INTEGRATED IMPACT ASSESSMENT OF A SMALL RESERVOIR ON LAND USE AND LIVELIHOOD IN BURKINA FASO

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1 Introduction

Growing population, low farm productivity, water shortage in dry season, and subsequently food insecurity are major problems in Sub-Saharan African like Burkina Faso. Since rainfall is the most determinant environmental factor for agricultural production, irrigation agriculture and construction of dams are very vital for sustaining and improving rural livelihoods. Irrigation can also come along with negative impacts such as water-born diseases or displacement of marginal farmers. However, through improved planning and management these negative impacts can be compensated. In addition to direct benefits like increased crop production, farm income and farm employment, irrigation has some indirect benefits as well. The paper focuses, however, on exploring direct impact of irrigation on farmers' livelihood since it is difficult to quantify all direct and indirect impacts such as social and environmental costs of irrigation (Intizar and Bhattarai; Bhattarai, Sakthivadivel et al. 2002).

Irrigation agriculture has no tradition in Burkina Faso and was only recently given a priority by the Burkinabé government after a period of drought in the 1970s and 1980s. The main objectives of promoting the construction of dams are an increase in food production and the provision of additional employment opportunities in dry season. Further, the organizational development of farmers by forming cooperatives of water users in order to improve land and water resource management should be encouraged. Besides, an increase of rice production to reduce the dependency on rice imports is a major concern (Aouba 1993).

There is, however, only little known about the actual impact of irrigation project and how to integrate impact considerations into adequate foresight and planning to avoid unfavorable impacts of reservoirs on affected livelihoods in Burkina Faso. Regarding this, one of the needs is an improved understanding of actual impacts of new agricultural technologies, particularly reservoirs, on livelihood and income strategies of different types of farmers. This focus requires research methods which combine quantitative and qualitative information in order to explain given outcomes from different perspectives and provide more options for interpretation of the outcome (Adato and Meinzen-Dick 2002; Adato and Meinzen-Dick 2007; La Rovere and Dixon 2007).

The paper presents a case study of impact assessment for the Moutori reservoir, a small irrigation project, in Southwest Burkina Faso using quantitative and qualitative information in order to explore in what ways the project affects the livelihoods of the target groups. Accordingly the distribution of benefits among

different groups of beneficiaries is assessed. To identify the overall contribution of the project to development, impacts are rather assessed in terms of livelihood change than in terms of project objectives. Further the dynamics of the project on income inequality is measured using the Gini index. Additionally, perceptions of concerned farm households on the irrigation project provide some insights from the beneficiaries' perspective before giving conclusions and deriving some recommendations.

2 The livelihoods approach for impact assessment

The livelihood approach[1] was chosen because it focuses on the farmers concerned and subsequently on the contribution of the project on development and rural livelihoods. Impact assessment based on s livelihoods approach examines changes in factors that affect livelihoods in their capital assets, institutional structures or processes, vulnerability as well as livelihood strategies and outcomes (La Rovere and Dixon 2007). Here, mainly impacts on capital assets and outcomes are measured. The five interlinked capital assets, natural, financial, social, human and physical, are the heart of the Sustainable Livelihood (SL) framework. Within the SL framework water can be seen as a productive asset that can produce certain types of income. Increasing scarcity of or better access to water can change household capacity to combine water with other assets to generate income. Applying the framework to the water sector aims on an understanding the irrigation project affects different aspects of livelihoods. Since the Sustainable Livelihood framework is used as an analytical tool, impacts on assets are considered Analyzing how the irrigation project fit or conflict with different livelihoods helps to identify ways in which benefits can be enhanced or negative impacts can be avoided (Ashley 2000; Adato and Meinzen-Dick 2002; Adato and Meinzen-Dick 2007; La Rovere and Dixon 2007; Pant, Thapa et al. 2005).

3 Profile of the study site

3.1 Site description

Dano is a small market town with in Southwestern Burkina Faso in the province of Ioba. This used to be the area occupied by the Dagara, but as a result of migratory movements the different ethnic groups are now scattered throughout the country.

The region experiences an annual rainfall of 700-900 mm in a single rainy season lasting about 5 month from April to September. Despite of recent infrastructure development such as road construction and new employment opportunities in the service sector agriculture remains the main source of income for the majority of residents in Dano. About 86 % of the population generates income from farming activities. The prevalent farming system is subsistence crop production. Rainfall pattern determines the cropping calendar. Major crops are cereals such as millet, sorghum, maize, and rarely rice. Further, cash-food crops

[1] The livelihood approach follows the under standing of the Sustainable Livelihood Guidance Sheet of DFID.

like cotton, chili, and oil crops (groundnut and soybeans) are cultivated as well as non-cereal food crops such as vegetable, tubers, and legumes. During dry season from October to March rain is very rare and agricultural production is only possible under irrigation. Farmers mainly grow maize and vegetable in that period. Apart from agriculture, livestock, trade and crafts provide a source of income (BADCOM 2003).

3.2 Status of the Moutori dam project

The dam was constructed in 2001 / 2002 by the German Dreyer Foundation to store rain water for agricultural irrigation in dry season. As a result a reservoir that covers 25 hectares and 20 hectares of irrigated land were created. The irrigation area (perimeter), subdivided into 88 plots, was mainly donated to farmers' families who farmed on the project terrain before the construction of the dam. On average, every household got 2.4 square meters of arable land. In 2004 the reservoir stored a sufficient volume of water for the first time to allow cultivation of a second crop during the dry season. In order to manage the complex and unknown farming practices farmers are now organized in a cooperative, the Timisso Dreyer Farmers Cooperative. The cooperative is organizationally and financially supported by the foundation. In addition, the foundation provides small loans to individual farmers for the procurement of seeds and fertilizer. These loans are mostly repaid in natural produce which the foundation uses for a students meal program. Further, the foundation offers a continuing agricultural extension program that is carried out by a local agricultural consulting service. The program includes educational and informational seminars on utilization and maintenance of the irrigation system and farming practices, particularly for paddy rice cultivation (Dreyer Foundation 2008).

4 Livelihoods within the water user cooperative

4.1 Data collection

Impact on livelihoods is measured in terms of changes in various indicators due to the irrigation project. The measurement of impact is based on data from a survey that was conducted within a period from September to October 2006, and March to June 2007. The survey method was used to generate quantitative data and included 44 randomly selected households, 50 % of all households farming in the perimeter of the Moutori reservoir. Because farming is the primary source of income-generating activity in the research region, household were defined as a group of individuals working on the same plots, having meals together and sleeping under the same roof. Each household was interviewed two times using structured questionnaires. The topics addressed in the first questionnaire were household composition, education, migration, household and production assets, membership in organizations, livestock, sources of income, access to credit as well as information on agricultural extension programs particularly on the irrigation project. The second survey phase involved a questionnaire covering relevant plot data such as cropping patterns, farmer's perception on land cover and soil fertility, land tenure, land

management practice including soil conservation methods and application of fertilizers, harvest and labor allocation on plot.

4.2 Household classification

Households considerably differ in their socioeconomic characteristics and asset endowment in terms of human, financial, social, physical, and natural capital to support their livelihoods. Due to these difference households are not equally affected by projects and programs that aim on poverty reduction and improved natural resource management. Indeed all households have unique socioeconomic characteristics and behavior but for planning and administration of development programs and projects it is impossible to consider every individual household (Emtage 2004; Emtage and Suh 2005). Impact is measured across households in terms of the degrees of affectedness by the project to examine the distributional aspects of the impact.

Therefore, a typology of households in relation to the degree of intervention by the irrigation project based on households' share of irrigated land of total landholdings was developed. This classification helps to understand how the support of the Dreyer Foundation affects farmers in their socioeconomic conditions and how farmers may respond to different types of assistance and information.

Table 1: Share of irrigated land of total landholdings and degree of intervention for three household groups

	N	Mean	SE	SD	Min	Max
Household group I Little intervention	17	11.1	0.72	2.96	4.7	14.7
Household group II Medium intervention	15	21.7	0.91	3.52	15.8	28.4
Household group III Strong intervention	12	37.2	1.89	6.53	30.4	50.1

In terms of the average share of irrigated land of total landholdings the classification resulted in three household groups I, II and III with group size 17, 15 and 12, respectively (see Table 1). The groups defined are relatively homogenous with regard to their share of irrigated land of total landholdings of the household. The first group shows a relatively small proportion of irrigated land of total landholdings and is in terms of livelihood therefore not as much affected by the irrigation project as household group II and III. Households of the third group are strongly affected by the project since more than one third of their landholdings are irrigated land. T-tests confirmed that the share of irrigated area is significantly ($p < 0.05$) different between the three household groups.

4.3 Asset endowment of household groups

Apart from the share of irrigated land of total landholdings, there are numerous variations in socioeconomic characteristics that discriminate the three household groups. The following section describes and characterizes the groups in terms of main livelihood assets.

Table 2: Average asset endowment of the three household groups

	Household group I	Household group II	Household group III
Natural Capital			
Total landholdings (ha)	1.60	0.77	0.58
Total landholdings/capita (ha)	0.23	0.12	0.11
Human capital			
Household size	8.8	9.5	12.3
Labor	7.2	7.5	9.5
Dependency	0.6	1.0	0.7
Education index[2]	2.2	2.3	1.0
Physical capital			
Livestock per capita (1,000 F CFA)	34.6	13.0	58.7
Production means incl. transportation per capita (1,000 F CFA)	46.6	28.5	38.2
Financial capital			
Gross non-farm income (1,000 F CFA)	492.1	270.6	321.9
Gross income from crop production (1,000 F CFA)	402.3	311.2	352.3
Total gross income (1,000 F CFA)	900.3	588.5	686.9
Total gross income / capita (1,000 F CFA)	109.8	81.0	90.3
Social capital			
Participation in community organization (number of households/%)	4/23.5%	1/7.1%	3/25.0%

Household group I

Households of group I are the richest in terms of total land holdings as well as land holdings per capita (see Table 2). The social capital that is crucial with regard to water user cooperative is participation. Participation in resource management is widely seen as a social capital since it creates networks which support the poorest households and strengthens the organizational capacity of a community for better natural resource management (Nicol 2000; McCarthy, Dutilly-Diané et al. 2004). Apart from their participation in the irrigation projects, only four households of group 1 are engaged in other community organizations.

In terms of human capital, this group has the smallest household size and the lowest dependency ratio. Further, group I households are characterized by a relative high education index and good endowment

2 The education index is a composition of type of school attended and years of schooling.

with production means and means of transportation. Among the three household groups they are the richest in terms of income generating most income from non-farm activities.

Household group II

Households of group II have the highest dependency ratio but also the highest education index. Although group II households have more farm land than households of group III they are the poorest among the three groups regarding physical and financial capital. Farm income is the most important source of income indicating that these households rely more on natural capital than the other groups. Further, this group is characterized by a very low level of involvement in community organizations.

Household group III

In terms of human capital these households are characterized by a large household size, high labor availability, a low education index and moderate dependency ratio. They differ considerably from the two other groups in their livestock endowment indicating that income from livestock is relatively important for this group. While the households of this group have the smallest size of total landholdings and landholdings per capita they are not the poorest households among the beneficiaries of the irrigation project regarding income since they generate almost half of their income from non-farm activities.

5 Impacts of the Moutori dam project on rural livelihoods

Impact of development projects on rural livelihoods can be assessed in different ways. Here, before and after situations of the same households participating in the project are compared. Since there are no baseline data available, the comparison is done reflexively (Ravllion 2001). The major problem regarding this is that there are no plot size data before the construction of the dam available. Because agriculture is the principal income-generating activity, size of farm land is the determining criterion for well-being of households. Therefore, the plot sizes are assumed to be the same like at the present time. Since the time lag is not more than five years, 'before' information were still in people's memory. In the following section livelihoods impact is measured in terms of changes in land use pattern, productivity, labor and fertilizer application as well as income.

5.1 Changing land use in the flood plain

Figure 1 illustrates that the construction of the irrigation system led to a change of land use pattern. Before the dam, sorghum and maize were the principal crops. Only a few farmers of each household group grew rice in rainfed agriculture. Although rice and maize remain the major crops, farmers started to

diversify crops in a limited scale. There are instances where farmers started growing vegetable and horticultural crops.

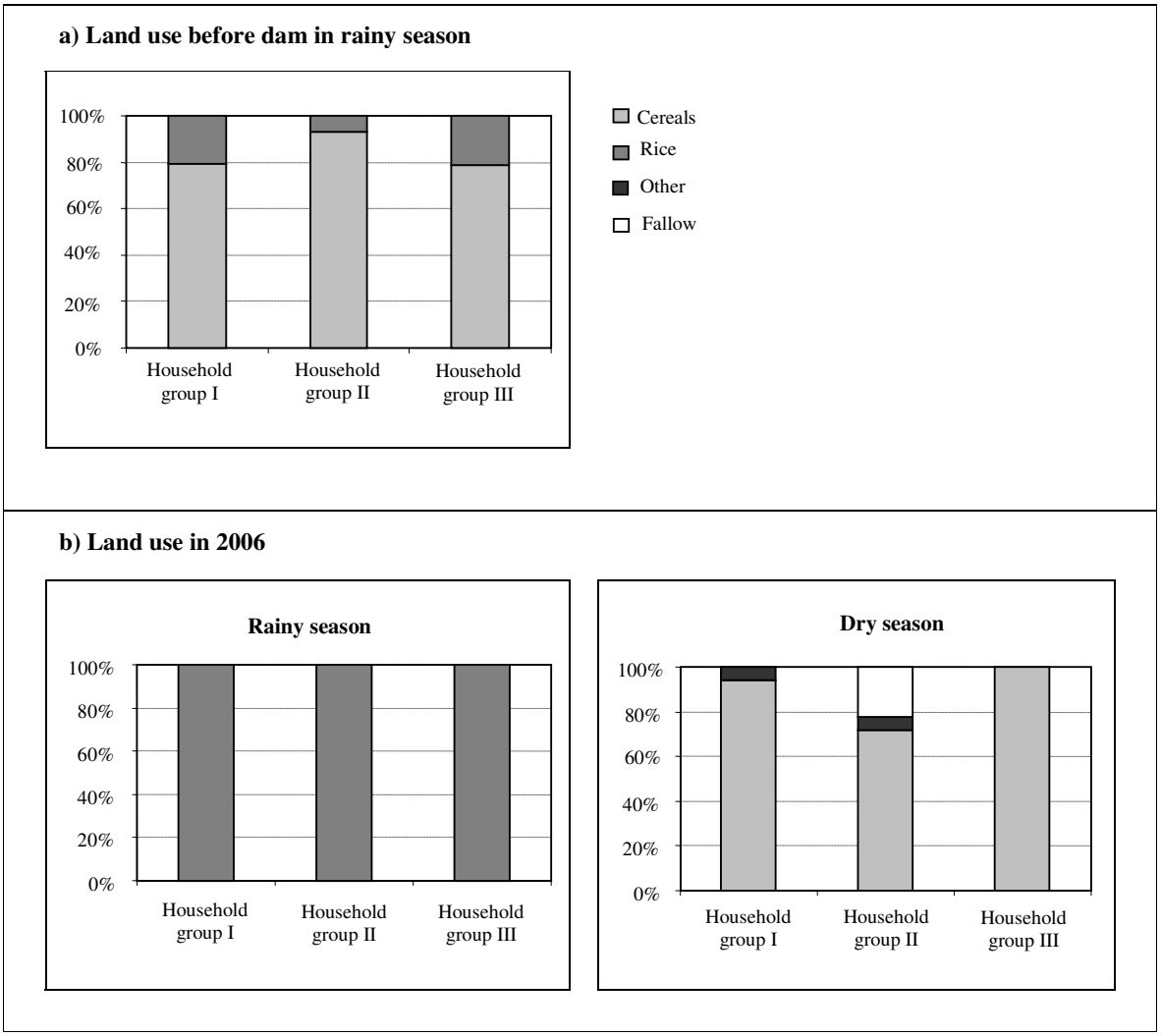

Figure 1: Land use in the perimeter before the construction of the dam and in 2006

Besides land use pattern, the cropping intensity changed. The permanent availability of water allows two cropping seasons whereas in rainy season farmers grow mainly paddy rice and maize or vegetable in dry season. Among the observed households all farmers grew paddy rice in rainy season. In dry season, however the cropping patterns differ. Whilst all households of group III grew maize, some households of the first and third group cultivated vegetable. Since irrigation has no tradition in the region, farmers were not used to two cropping seasons. In the first years after the construction of the dam, many plots in the perimeter were not farmed in dry seasons. In 2006, however, the majority of plots were cropped in dry season and only a few households of group II did not cultivate their plots.

5.2 Impact on productivity

The following section shows that not only land use changed but also crop yields, particularly rice and maize yields.

Rice production

Before the construction of the dam only a few households grew rice, whereas in 2006 all interviewed households grew rice. Figure 2 illustrates a significant increase of productivity in rice cultivation among all household groups. Nevertheless, crop yields varied significantly from one plot to the next mainly because the cooperative could not yet sufficiently organize the coordination of the irrigation routine. Household group I had most substantial increase of rice yields after dam construction and the highest productivity among the three groups whereas households of the third group had the lowest productivity before and after the construction of the dam. In general, farmers assign higher priority to paddy rice cultivation nowadays. Before irrigation was possible, only 8 of the interviewed households had rice plots on the terrain. Rice is also cropped outside the perimeter in rainfed agriculture. However, only a few of the observed households had rice fields with significant lower crop yields.

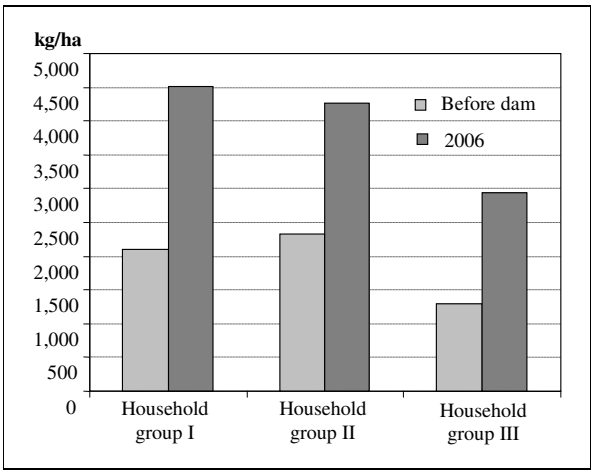

Figure 2: Productivity of rice before dam and 2006

Maize production

While all households had about the same per hectare yields of maize before the construction of the irrigation system there can be significant differences observed at the present time (see Figure 3a).

Household group II has the most significant increase in maize productivity. Per hectare yields almost doubled and are two time higher than per hectare yields of group III. Maize yields of third group even decreased after the construction of the dam. The decrease could be, however, also less than the results suggest taking into account the assumption of the same plot size before and after the construction of the dam. In 2006, households of group I had about the same per hectare yields of maize then before.

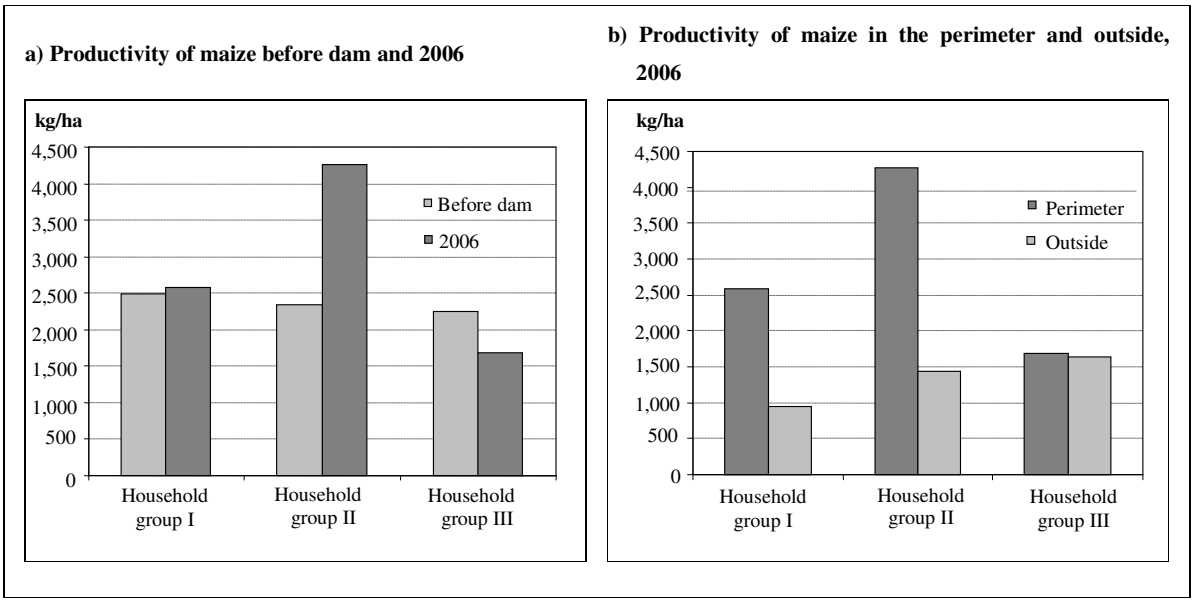

Figure 3: Productivity of maize

Since maize is a major crop of the study site and cultivated by almost all observed households also outside of the perimeter, the productivity of maize can be compared with per hectare yields in the irrigated area. In total, the productivity in the perimeter is significantly higher among all household groups indicating improved land use practice in the irrigated area. Figure 3b) suggests that group I and II have significant lower per hectare yields outside the perimeter whereas the first group has the lowest productivity. Household group III shows the highest per hectare yields outside of the perimeter, which are about the same on the irrigated land.

5.3 Impact on farm input

The results above indicate an intensification of land use. The following section therefore sheds light on some input indicators, namely working days and application of chemical fertilizers.

Irrigation agriculture is regarded as beneficial in terms of creating employment opportunity (see e.g. Intizar and Bhattarai; Bhattarai, Sakthivadivel et al. 2002). The results from the analysis suggest that there is an evidence for more employment after the construction of the irrigation system. Taking into account that there two cropping seasons the number of working days increased significantly although farmers of household group II and III spend less time for maize production nowadays (see Table 3).

Households of group I show the highest labor input in rice and maize production as well as the most considerable increase in labor. They also apply the largest amount of chemical fertilizer among the household groups. This points to intensification of land use and explains the high per hectare yields in rice production. Group II also increased labor for rice production but decreased labor input for maize

cultivation. The increase of productivity in maize production has therefore to be explained by significant higher fertilizer application of both NPK and Urea in 2006.

Table 3: Changes of inputs

Indicator		Before dam		2006		Change
		N		N		
Working days for rice/ha	Household group I	4	327	17	512	184
	Household group II	1	349	15	453	104
	Household group III	3	278	12	319	40
Working days for maize/ha	Household group I	13	534	15	555	21
	Household group II	11	340	11	305	-35
	Household group III	9	447	12	307	-140
NPK (kg / ha)*	Household group I	11	230	17	342	111.7
	Household group II	9	189	15	313	124.1
	Household group III	5	88	12	248	159.5
Urea (kg / ha)*	Household group I	9	149	16	312	162
	Household group II	5	87	15	313	226
	Household group III	5	88	10	211	123

* In total for rice and maize together

Table 3 shows that household group III has significant fewer working days per hectare for maize production compared to group I and II and before the irrigation project. This might also explain the above mentioned decline in maize productivity of household group III.

5.4 Impact on income from the irrigated land

Changes of income and income composition are key indicators of assessment of development projects and aim on its financial viability. Mainly due to the fact that farmers can derive income from two cropping seasons per year, net income from the irrigated land has increased substantially for all three household groups. This increase is uniform in all households. However, there can be substantial differences in the composition of the net income from the perimeter plots among the three household groups observed. Moreover, table 4 suggests that the degree of the increase of income differs.

Household group I shows the highest increase of net income from rice and maize as well as a high net income per hectare per capita in the comparison. Although households of the second group have the lowest increase of income from rice, they have the highest increase in net income per hectare per capita from the perimeter parcel. Compared to group I and II, household group III is less beneficiary in terms of income. The observed decline in per hectare yields led to a decline of net income from maize.

Table 4: Change in net income from irrigated land

Indicator		Before dam	2006	Change	
				Total	%
Total net income from rice	Household group I	14,265	57,504	43,239	403.1
(1.000 F CFA)	Household group II	49,100	61,573	12,473	125.4
	Household group III	36,175	58,058	21,883	160.5
Total net income from	Household group I	23,188	31,568	8,380	136.1
maize (1.000 F CFA)	Household group II	23,384	31,108	7,724	133.0
	Household group III	31,858	21,990	-9,868	69.0
Net income/capita/ha	Household group I	35,146	93,172	58,026	265.1
(1.000 F CFA)	Household group II	19,590	80,697	61,107	411.9
	Household group III	24,144	62,583	38,439	259.2

5.5 Impact on income inequality among the three household groups

Equity in distribution of benefits is essential for improving livelihoods, to avoid conflicts and to enhance participation (Fofack, Monga et al. 2001). To measure the dynamics of the project on income inequality the Gini index before the construction of the dam and in 2006 is estimated. It is derived using the following discrete representation:

$$G = \left(\frac{1}{2n^2 x} \right) \sum_{i=1}^{n} \sum_{j=1}^{n} \left| x_i - x_j \right|$$

The index can take values between 0 (the minimum) and 1 (the maximum) whereas the maximum value represents perfect inequality.

Table 5: Gini coefficients before the construction of the dam and in 2006 of the three household groups

	Household group I	Household group II	Household group III
Before dam	0.49	0.33	0.25
In 2006	0.26	0.40	0.28

Table 5 shows the equity level, indicated by the Gini coefficient of net income from the perimeter plot for the three household groups. The results suggest a declining income inequality among farmers of household group I. Household group II and III, however, show an increasing income inequality.

6 Farmers perceptions on the Moutori reservoir project

In order to gather information on farmers' perception of impacts of the project on their livelihood and land use practice as well the importance of the assistance through the Dreyer Foundation focus group

discussions were conducted. During the discussions farmers were asked to score and to rate the importance of sources of income and constraints of agricultural production in the perimeter.

Perception on change of income

In general farming households are enthusiastic about the Moutori dam project. Table 6 illustrates that farmers perceive the access to irrigation as a crucial benefit. Particularly the provision of an additional income in dry season and the opportunity to grow paddy rice are seen as favorable impacts. Despite of the higher input requirements, rice production is more profitable than maize or sorghum. Moreover, the extension service provided by the Dreyer Foundation is considers as very important and valuable regarding rice production. Apart from rice, the cultivation vegetable became more important with the irrigation project.

Table 6: Farmers perception on changes of sources of income

Source of income	Before dam	2006	Change
Rice	2	20	18
Maize	9	15	6
Vegetable	2	10	8
Non-farm activities	3	10	7
Sorghum	4	5	1
Cotton	4	4	0
Millet	3	3	0
Chili	3	2	-1
Total	**30**	**69**	**39**

Since cotton and millet are traditionally not cropped in the flood plain and were not externally affected recently, their importance remained the same. However, the terrain used to be also an area of chili production that decreased after the construction of the dam. According to farmers, there is too much moisture in the soil for proper chili cultivation. Since chili is a cash crop farmers regret this development but seem to be sufficiently compensated for the loss by income from rice.

Interestingly, income derived from non-farm activities also increased. Farmers explained this with the construction of the concrete road and the development of the service sector in Dano in recent years.

Perception on concerns

According to farmers, the intensity and the type of problems or issues in terms of farming substantially changed with the implementation of the irrigation scheme (see Table 7).

Table 7: Farmers perception on changes of concerns

Perceived problem/issue	Before dam		In 2006	
	Score	Rank	Score	Rank
Animal destruction	2	7	10	**1**
Increase in input prices	1	8	5	2
Distribution of irrigation water	0	**9**	3	3
Lack of production assets	5	4	3	3
Lack of expertise	10	**1**	3	3
Lack of experience	7	3	3	3
Position / location of plot	0	**9**	3	3
Lack of water	10	**1**	2	8
Low soil fertility	5	4	2	8
Lack of labor	3	6	1	**10**
Total	43		35	

The Dreyer Foundation provided access to irrigation water and extension service, which was considered as most concerning before the irrigation project. Although farmers reported some problems with microorganisms, soil fertility situation has improved. Currently, the major concern is animal destruction particularly in dry season. Over the last two years this resulted in conflict among farmers. Apparently, the farmers of the cooperative are not able to solve this conflict by themselves. On the other hand, they did not want to report the seriousness of the conflict to the Dreyer Foundation. A second conflict that came up with implementation of the project is the distribution of irrigation water since the cooperative could not yet sufficiently manage the coordination of the irrigation routine. Another concern is raising input prices, which might lead to a decrease in benefits in the future. Surprisingly, farmers reported that despite of the higher labor demand at the present time, labor availability improved with the irrigation project but could not give a proper explanation for that.

7 Conclusion and Recommendations

There is evidence that the Moutori irrigation project led to land use change and considerably contributes to increasing farm income and subsequently to improved livelihood. The benefits of the irrigation are, however, not equally distributed among the three identified groups of beneficiaries. It is very vital to take into account these differences of the farm households to ensure that they can benefit from the project. In order to find common interests and concerns it is therefore important to conduct a stakeholder analyses.

Households of group I, who are less affected by the project in terms of share of irrigated landholdings of total landholding seem to benefit most since no negative development of livelihood indicators could be observed. This indicates that these households are well adapted to the new technologies. Households of the second group who are medium affected by the irrigation scheme remain the poorest among all

households but benefited most in terms of income. Group III households who are strongly affected by the project seem to have fewer benefits from the project than the other groups.

The most striking observation of the assessment is an increasing income inequality in the second and third household group. Decrease of income inequality in order to avoid conflicts among farmers and between farmers and the Foundation should therefore be a major concern of the Dreyer Foundation. Focusing on actual needs of these household groups and providing better tailed support and enhanced participation might improve the situation. In terms of participation, farmers concerned perceive the co-operation with the Dreyer Foundation still rather as a dependency and an opportunity to extract resources than as a participatory development project. Enhanced participation more communication among the stakeholders is therefore inevitable to meet the objectives of the Moutori dam project and to further strengthen the livelihoods of concerned farmers.

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