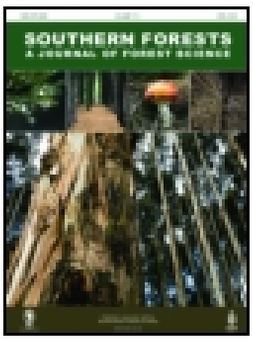

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Evaluation of the sustainability of participatory management of forest plantations: the case study of Wari-Maro Forest Reserve, Republic of Benin

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This study assessed ecological and socio-economic impacts of a participatory forest management project in the Republic of Benin. The study focused on the Wari-Maro Forest Reserve and the 'Projet d'Aménagement des Massifs Forestiers' five years after its completion. A forest inventory was carried out using 37 square plots of 729 m² each to characterise the population structure of two types of plantations established: plantations with exotic species and plantations with native species. In addition, individual surveys were conducted with local households, organs of joint forest management and forestry officers to evaluate their perceptions about the participatory management of the plantations. Finally, the sustainability of the participatory management was assessed with an established rating system. Results showed that plantations with exotic species were more successful than plantations with native species. Local communities argued that they have not been involved in the plantations design but only in the implementation step and that their standards of living have decreased after the project completion. The rating system used showed that the participatory management of plantations had a short-term sustainability. The findings suggest that future projects should be designed and implemented with better participation of local communities as full partners.

Keywords: community livelihood, community participation, joint forest management, structural characterisation

Introduction

For the past several decades, most forests in Africa have been managed by government institutions, with little involvement of local populations as well as their needs (Raphael and Swai 2009). The management of forests was repressive and exclusive (Djogbénou 2010). Yet most of the people living close to these forests depend on a wide range of forests goods and services for their subsistence (Phiri et al. 2012). This lack of local community participation in forest management has generally resulted in creation of negative attitudes in communities towards conservation efforts and the enforcement of conservation-related regulations (Obua et al. 1998; Phiri et al. 2012). This in turn has resulted in uncontrolled and exploitative use of the forest resources (Andriananja 2006). The need to modify states' policies and strategies to involve people living in and around forests (Castrén 2005; Nath and Makoto 2010) has led to the introduction of 'participatory forest management' schemes. Participatory management of forest resources was expected to achieve the dual goal of contributing to the sustainable management of forests and improving the socio-economic status of the local community (Gobeze et al. 2009).

Joint forest management (JFM) has the potential to involve local users in management strategies to reduce anthropogenic pressures on the forest resources and improve local people's livelihoods (Brown et al. 2002; Islam and Sato 2012) in a sustainable way. Sustainability is usually considered as the main purpose of forest management (Charron 2005). The concept of sustainability has a temporal dimension, i.e. it satisfies needs of the present without compromising the ability of future generations to satisfy their own needs (WCED 1987). Gobeze et al. (2009) stated that the sustainability of participatory forest management is appreciated through its capacity to (1) achieve the dual purposes of improving forest conservation and livelihoods of the participant local communities and (2) to ensure the continuity of these achievements in the future, which hinges on the entire participation of the local people. The sustainability is therefore based on the ecological, economic and social outcomes (PAMF 2007).

[§] This article is based on a paper presented at the African Forest Forum workshop 'Forests, People and Environment' held on 4–5 September 2015 preceding the XIV World Forestry Congress in Durban, South Africa

In Benin, policies for forest management that were also repressive and exclusive have been adapted to the new approach of participatory management (PM) (Gbedomon et al. 2016). This is the case for the Wari-Maro Forest Reserve (WMFR), a biodiversity hotspot on account of its richness in flora and fauna in the subhumid zone of Benin (Sinsin et al. 1998; Yaoitcha et al. 2015). Nevertheless, the WMFR is subject to high anthropogenic pressure (Amagnidé et al. 2015; Yaoitcha et al. 2015). To reduce the pressure while sustaining local people's livelihoods, the 'Projet d'Aménagement des Massifs Forestiers' (PAMF), the most important project the forest has ever benefited, was implemented from 2002 to 2007, in WMFR. Reforestation has been carried out using a PM approach to improve forest productivity and to reduce human pressure. So far, establishment of forest plantations has proven to be an important approach of 'ecological restoration' of the environment in forest management (Marien and Mallet 2004). The plantations could be established using either exotic species or native species, which will likely result in differential performances depending on the ecological conditions, the knowledge of the species, silviculture and monitoring of the plantations. Within the framework of PAMF, plantations of both exotic species and native species were established. Several investigations have been carried out on plant communities and population structures of the natural patches of WMFR (Glèlè Kakaï et al. 2009; Assogbadjo et al. 2010; Mensah et al. 2014). However, studies on the achievements of the PM approach, in terms of the contribution to forest conservation, plantation growth and management, and the improvement in standard of living of local populations, have been poorly documented. The perceptions of local populations about the management strategies are thought to be a good indicator of whether PM has either succeeded or failed (Islam and Sato 2012). In this context, the sustainability of the PM of forest plantations could be assessed through the growth and monitoring of plantations, the level of participation of local communities, the changes in their standard of living, and the existence and functioning of organs of joint forest management.

Based on the above, this study aimed to (1) characterise the population structures of the different types of plantations established in WMFR within the framework of PAMF, (2) assess the perceptions of local populations on the PM of plantations during the implementation of PAMF and how this is related to their socio-economic characteristics, and (3) assess the sustainability of the PM of plantations established in WMFR during PAMF.

Materials and methods

Study area

The WMFR is located in the centre of the Republic of Benin in West Africa, between 8°50′ to 9°10′ N and 1°55′ to 2°25′ E (Figure 1). The forest covers an area of about 107 500 ha. It is located in the subhumid zone defined by White (1983) as 'Sudanian woodland mainly composed of *Isoberlinia*'. The vegetation of WMFR is constituted of dense forest, gallery forest, woodlands, wooded savannas, savannas and bushlands, fallows and plantations (Amagnidé et al. 2015).

The climate is made up of two seasons: a dry season that runs from November to March and a rainy season from April to October. Annual rainfall in the period 1964–1997 fluctuated between 1 000 and 1 100 mm with a mean of 1 052 mm (Orthmann 2005). The annual average temperature is about 27 °C. Monthly average relative humidity ranges between 50% and 80%. Potential evapotranspiration is about 1 500 mm y^{-1}. The average annual insolation varies between 2 200 and 2 400 h y^{-1} (Amagnidé et al. 2015).

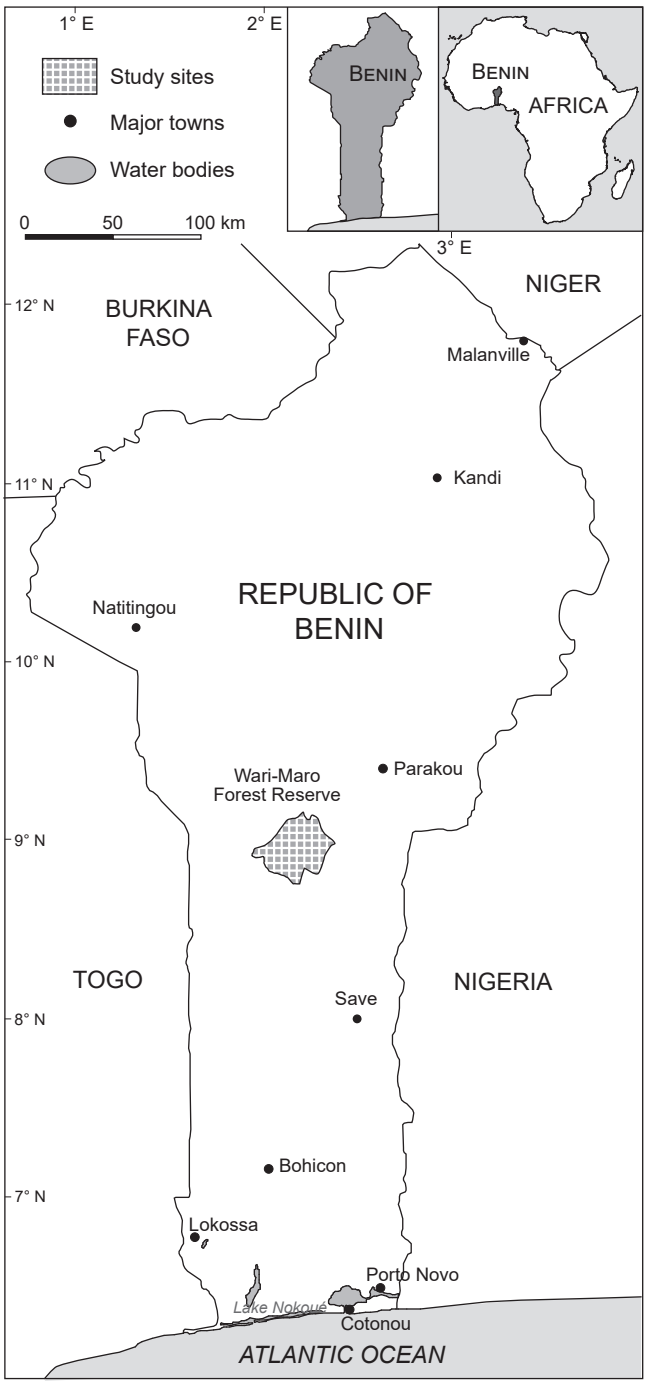

Figure 1: Location of Wari-Maro Forest Reserve in Benin

The population of the three districts surrounding the forest is estimated at 26 839 inhabitants (INSAE 2003). The most important activities of the local populations are agriculture, animal husbandry, hunting, and exploitation of timber and non-timber forest products.

Sampling and data collection

Structural characterisation of the plantations

Two types of plantations were established during the PM of WMFR: plantations of exotic species (PES), which were wholly planted with *Tectona grandis* and *Gmelina arborea* as major species; and plantations of native species (PNS) established with endangered native species, such as *Khaya senegalensis*, *Milicia excelsa*, *Afzelia africana*, *Ceiba pentandra* and *Erythrophleum guineense*. Both types of plantations were established on several delimited stands. Between October and December 2011 when the study was conducted, the age of the plantations was 5, 6 or 7 years.

A random sampling scheme was used to select one stand per age and per plantation type. For each selected stand, the number of plots was determined by dividing the area of the stand by the plot size of 27 m × 27 m. Thus, 37 plots (19 for PES and 18 for PNS) were established. The sampling rate was 25% of the total area of plantations. In each plot, the number of seedlings that survived (survivors), number of regrowths, the basal diameter (cm) and height of seedlings (m) were recorded.

Local perceptions of the participatory management of plantations

Twelve forest riparian villages were selected following two criteria: the existence of plantations of PAMF and the availability of demographic data. The sample size (n) was determined using the normal approximation of binomial distribution (Dagnelie 1998):

$$n = [(U_{1-\alpha/2})^2 \times p(1 - p)]/d^2$$

where $U_{1-\alpha/2} = 1.96$, which is the value of the normal random variable for a probability $\alpha = 0.05$, p is the proportion of project beneficiaries, and $d = 0.08$, which is the margin of error of the estimation of any parameter to be computed from the survey.

In total, 113 households from the 12 villages were randomly surveyed among those that benefited from the project. In order to facilitate the participation process, one organ of JFM was created per village implementing the project. An organ of JFM is a group of local stakeholders or local communities involved in forest management with the state forest departments. In addition to the households, 12 organs of JFM (one organ per village) were surveyed. All of the 12 forestry officers (one forest officer per village) in the field were also systematically surveyed. The survey was performed using a semi-structured questionnaire. Interviews were focused on socio-economic data (gender, age, level of education and socio-professional activity) of the respondents, respondents perceptions regarding their association with plantations design (associated/not associated), change in respondents standard of living after the project (increase/decrease/no change), agreement for the pursuit of reforestation during a second phase of the project (agree/not agree) and whether the forest officers play their role (apart from repression) in the PM process (yes/no).

Sustainability of the participatory management of plantations

Three criteria of sustainable development were used to assess the sustainability of the participatory management of forest plantations under the PAMF: environmental, economic and social criteria. To determine the sustainability score for participatory management of plantations according to the above criteria, some indicators were predefined and variables were measured accordingly. The indicators and their corresponding variables and methods used are described in Table 1.

A three-level scale (1 to 3) (Table 2) was used. Each variable was assigned a score after comparing the results of the project with the reference data (data from evaluation reports, progress reports or completion report). The sum of the scores for each sustainability criterion was intended to estimate the sustainability of plantations PM. The ecological and economic sustainability criteria had three variables (Table 1). As such, the minimum score was three and the maximum was nine. For social sustainability the minimum and maximum scores were seven and 21, respectively.

Table 1: Indicators and variables measured for the assessment of sustainability. Sources: PAMF (2007) and field survey conducted in 2011

Indicator	Variable	Method
Ecological and economic sustainability		
Reforested areas and enriched areas	Survival rate	Forest inventory
Number of illegal activities affecting plantations	Number of illegal activities	Community survey
Standard of living of populations after the project	Standard of living of populations after the project	Community survey through local perceptions
Social sustainability		
Installation of joint management organs	Number of organs installed	Community survey
	Number of forest officers in the field	Community survey
Transparency in the management of joint management organs	Respect of meetings regularity of different organs	Community survey
	Regularity of renewal of the organ executive board	Community survey
Transparency in the management of the financial resources	Respect of procedures for the distribution of funds	Community survey
	Regularity of receipts for funds use by different organs	Community survey
Functionality of organs	Respect of the rules regulating organ functions	Community survey

Data analysis

Five structural parameters were used for the structural characterisation of both types of plantations (see Table 3).

The mean and the standard deviation for all parameters were calculated with respect to age and type of plantations and subjected to two-way analyses of variance (type of plantation and age of plantation were considered fixed factors) with interaction. Data were examined for normality and homoscedasticity and, where required, natural log transformation was applied. In addition, the stem diameter size-class distributions (SCDs) were established for the two types of plantations. To this end, trees were grouped into 2-cm-diameter classes. The three-parameter Weibull distribution (Johnson and Kotz 1970) was adjusted to the observed SCDs. The density function of the three-parameter Weibull distribution for a given tree diameter x is expressed as follows:

$$f(x) = c/b[(x - a)/b]^{c-1}\exp[-((x - a)/b)^c]$$

where x = tree diameter, a = location parameter and is equal to 2 cm, b = scale parameter linked to the central value of diameters, and c = shape parameter of the structure.

Tree diameter was used to estimate the parameters b and c based on the maximum likelihood method (Johnson and Kotz 1970). The log-linear analysis (Caswell 2001) was performed to test for the adequacy of the Weibull distribution to the observed structure. Statistical analyses were performed using R 3.1.2 software (R Development Core Team 2013).

With regard to local perceptions of the participatory management of plantations, relative frequencies (%) were used to describe socio-economic characteristics of respondents and their perceptions of the participatory management of plantations. A Burt table was developed from the survey data and subjected to multiple correspondence analysis (MCA) to describe the relationships between local perceptions and their socio-economic characteristics (gender, age, level of education and socio-professional activity).

Finally, to assess the sustainability of the participatory management, scores of each criterion were compared with the average minimum and maximum values.

Results

Structural characteristics of plantations

There was a significant variation ($p < 0.05$) in the survival rate and the density of survivors between types and ages of plantations (Table 4). The highest values were recorded for the PES and the 5-year plantations. The density of regrowth varied significantly ($p < 0.001$) between the ages of plantations, but not between the types of plantation (Table 4). The highest values of the density of regrowth were observed for the 7-year plantations. For the mean diameter, there was significant variation ($p < 0.001$) only between types of plantations with the highest values observed for the PES. The mean height varied significantly between types ($p < 0.001$) and ages ($p < 0.05$) of plantations, with the highest values recorded for the PES and the 5-year plantations.

Table 2: Rating grid for the assessment of sustainability. Sources: PAMF (2007) and field survey conducted in 2011

Variable	Score		
	1	2	3
Survival rate of plantations	<30%	30–60%	>60%
Number of illegal activities	2 and over	1	0
Standard of living of populations	Decreased	No change	Increased
No. of organs of joint management	0	<12[a]	12
No. of forest officers in the field	Insufficient	Just enough	Sufficient
Respect of administrative meeting	No meetings	Meetings without respect of periodicity	Meetings with respect of periodicity
Regularity of renewal of organs of joint management	No renewal	Irregularity of renewal	Regularity of renewal
Respect of exit procedures of funds	No respect of procedures	–	Respect of procedures
Regularity of voucher of different organs	No voucher	Irregularity of voucher	Regularity of voucher
Respect of the rules of organs functioning	No functioning	Functioning without respect of rules	Functioning with respect of rules

[a] The threshold of 12 was used because the project was conducted in 12 villages

Table 3: Parameters computed for structural characterisation of the study plantations

Parameter	Formula	Interpretation
Survival rate (T_s; %)	T_s = (No. of survivors/No. of seedlings sown) × 100	–
Current density of survivors (N; stems ha^{-1})	$N = n/s$	n = number of survivors s = unit of area
Density of regrowth (R; stems ha^{-1})	$R = r/s$	r = number of annual regrowth s = unit of area
Mean diameter of trees (D_g; cm)	$D_g = \sqrt{\frac{1}{n}\sum_{i=1}^{n} d_i^2}$	n = number of trees d_i = diameter of the ith tree (in cm)
Mean height (H_m; m)	$H_m = \sum H_i/n$	H_i = height of the ith tree (in m) n = number of trees

The interaction between types and ages of plantations was also highly significant ($p < 0.0001$) for all parameters except for the density of regrowth ($p = 0.807$) (Table 5). Therefore, the observed differences in the structural characteristics between the two types of plantations depended on the age of the plantation. Similarly, the observed differences in the structural characteristics between the ages of plantations depended on the type of plantation. In fact, for the survival rate of both types of plantations, a slight gap was observed for the plantations of 6 years (2.96% vs 2.06%), whereas a larger gap was observed for those of 7 years (0% vs 8.47%) and of 5 years (81.79% vs 0%) for PES and PNS, respectively.

There was a good adjustment of the Weibull distribution to the observed diameter structure (log-linear analysis, $p > 0.05$). The diameter structure of survivors ($D_g > 2$ cm) of PES (Figure 2) was bell-shaped with a Weibull shape parameter = 2.4. This indicated the predominance of trees with intermediate diameter (5–10 cm). As for the PNS, the diameter structure of survivors (Figure 2) did not fit the bell-shape, presenting a left dissymmetry with Weibull shape parameter close to 1. This shape parameter was indicative that PNS were constituted of populations with relatively more young individuals ($D_g < 6$ cm) (Figure 2). The survivors in PES were mainly individuals of *T. grandis* and *G. arborea*. Individuals with diameter between 6 and 8 cm were the most represented. With regard to the PNS, the rare survivors were those of *C. pentendra* and *K. senegalensis*. Individuals with diameters between 2 and 6 cm were the most represented (Figure 2).

Local perceptions of the participatory management of plantations

Most of the respondents were men (63.72%; Table 6). The majority (69.03%) of the respondents were adults and more than half had no formal education (54.87%) and were not farmers (52.21%). Only 30.1% of the respondents claimed that they had been involved in the establishment of the plantations. According to 65.49% of the respondents, forest officers played their role during the participatory management process. The majority (89.38%) of the respondents claimed that their standard of living had decreased after the project. More than half (57.52%) of the respondents asserted that they had no interest in the pursuit of reforestation in a second phase of the project.

The MCA assessing relationships between socio-economic characteristics and local perceptions of PM of plantations indicated that 66.1% of the initial variation was captured in the first three factorial axes. Based on the most important contributors (Table 7), Figure 3 reveals on Axis 1 that educated men who had been associated with the plantations design perceived that their standard of living had not changed after the project (compared with that before the project). On the same axis, educated men felt that forest officers did not play their role. On Axis 2, young people with a higher education also claimed that their standard of living had not changed, that forest officers played their role, and agree with the continuation of reforestation during a second phase of the project. Axis 3 showed that old people who are not farmers, not educated but were involved in the plantations design had a

Table 4: Comparative analysis of parameters according to the main effects of the type and age of plantation. Means in the same row followed by the same superscript letter are not significantly different (Tukey's test). PES = plantation with exotic species, PNS = plantation with native species

Parameter		Plantation type		Plantation age (y)		
		PES	PNS	7	6	5
Survival rate (T_s; %)	Mean	23.00[a]	3.64[b]	4.94[a]	2.66[a]	27.30[b]
	SD	37.41	9.15	10.99	4.22	40.90
Density of survivors (N; stems ha^{-1})	Mean	250.00[a]	40.40[b]	54.90[a]	19.80[b]	303.00[c]
	SD	418.00	101.60	122.10	30.80	455.00
Density of regrowth (R; stems ha^{-1})	Mean	109.70[a]	98.30[a]	195.50[a]	118.90[b]	0[c]
	SD	131.90	232.70	272.00	121.90	0
Mean tree diameter (D_g; cm)	Mean	5.09[a]	1.67[b]	3.13[a]	2.28[a]	4.02[a]
	SD	4.89	3.86	4.33	2.92	5.98
Mean tree height (H_m; m)	Mean	2.53[a]	0.55[b]	1.06[a]	0.76[a]	2.35[b]
	SD	2.97	1.17	1.29	0.82	3.56

Table 5: Comparative analysis of parameters according to the interaction of type and age of plantation

Parameter		Exotic species plantation			Native species plantation			Prob.
		7	6	5	7	6	5	
Survival rate (T_s; %)	Mean	0	2.96	81.79	8.47	2.06	0	<0.0001
	SD	0	4.80	14.13	13.66	3.56	0	
Density of survivors (N; stems ha^{-1})	Mean	0	18.29	908.78	94.06	22.86	0	<0.0001
	SD	0	29.63	156.95	151.81	39.60	0	
Density of regrowth (R; stems ha^{-1})	Mean	175.58	128.03	0	209.68	100.59	0	0.8073
	SD	132.07	142.73	0	351.31	88.19	0	
Mean tree diameter (D_g; cm)	Mean	1.92	3.08	12.07	4.00	0.68	0	<0.0001
	SD	1.09	3.35	1.25	5.62	0.68	0	
Mean tree height (H_m; m)	Mean	0.72	1.01	7.05	1.30	0.24	0	<0.0001
	SD	0.42	0.90	1.49	1.66	0.28	0	

standard of living unchanged after the project. In summary, local perceptions of the PM were linked to gender, level of education, age and socio-professional activity and, in particular, the involvement of people in the plantations design and the change in the standard of living after the project. The perception of the forest officers' role was linked to gender, age and level of education, whereas the agreement to continue plantation in a second phase of the project was linked to age and level of education.

Sustainability of the participatory management of plantations

Table 8 summarises the sustainability scores of the PM of the WMFR for the PAMF. The overall survival rate

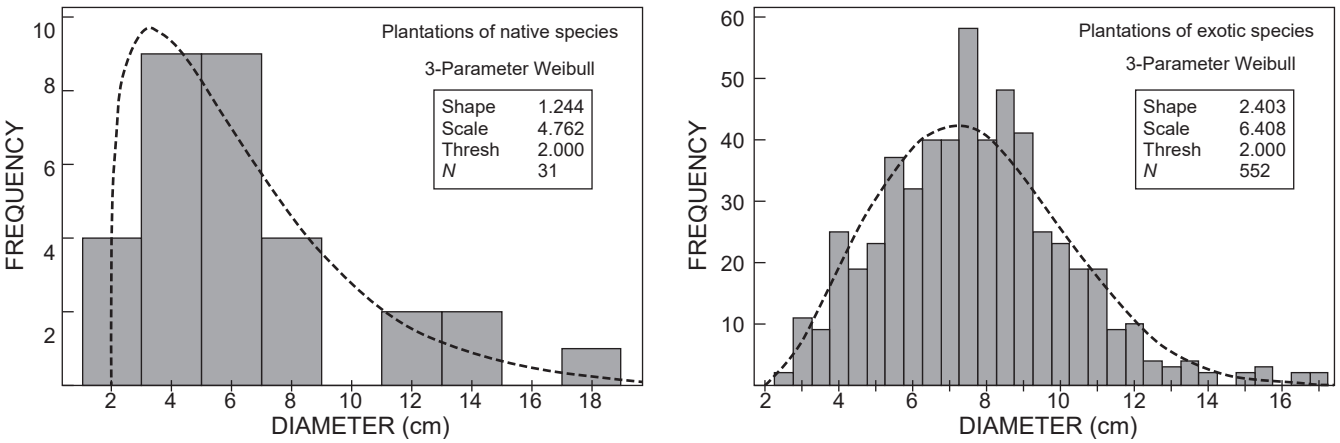

Figure 2: Diameter structures of plantations

Table 6: Distribution of the respondents according to their socio-economic characteristics and their perceptions of participatory management

Variable	Frequency	Percentage	Variable	Frequency	Percentage
Socio-economic factors			**Perceptions**		
Gender			Association with plantations design		
Man	72	63.72	Associated	34	30.09
Woman	41	36.28	Not associated	79	69.91
Total	113	100	Total	113	100
Age			Standard of living after project		
Young (<30)	20	17.70	Increase	2	1.77
Adult (30–60)	78	69.03	Decrease	101	89.38
Old (>60)	15	13.27	No change	10	8.85
Total	113	100	Total	113	100
Education level			Foresters play their role		
No education	62	54.87	Yes	74	65.49
Elementary school	41	36.28	No	39	34.51
High school	10	8.85	Total	113	100
Total	113	100	Agreement for the second phase of the project		
Socio-professional activity					
Farmer	59	52.21	Agree	48	42.48
Not farmer	54	47.79	Not agree	65	57.52
Total	113	100	Total	113	100

Table 7: Correlation between variables and factorial axes

Variable	Axis 1		Axis 2		Axis 3	
	R^2	p	R^2	p	R^2	p
Gender	0.608	$2.50E^{-24}$	–	–	–	–
Age	–	–	0.546	$1.37E^{-19}$	0.306	$1.85E^{-09}$
Education level	0.448	$6.54E^{-15}$	0.459	$2.19E^{-15}$	0.339	$1.31E^{-10}$
Socio-professional activity	0.065	$6.42E^{-03}$	–	–	0.412	$1.88E^{-14}$
Association with plantations design	0.377	$4.67E^{-13}$	–	–	0.105	$4.48E^{-04}$
Standard of living after the project	0.347	$6.70E^{-11}$	0.148	$1.53E^{-04}$	0.099	$3.26E^{-03}$
Foresters play their role	0.239	$3.91E^{-08}$	0.188	$1.63E^{-06}$	–	–
Agreement for the second phase of the project	–	–	0.347	$6.99E^{-12}$	–	–

was 18.18%. Three illegal activities that undermined the growth of plantations were recorded, namely grazing, bush fires and pruning. According to the local population, their standard of living had not changed after project implementation. Field survey also revealed that there were eight forestry officers for the project units and four for the forestry post. This number is likely to be insufficient to cover the whole extent of the forest reserve, which is 107 500 ha, equating to more than 8 900 ha per forest officer. All of the 12 JFM organs that were planned in the project were established and observed during field survey, but none of them had regular meetings. Regulations that established the organs of JFM stipulated that the executive board must be renewed every three years and a general assembly held twice a year. It was found that renewal of the board only took place in one village and the general assembly was practically not observed. Local populations in general, and women in particular, expressed doubts about efficiency and transparency as well as respect of procedures in financial management by JFM organs. In total, ecological, economic and social sustainability had a score below the mean. As a result, the overall sustainability also had a score below the mean. As such, PM of plantations established in the WMFR under the PAMF showed short-term sustainability.

Discussion

Status and structural characteristics of plantations established during participatory management under the PAMF project

Structural characteristics of plantations of different types and ages suggest a failure of plantations established in WMFR during PAMF. The better structural characteristics observed for PES and 5-year plantations are likely due to

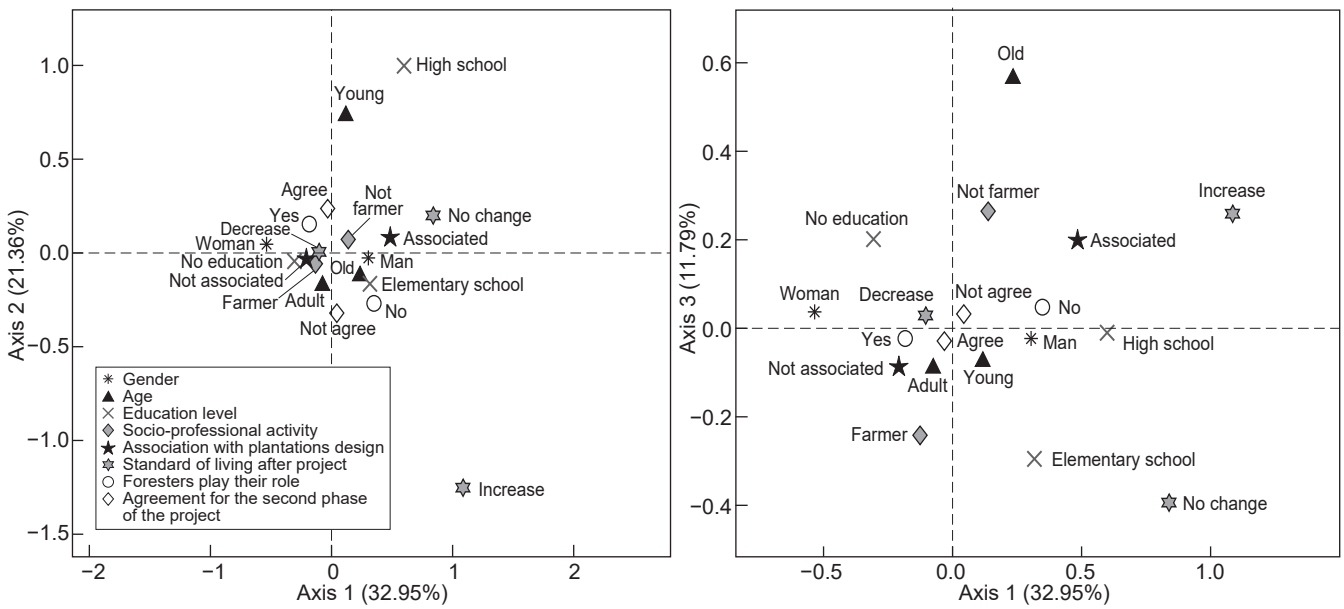

Figure 3: Variables representation on the multiple correspondence analysis factors

Table 8: Sustainability scores

No.	Variable	Scores	Minimum	Maximum	Mean
Ecological and economic sustainability					
1	Survival rate of plantations	1	1	3	2
2	Number of illegal activities	1	1	3	2
3	Standard of living of populations	1	1	3	2
Subtotal 1		3	3	9	6
Social sustainability					
4	No. of forestry officials	1	1	3	2
5	No. of organs of joint management	3	1	3	2
6	Respect of meeting periodicities by different organs	2	1	3	2
7	Regularity of renewal of organs of joint management	2	1	3	2
8	Respect of exit procedures of funds	1	1	3	2
9	Regularity of voucher of different organs	1	1	3	2
10	Respect of the rules of organs functioning	2	1	3	2
Subtotal 2		12	7	21	14
Total		15	10	30	20

the fact that the species used were introduced species such as *T. grandis* and *G. arborea*. The viability of the seeds and the soil properties could also explain the differences of survival rates observed between the plantation types. Therefore, the introduction of exotic species in plantations in WMFR could be considered a relative success as in many other forest reserves (Wafo Tabopda and Fotsing 2010). Despite these good results, characteristics of trees in PES and 5-year plantations were very low compared with findings on the same species in Ghana (Nwoboshi 1994), Nigeria (Onyekwelu et al. 2003), Côte d'Ivoire (Dupuy et al. 1999) and in the humid zone of Benin (Ganglo and Lejoly 1999). Differences in the characteristics of *T. grandis* and *G. arborea* among countries could be due to differences in ecological conditions (mainly soil and rainfall) of the sites. One additional reason for these differences may be the lack of plantation monitoring and maintenance, resulting from the unwillingness of local communities to pursue post-project activities due to their non-involvement during the plantations establishment. The PM of forest plantations, in the way it has been implemented in WMFR, has not promoted tree growth. Other studies reported a remarkably positive impact on the forest and plantations status with exhibition of better population structure after the PM process, e.g. Bekele et al. (2004) and Gobeze et al. (2009) in Ethiopia, Kajembe et al. (2005) in Tanzania and Prasad (1999) in India. This suggests that responses to PM are context-dependent and specific to how PM management has been implemented.

Compared with PES, poor growth was obtained for PNS where species such as *K. senegalensis*, *M. excelsa*, *A. africana* and *C. pentandra* were found. These poor results of PNS might be mainly due to the fact that more than 50% of plantations were established in 2006 (Sinsin et al. 2006) and were only maintained and monitored for one year before the completion of the project. This time was not sufficient to ensure the growth of seedlings because management by the project was planned to last five years after their establishment. Annual regrowth was encountered for native species that had poor resistance to vegetation fire, parasite attacks, and anthropogenic pressures from grazing and pruning. As a result of fire occurrence, the leaves of seedlings are often burned, thereby slowing their growth (Ouédraogo and Delvingt 2002). The observed low survival rates for native species may also be due to the fact that such species have undergone little or no genetic improvement to enhance their performance as compared with exotic species. In addition, the poor knowledge and skills of the silviculture of native species often hinder their successful integration in restoration programs. According to Ray (2012) and Akpona et al. (2016), genetic improvement could be the future of *K. senegalensis* plantations. In addition, silviculture techniques for good productivity and pest management influence the successful propagation of *K. senegalensis* (Akpona et al. 2016).

Local perceptions of the participatory management of plantations under the PAMF project

Local communities were only involved in the project at the implementation stage of plantations during the PM process. This involvement varied according to gender, age, level of education and socio-professional activity. It is believed that the communities were used not as partners but rather as labour. This is contrary to the philosophy of the PM approach, which stipulates that external stakeholders and states must recognise local communities as full partners in development, including decision-making (FAO 2004). There was no gender equity in the PM of WMFR plantations because women were mostly discriminated against (see Figure 3). Yet, Gobeze et al. (2009) found that gender equity had a positive effect on the PM process in Ethiopia. From the field survey, women argued that they could form a cooperative and voluntarily pursue plantations monitoring if they had been more involved in the PM process. Similar feelings of women working together in a partnership in forest PM activities have been observed in Burundi (see Nyengayenge 2002).

While the standard of living of local communities was improved during the project life time, no change was observed after the project compared with before the project. In addition, the activities providing incomes (except for wood-based activities) had not been developed and only 4.74% of the amount planned for granting credits to women for developing these activities was disbursed (Sinsin et al. 2006). Opposite results were observed in other countries where PM of forests had increased the livelihoods of local communities after project implementation (see Terefe 2002; Safa 2004; Gobeze et al. 2009). For instance, in Ethiopia, the PM of forest in Bonga showed positive impacts on the livelihoods of participating households (see Gobeze et al. 2009). Unlike the WMFR, the PM of forests in Bonga identified participants with gender equity and activities generating incomes (other than wood-based activities) were developed with Forest User Cooperatives.

Perception of local communities on the role of forest officers in the PM of plantations was exclusively related to repression, not with regard to PM of plantations. According to the local community, forest officers commit misappropriation of funds in the management of tax collected. Siebert and Elwert (2004) observed that Beninese forest officers corrupted by entrepreneurs and loggers ignore their duty of law enforcement and often perpetrate illegal logging themselves. In view of all the above, local communities did not have an optimistic view of the project achievements and their sustainability. This negative attitude has resulted in their non-interest in the pursuit of reforestation during a second phase of the project.

Sustainability of the participatory management of plantations under the PAMF project

Ecologically, results showed an unhealthy status of plantations established in WMFR with very poor structural characteristics. As far as the economic outcomes are concerned, the results showed that the standard of living of local communities did not change after the project. If the standard of living had improved this would have shown a reduction in the anthropogenic pressures on plantations. As far as the social aspects are concerned, findings highlighted the poor involvement of local communities in all stages of plantations establishment, the poor functioning of organs of JFM and the ineffectiveness of forest officers in the PM of plantations. There is clearly a lack of achievement in terms

of ecological, economic and social outcomes and hence no continuity in the project achievements. This likely explains the short-term sustainability obtained for the PM of plantations established in WMFR under the PAMF. Conversely, the PM approach as a system of forest management appeared in other forests to have achieved the purposes of improving forest conservation and management and livelihoods of the participant local communities (see Gobeze et al. 2009; Phiri et al. 2012). Generally, the continuity of these achievements hinges on the cooperation of the local people, which is won through the granting of user rights to the forest resources, and subsequent empowerment in decision-making regarding the forest management (Gobeze et al. 2009). Sustainable forest management should create a balance between the different uses of the forest while ensuring its ecological functioning (Charron 2005).

Conclusion

Participatory management is crucial for long-term sustainability in management projects. Through the PM of plantations in WMFR, this study concludes that established plantations failed overall and that those planted with exotic species exhibited better structural characteristics than those planted with native species. The perceptions of the local communities on the PM of plantations varied among respondents and were linked to their socio-economic status. Findings also suggest that the PM of plantations had a short-term sustainability. For future projects, in addition to effective and full involvement of local communities in all stages, plantation monitoring for at least five years after establishment is recommended. Development of activities providing incomes other than wood-based activities is recommended to ensure the improvement of the livelihoods of local communities after project implementation. This study was conducted 5 years after the completion of the project. An assessment of the project at a relatively longer period (e.g. 10 and 20 years) will shade the conclusions of the present assessment. An additional important issue is a need to conduct research on improved silvicultural management of native timber species in order to achieve their proper integration into reforestation programs.

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