini	0.47		
Poverty rate	0.37		
Poverty gap	0.18		
Poverty severity	0.12		

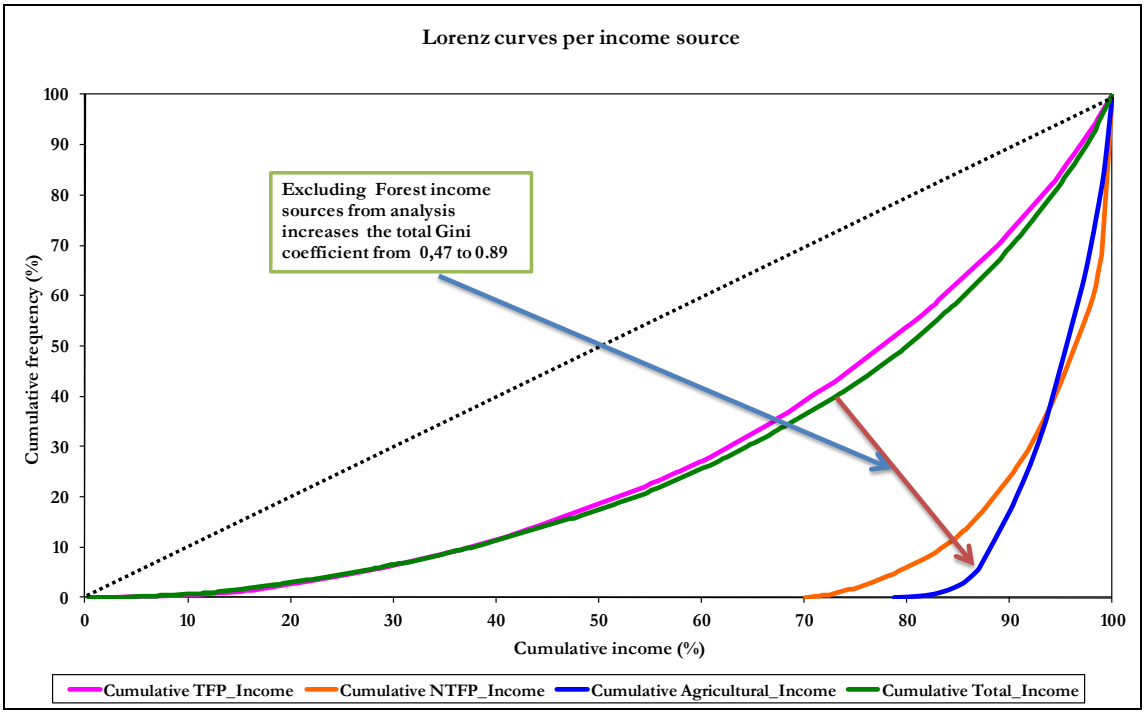
Source : Data analysis **of loggers survey in Burkina Faso /CIFOR (**May-June 2005).

As may be seen in table 4, most of the source income Gini coefficients are higher than the aggregate income Gini for the study site. This result shows that diversification of income sources reduces the inequality across the study area. Likewise, not all sub-sources reduce this inequality since the share of total income inequality attributed to each income source shows that TFPs contribute the highest share to total income inequality for JFM villages, followed by farm. This is largely because income from forest source accounts for the greater share of aggregate income.

Following (Das, 2010), we use the relative marginal effect defined as the difference between proportional contribution of a source to inequality and its share in total income in order to assess whether a given source of income reduces or increases income inequality. As its direction and magnitude gives the effect of change in income source to total inequality on the margin, the negative sign of the sources of forest income namely TFPs and NTFPs indicates a decrease in total inequality due to an increase in income from those sources for JFM villages. The marginal effect of TFPs is -1.3 indicates that an increase in TFPs income of 1% decreases the total income inequality of 1.3%. TFPs have the larger contribution to inequality reduction in JFM villages, followed by farm income source with a marginal effect of -0.11. Investigations of Das (2009) showed positive marginal effects for NTFPs and TFPs income sources and for non-forest (farm) income source to total income inequality. Although, his findings for forestry wage after JFM reveal negative relative marginal effect. In the case of JFM in Burkina Faso, the woodcutter' income represents a wage from wood logging, woodcutter's income per cubic meter of wood cut is 1100 FCFA (Ouedraogo, 2007). This is in conformity with some findings of Das (2009).

Figure 3 presents the impact of forest income on income inequalities JFM villages. Lorenz curves with the data for households' income including or excluding show that addition of forest income to total income reduces the departure of the curve from the line of equal distribution.

Figure 3: Impact of forest income on reducing inequalities in JFM villages.



If forest (TFPs and NTFPs) sources of income are excluded from analysis, the estimated Gini coefficient increases from 0.47 to 0.89 which shows that addition of forest income reduces measured income inequality of 42%, all else equal. This result is in conformity with a number of studies (Das, 2010; Fisher, 2004; Cavendish, 1999: Reddy and Chakravarty, 1999). Yet again, the lower values of poverty indices (see table 3) for JFM villages compared to rural national ones might signify that forest income plays the dominant role in reducing income inequalities due their involvement in the JFM scheme in Burkina Faso. This outcome is also confirmed by Das (2010) findings.

4.3. Coverage of poverty rate, poverty gap and severity in JFM sites

The report on the poverty's profile in Burkina Faso noted that to classify individuals by level of poverty, an indicator of standard of living close to the per capita income in a household has been calculated (INSD, 2000). The used indicator is the households' expenditure level, namely called poverty line. The choice of a poverty line is, at least in part, a subjective process. If using a concept of absolute poverty and per capita consumption as a measure of welfare, the poverty level would be the minimum income necessary to enable an individual of a given society to survive. In this case, the poverty line is a normative level of expenditure below which people are considered poor. The priority surveys number I, II and III of Burkina households living conditions have established the absolute poverty line respectively to the sum of 41 099 FCFA per capita per year (INSD, 1996), 72 690 FCFA per capita per year (INSD, 2000) and 82 672 FCFA per person per year (INSD, 2003) based on the change in price level and changing of the consumption structure of basic needs.

To better understand the state of poverty among forest fringe rural households, the determination of poverty indices is necessary. The indices are calculated using the formula developed by Foster-Greer-Thorbecke (FGT) (1984). These FGT poverty index are widely used in the literature and empirical studies. Interpreting FGT index levels differ depending on the importance given to the inequality among members of a population. The main index of the FGT family are the poverty rate, the poverty gap (depth) and the poverty severity. The main formula of theses indexes are given by equation 3:

$$P_{\alpha}(Z,Y_i)=\frac{1}{n}\sum_{1}^{q}\left(\frac{Z-Y_i}{Z}\right)^{\alpha} \quad (3)$$

α = diversion for poverty

Z = national poverty line established at 82 672 FCFA per person and per year (2003)

Y_i = ith individual income

q = number of poor

n = population size

Where individuals are ranked in ascending order, from the poorest (i = 1) to richest (i = n where n is the total population), q is the number of people regarded as poor, α is a parameter representing the importance placed on the welfare of the poorest of the poor. The rate (P0), gap (P1) and severity (P2) of poverty are computed respectively by replacing respectively α in Equation 1 by 0, 1 and 2. Thus, we obtain respectively these three indices in Equations 4, 5 and 6 below:

$$P_0=\frac{1}{n}\sum_{1}^{q}\left(\frac{Z-Y_i}{Z}\right)^{0} \quad \Rightarrow P_0=\frac{q}{n} \quad (4)$$

$$P_1=\frac{1}{n}\sum_{1}^{q}\left(\frac{Z-Y_i}{Z}\right) \quad (5)$$

$$P_2=\frac{1}{n}\sum_{1}^{q}\left(\frac{Z-Y_i}{Z}\right)^{2} \quad (6)$$

A numerical application of equations 4, 5 and 6 on each of the seven forest areas studied is sum up in the table 3 below.

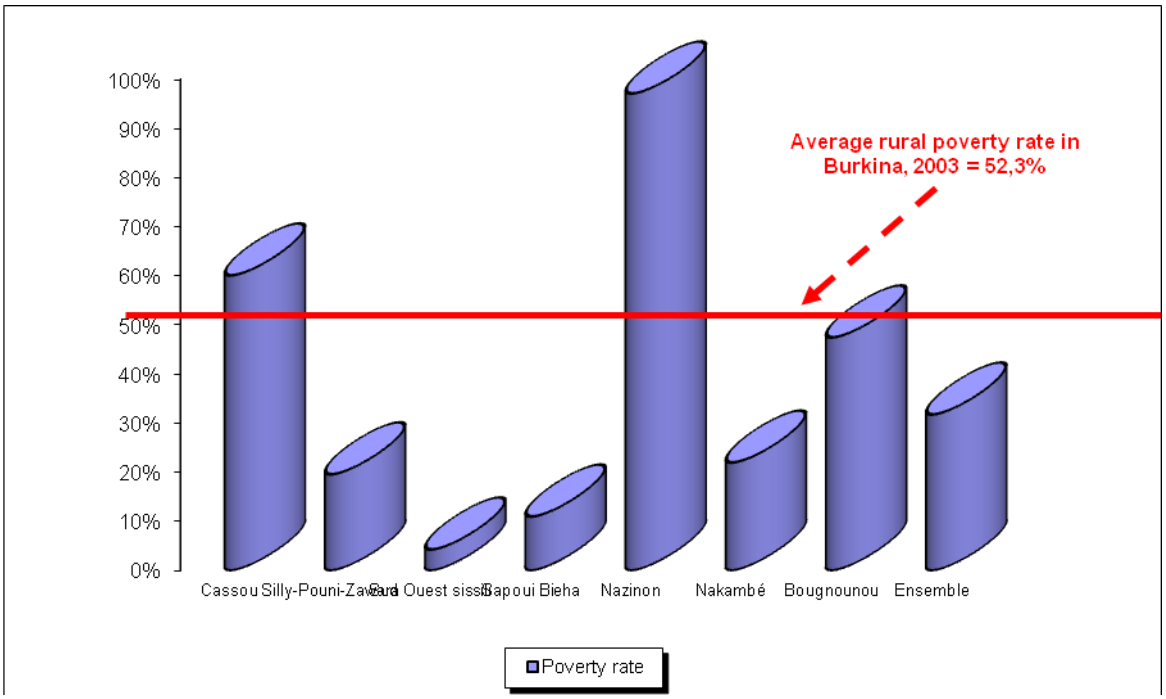
Table 3: Poverty indexes in JFM Villages in Burkina Faso (2004)

JFM areas	Villages	FGT poverty indexes		
		Poverty rate (%)	Poverty gap (%)	Poverty severity (%)
Cassou	Pro	53.85	21.75	9.70
	Oupon	60.00	40.16	28.02
	Ouayou	100.00	71.57	51.41
Silly-Pouni-Zawara	Kouri	13.33	3.25	1.10
	Baporo	13.33	5.27	2.08
	Ladio	66.67	18.54	7.52
	Niminlaye	33.33	12.77	5.20
Sud Ouest sissili	Ly	0.00	0.00	0.00
	Korobou	13.33	4.46	1.54
	Ti	0.00	0.00	0.00
Sapoui Bieha	Bourra	0.00	0.00	0.00
	Dianzoé	13.33	5.27	2.13
	Tiagao	26.67	13.36	8.61
	Nébrou	6.67	0.01	0.00
	Sayaro	0.00	0.43	0.00
Nazinon	Bawiga	100.00	70.13	59.88
	Nadonon	100.00	81.55	69.02
	Gallo	100.00	81.05	67.31
Nakambé	Silkouka	31.25	6.91	1.73
	Kalwiga	18.75	6.65	2.61
Bougnounou	Loro	78.57	24.14	9.32
	Nago	53.33	13.42	5.76
	Aziga	77.78	14.61	4.20
All JFM village	**Average**	**37.33**	**17.63**	**11.57**
National rural (INSD; 2003)	**Average**	**52.3**	**17.9**	**6.8**

Source: Data analysis of loggers survey in Burkina Faso (May-June 2005).

The figure 2 below compares the poverty rate (2004) in the main 7 managed forests zones in Burkina Faso with the national rural poverty rate.

Figure 2: The incidence of poverty in the 7 main forest managed areas



The average poverty rate in all JFM sites is 31.67%: this result means that 31.67% of the population JFM villages are poor, considering the poverty line of 82 672 FCFA per person per year (INSD, 2003). This rate is lower than the national rural poverty rate of Burkina Faso which reaches 52.3% (INSD, 2003). The poverty rate is observed in forest rural fringe households with a sharp disparity between JFM sites and between JFM villages.

Ravallion (1996) gives a very concrete interpretation of the poverty gap, considering it as the minimum cost for eliminating poverty using targeted transfers which just equal the sum of all poverty gaps. The poverty gap in all JFM sites is 15.32%. This rate is still lower than the poverty gap observed in rural country that is in the range of 17.9% (INSD, 2003). The poverty gap indicates the threshold of absolute poverty, the percentage change in income or expenditure statements of the poor. Thus, a poverty gap of 15.32% indicates that the average change in % of the poor annual income from the poverty line is 15.32%.

The severity of poverty is 10.12% across all JFM sites. This indicator is very high compared to the rural national severity of poverty which the rural level is 6.8% (INSD, 2003). This index indicates the average variability of the poor income from the poverty line. In other words, it shows that among the poor there is a diversity of poverty situations. Thus, this means that among the poor, the level of poverty of these individuals vary by an average of 10.12% from one individual to another.

These indices allow emphasizing that fringe forest households in JFM sites are less poor than rural households in national size. This result confirms the hypothesis that forest income source contribute to poverty reduction JFM sites in Burkina Faso. Reddy and Chakravarty (1999) concluded in their paper that there is a dramatic increase in poverty if forestry income is set to zero. The reason is that some of the poorest of the poor are disproportionately dependent on forestry income, and the FGT measure is sensitive to the income of the poorest.

5. Poverty and environmental conditions in JFM areas: an ecological inequality perspective

Although the concept of ecological inequalities is not yet well defined, various definitions of ecological inequalities may exist in the literature (Chaumel et al., 2008). From an historical viewpoint, ecological inequalities cannot be understood without referring to the question of environmental justice which emerges in the eighties in the USA. Environmental justice is understood as the exposure to environmental pollutions which are unevenly distributed across racial and class groups, with racial minorities and the poor generally suffering more from pollution, environmental risk or toxic waste than whites and the middle class (Berthe and Ferrari., 2012). Furthermore, ecological inequalities may consider people both as a producer and a victim of inequalities (Emelianoff, 2006). This analysis is related to important questions such as fairness in the distribution of environmental resources in a broad sense among different groups or the role of these inequalities in assessing the well-being of a population (Torras, 2006).

To study ecological inequalities, one have to consider the two complementary dimensions of the concept. First, the distribution of the social cost associated with resource depletion, environmental damages, and access to environmental resources is not fair. There are inequalities at the hands of environmental goods (natural resources access) and bads (pollutions, ecosystems damages). When an ecological inequality is recognized, it has a negative impact mainly on the well being of poor people: they are generally victims of various pollutions (and no means to fight) and have a limited access to natural resources for their basic needs (drinking water...) because they are too poor. Second, the population may be the main production factor of such an inequality. In the case of forestry, the production of wood energy for instance may be a key factor regarding deforestation or erosion phenomena. But because people are used to maintain specific resource use patterns, the situation may be worse for the poorest population whose survival depends on the forest: in some places, the stubble-burning practices lead to the deterioration of the land quality and finally contribute irreversibly to forest resources' depletion. This comes also with negative impacts on some ecological functions supported by the forest such as habitats for wildlife species or climate regulation. Within such a context, inequality is a major cause of environmental degradation (Boyce, 1994).

Thus, this section attempt to analyse more closely the role and the incidence of forest income on reducing poverty and income inequalities among forest fringe households in JFM areas. We want to highlight the possible relationship between the environmental variable "rainfall" and the forest income sources on the one hand, and also with the FGT poverty indicators for local forest fringe households on the second hand. We mainly assume that the JFM sites agro-climatic differences offer to these sites different economic opportunities that could explain the disparity of households' income between these sites.

The scatter plot in Figure 4 shows a positive correlation between both forest revenues and farm income and levels of rainfall in the villages bordering the forests. This correlation is in the range of 0.65 for forest income and 0.73 for farm income (Table 5).

Figure 4: A positive relation between forest income and rainfall

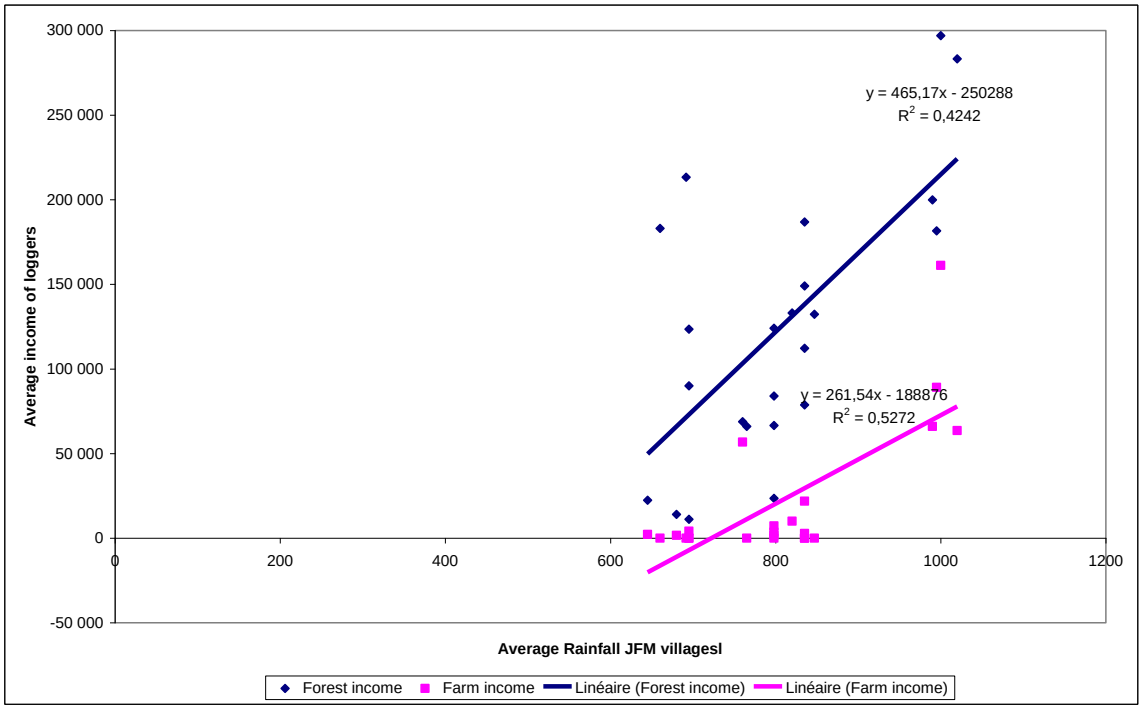


Figure 5 indicates a negative correlation between the incidence of poverty and the level of rainfall collected in the villages bordering the forests in Burkina Faso.

Figure 5: A negative relation between poverty rate and rainfall

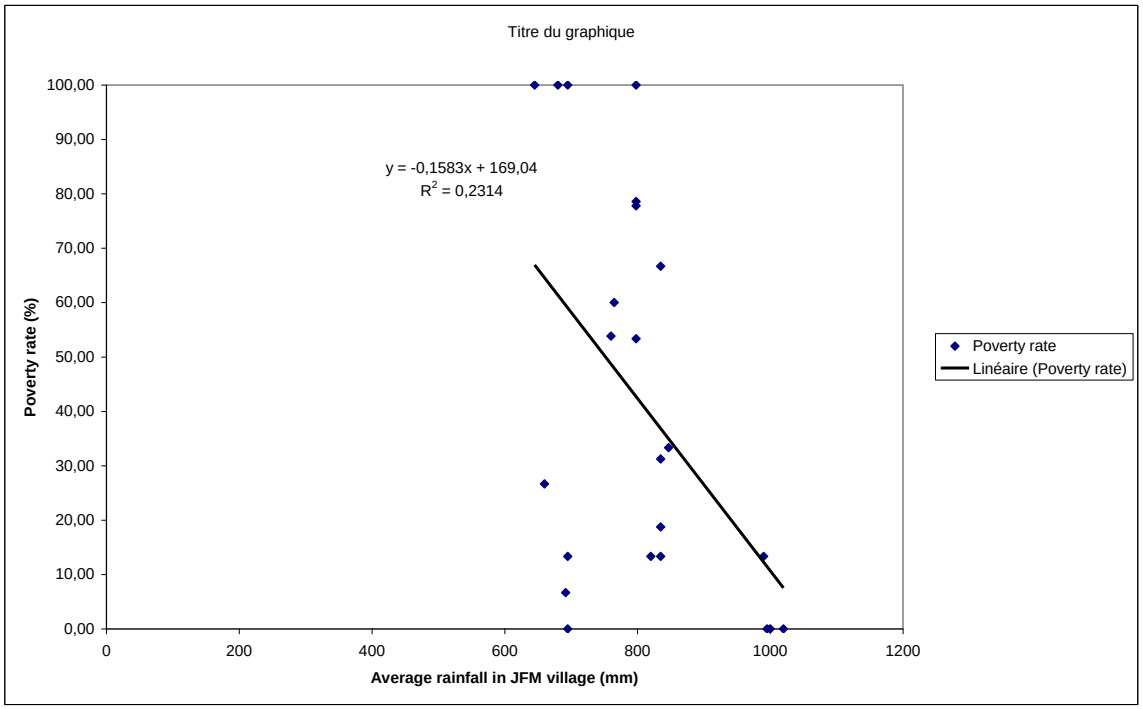


Table 5 below provides estimations of bilateral correlation coefficients of Pearson with a maximum confidence interval of 5%. These estimated correlation coefficients are significant at the 5% maximum.

Table 5: Emphasizing the relation between income sources, poverty index and rainfall (Pearson Bilateral correlations)

	Forest income	Farm income	Total income	Poverty rate	Poverty gap	Poverty severity	Rainfall
Forest income	1,00	0,63**	0,96**	-0,84**	-0,77**	-0,70**	0,65**
Farm income		1,00	0,83**	-0,44*	-0,33	-0,29	0,73**
Total income			1,00	-0,77**	-0,68**	-0,62**	0,74**
Poverty rate				1,00	0,89**	0,82**	-0,48*
Poverty gap					1,00	0,99**	-0,49*
Poverty severity						1,00	-0,49*
Rainfall							1,00
**	Significant correlation at the level 0.01 (bilateral).						
*	Significant correlation at the level 0.05 (bilateral).						

Source : Data analysis **of loggers survey in Burkina Faso /CIFOR (**May-June 2005).

There is a positive correlation between rainfall and both forest income levels and agricultural revenues. In other words, high levels of rainfall contribute to improve households' incomes in the JFM villages. The correlation between the total income of loggers and the level of rainfall is 0.74, indicating that the living standards of these households are subject to climatic fluctuations significantly.

The study of the correlation between Pearson's bilateral poverty indicators (incidence, gap and severity) and levels of rainfall recorded in the forest reveals a significant negative correlation. This result shows also that the well-being of these actors depend highly on this climatic variable. This correlation is -0.48 for the incidence of poverty, -0.49 for the poverty gap and -0.49 for the severity of poverty.

6. Concluding remarks

After more than two decades of experience in natural forest management based on a participatory approach, issues of sustainability of these forests and their contribution to poverty reduction are a proven public interest for Burkina Faso. The concession for the management of forest areas to village forest management groups and the continuation today of the establishment of new forest management sites justify the relevance and the sustainable management practices adopted. However, despite the integration of logging in the Millennium Development Goals (MDGs) and the implementation of the Strategic Framework for the Fight Against Poverty (FFAP) in national development strategy of Burkina Faso, no studies using poverty and inequality analysis tools has never been conducted on the analysis of the specific contribution of forestry in reducing poverty and inequalities in Burkina Faso before this study.

Recapitulating our discussions and evidence, some findings could be underlined for this study.

First, the natural forest management has been helped to generate new revenue sources for local communities around these forests. Then, forest accounts for the major share in income for households over all JFM sites in 2005. Non-timber forest products' income includes revenue from the collection of wild fruits (grape, pulp Shea, almond Shea, etc...), beekeeping, harvesting of tree seeds, nursery production, production of fodder, construction of firebreaks. Most of these activities are resulting from initiatives and organization of the Technical Direction of these JFM sites. The activity of gathering and production of NTFPs whose marketing activities concerns mostly women, provides

significant revenue to this specific vulnerable social group. Although the plant species involved (Butyropermum paradoxum, D. microcarpum, Bombax costatum, Balanites aegyptiaca and Adansonia digitata, etc. ..) are already protected by legislation and laws in the country, they should be subject to specific policies sustaining the activity. For authors such Arnold and Townson (1998), Kaimowitz (2003) and Coulibaly-Lingani et al. (2009), over two-thirds of Africa's 600 million people obtain a major proportion of their subsistence and some cash income from a large and diverse set of forest products and forest-related activities.

Second, the use of FGT poverty indicators in the 23 JFM villages, provide relevant insight with the incidence, the gap and the severity of poverty in these forest areas. The FGT poverty indexes and their decomposition show a disparity in the incidence, the gap and the severity of poverty among loggers in the same village, among those of different villages and even among different types of operators (woodcutters and charcoal burners). This disparity can be explained partly by differences in forest agro-climatic potentialities offered by these different JFM sites, and also by the personal initiative taken by the technical directors to develop projects (beekeeping, cattle fattening, nursery production, etc ....). Both poverty rate and poverty gap observed in all JFM sites are lower than those observed in all national rural areas which may signify that logging actually contributes to reduce poverty in JFM villages in Burkina Faso. Reddy and Chakarvarty (1999) finally concluded that Forestry makes a significant contribution to the alleviation of poverty.

Moreover, estimation of relative marginal effects of both TFPs and NTFPs incomes has provided negative coefficients: an increase in these forest income sources decreases the total income inequality. These outcomes are confirmed by those of Jaganathan and Pramodhkumar (2003) and those of Reddy and Chakarvarty (1999). Das (2010) showed positive relative marginal effects for NTFPs and TFPs income sources to total income inequality. Although, his findings for forestry wage after JFM has revealed negative relative marginal effect: that result is conform to the case of JFM in Burkina Faso because the woodcutter' income in Burkina JFM sites represents a wage from timber harvesting, woodcutter's income per cubic meter of wood cut is 1100 FCFA (Ouedraogo, 2007). Many other papers have examined the impact of forest income on income inequality in developing countries (Adams, 1994; Chinn, 1979; Shand, 1987). In common with their results, we note that TFPs and NTFPs income sources have an inequality-decreasing effect.

Testing and emphasizing the assumed relationship between forest fringe households' income sources, poverty and the variable "rainfall", we found a positive correlation between rainfall and both forest income levels and agricultural revenues. This showed that high levels of rainfall contribute to improving loggers' incomes in JFM villages. Otherwise, the Pearson's bilateral correlation between the FGT poverty indices and rainfall recorded in the JFM villages revealed a significant negative correlation, indicating that these forest fringe households' well-being highly depends on climatic variability.

The existence of a positive correlation between rainfall and both forest and agricultural incomes could be analysed as a significant factor of well being for the households located at the forest fringe. Further investigation could be done by analysing the impact of such an ecological variable on the various sources of income within a dynamic perspective, which can led to a better understanding of the way interactions work between the availability of natural products and the household's poverty level. In addition, as focused by some authors (Das, 2009, 2010; Reddy and Chakarvarty, 1999; Adams, 1994), changes in property rights emphasizing participatory resource management involving local communities and public agencies, generating an awareness among the local communities of the ecological and economic impacts of forest degradation, may serve as a starting point in attempts to reconciling the long-term requirements of forest conservation with the immediate problem of poverty. and a possible way to avoid or, at least, to contribute to the decrease of some ecological inequalities.

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