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Promoting Value Chains Impacts through Sedentary Based-Cropping Systems

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Abstract: ***Traditional cropping systems (shifting cultivation and slash-and-burn) contribute to the deforestation, land degradation and low agricultural productivity. Alternative systems emerge with combined efforts of smallholder farmers and researchers in the Sudan-Guinean zone of Benin. The study promotes value chains (sedentary-based cropping production settled marketing through the storage and processing) and impacts. Results show Increase of cropping systems productivity (healthy seeds yam production by minisetts technique, 10 t - 33 t/ha yam yield fresh matter, return on investment (20-60%), tubers storage for at least 7 months, tuber processing into pounded yam improved varieties of yam with good organoleptic quality , tuber processing with mechanical slicer in dried tubers (chips without aflatoxine attacks) with social and environment impacts.***

Keywords: Benin, Public-private partnership, sedentary-based cropping systems, Value chains, Yam

1. Introduction

In West Africa and Benin in particular, the traditional cropping systems (shifting cultivation and slash-and-burn) contribute to the deforestation, land degradation and low agricultural productivity.

Benin according to the FAO is one of the countries with a high rate of deforestation (22 000 ha corresponding to 21% of cultivable land). This rate of anthropogenic pressure on forest and soil resources is one of the strongest in the region, as a result of aggression associated with agricultural activities, livestock rearing, uncontrolled logging, and criminal wildfires (FAO, 2002). 62% of cultivated land in Benin is declared degraded.

Yam cultivation is one of the main causes of deforestation in West Africa. Some species such as *Vitelleria paradoxa*, *Parkia biglobosa* are endangered despite their socio-economic interests. Trees are exploited for multiple domestic and commercial purposes (wood energy, coal). From 1990 to 1995, Benin lost 298,000 ha of its forest cover, which corresponds to an average loss of about 60,000 hectares of forest per year (Sinsin and Kampmann, 2010). Thus, the forest area per capita of 1.63 ha in 1980 is passed to 0.87 ha in 1995, and is expected to reach 0.29 ha by the year 2025, if current trends continue (Schmidt-Soltau and Alimi, 2008). This loss of Habitat added is proportionally losses of species. In addition, deforestation in the tropics that is 60% due to agriculture by clearing burn directly releases 40 to 50% of the total carbon through burning of biomass (FAO, 2002). It follows as consequences of carbon emissions contributing to global warming of the Earth; it is likely the basis of climate changes characterized inter alia by the seasonal variability of precipitation (i.e. the delayed rains, the more or less long drought) and floods. In these cases, there is degradation of biodiversity (Dansi et al., 2003). Promoting soil fertility restoration technologies is therefore clearly an emergency in yam-growing areas long considered as being unaffected by the problems of availability of cultivable land. Research activities are oriented towards cropping systems that combine fixing agents, protection and recycling to avoid both a set-aside too long than one climbing in the means applied to maintain production. The alley cropping with *Gliricidia* system has implemented in research centers and was transferred in rural areas (Kang and Reynolds, 1986). But the adoption rate was low. The practice of alley cropping system is binding according to end-users, especially with regard to competition between tree-crop and labor for the clipping. Participatory research has also improved the system in Benin. Alternative sedentary based-cropping systems for enhancing the agricultural productivity and safeguarding forests emerge through the combined efforts of smallholder farmers and researchers in the Sudan-Guinean zone of Benin.

This study aims at promoting value chains (sedentary-based cropping production settled marketing through the storage and processing) and impacts.

2. Literature Survey

Agroforestry is thought to have the potential to improve soil fertility through the maintenance or increase of soil organic matter and biological nitrogen (N2) fixation from nitrogen fixing tree species (Nair et al., 1999). Biologically, agroforestry species that replenish soil fertility have the potential to reverse soil fertility decline, thereby increasing crop yields. Various studies have shown the potential of agroforestry as an approach to sustainable agriculture production and soil management, especially in the tropics (Nair et al., 1999). However, adoption of agroforestry technologies has generally been low (Maliki et al., 2012b).

It is well-known today that smallholders deeply readjust technologies developed in close relationship with researchers when confronted with various constraints (land, soil quality, labor, cash, etc). A first range of adaptations was implemented by smallholders in the Guinea-Sudan zone of Benin. This is focused on alley cropping system but included farmers criticisms and adaptations in order to develop a new range of technologies. The density of shrubs was reduced in order to reduce the labour required for repeated coppicing and herbaceous (legumes, graminaceous or crops) were included in the rotation cropping systems with yam in order to maintain soil fertility. In the agroforestry-yam based system at the end of the rotation, the plot remains under fallow during a few years before being cleared for yam and *Gliricidia sepium* usually grows to medium-sized shrubs.

Innovation is part of the promotion of the value chains (sedentary based cropping systems production settled marketing through the storage and processing). This concerns sedentary cropping systems technologies and the management modes integrating trees/shrubs/herbaceous in a dynamic of rotation with seasonal or annual crops (yam in particular).

3. Methodology

3.1. Study sites and experiment design

The study was carried out in the Guinea-Sudan transition zone of Benin (centre of Benin) in four sites: Miniffi (District of Dassa-Zoumè), Gomè and Ouèdèmè (Glazoué), Akpéro, Gbanlin and Malété (Ouessè) with latitudes 7 °45 ' and 8 °40' North and longitudes 2 °20 ' and 2 °35 ' East.

3.2. Yam tasting test

The tasting test was conducted at Miniffi and Akpéro for the evaluation of the organoleptic quality of the crushed yam for the varieties TDr 205, TDr 747 and Laboco).

3.3. Production technique of yam chips using the mechanical slicer

The mechanical cutting test with the slicer was carried out with the processor groups of Ouèdèmè (Glazoué) and Maléte (Ouessè) with the varieties of yams Florido, D. alata local, Gnidou and Kokoro.

4. Results and discussion

Increase of cropping systems productivity (healthy seeds yam production by minisetts technique, 12 t-33 t/ha yam yield fresh matter, return on investment (20-60%)) with herbaceous and or agroforestry systems (Table 1 and Figure 1), promotion of post harvest technologies (well pounded-yam quality with improved yam varieties (Tropical *Diocorea rotundata* TDr 747, TDr 205), tubers storage for at least 7 months with improved barn and sale at a keen price, pounded yam improved varieties of yam with good organoleptic quality, tuber processing with mechanical slicer in dried tubers (chips without aflatoxine attacks), clear and tender paste from the chips flour), handbook production process for technologies knowledge diffusion (Pictures 1-7).

The mechanical slicer is a material that has a number of strengths including its robustness, the possibility of local manufacturing, ease of transport and affordable price (between 35000 F to 75000 F). It improves the shelf life and increases the market value of yams.

The benefits taking into account different links from production to yam processing and other products of agroforestry systems are manifold and diverse: integration of the organic matter provides new ways to capture and to conserve nutrients and improve crop production (Maliki et al., 2016).. Rotations with legumes improve the physicochemical properties of soil and show higher productivity of land, labor and capital than traditional systems, except the agroforestry systems with *Gliricidia* (for example) demanding more labor in comparison with traditional slash-and-burn of natural forest fallow. Productivity of labor in the agroforestry system is higher than those herbaceous legumes-based cropping systems but less than the labor productivity in the traditional slash-and-burn-clearing forest fallow (Maliki et al., 2012a, 2012b). Progressively, smallholders deeply readjust; adapt technologies developed in close relationship with researchers when confronted with various constraints (land, soil quality, labor, cash, etc).

Technologies including off forest multipurpose trees (*G. sepium, Moringa oleifera, Jatropha curcas, Anacardium occidentale, Vitelleria paradoxa, Parkia biglobosa*...) with an adapted density could be used with herbaceous/forage legumes (*A. histrix, Mucuna cochinchinensis, Centrosema pubensis, Stylosantes guianensis*…) or grass in a dynamic rotation with seasonal or annual crops (maize, soybean, yam, cassava, potato, rice, cotton). Adapted agroforestry systems can include animal or mechanic traction, crops and livestock integration to ensure a consensual and sustainable management of agro-pastoral resources.

The application will allow to natural resources better preserved, agricultural production to be diversified, plant biodiversity to be better conserved access of smallholders to land resources to be improved, as well as their capacity to manage these resources, bio fuel and multiproduct to be promoted. In minimizing slash-and-burn and shifting cultivation practices by sedentary cropping systems or conservation agriculture.

These improved rotations with the “value chain” method are to contribute to the improvement of food security in the community, and for the additional incomes of smallholder farmers in rural areas and urban zones, in particular the poor and the women. Further, they contribute to reduce greenhouse gas emissions in land/soils related processes, or increase soil capacity to act as a carbon sink. *Jatropha curcas (rustic plant)* and other agro-forest trees, apart from their organic fertilizer supply and nutrient recycling role, control soil erosion. Indeed, the fruits of *Jatropha curcas*, particularly, contribute to Raw Vegetable Oil (RVO) which can be used directly in the diesel engines adapted in particular because of its relatively high viscosity. This bio diesel (or bi ester) does not contain sulphur, is not toxic and is highly biodegradable. The oil cakes obtained after extraction of vegetable oil can be used to produce biogas (methane). Methane can supply a thermal station (production of electricity) and CO_2 released can also nourish the micro algae's.

5. Conclusion

The study highlights the promotion of the value chains through sedentary-based cropping systems with enhancement of productivity (healthy seeds yam production by minisetts technique, 10 t-33 t/ha yam yield fresh matter, return on investment (20-60%), tubers storage for at least 7 months, tuber processing with mechanical slicer in dried tubers (chips without aflatoxine attacks)) with social and environmental impacts. With the "value chain" method a more sustainable approach is available that contributes to better preservation of the natural resources, the diversification of agricultural production and better conservation of plant bio-diversity, all important to leave an intact environment to our children. The dissemination of adapted systems requires further synergy between smallholder farmers, Research-Development, extension structures and private sectors.

6. Future Scope

More focus on sedentary-based cropping, crop-livestock integration, post-harvest technologies and extensions including storage, conservation, processing (chips, biofuel, juice, vegetable oil, butter, mustard, biscuit, SOAP, jam, ointment, biofertilizing, bioherbicide, biopesticides, etc.; green warrantage through multi-stakeholder platforms to facilitate green credit inputs and market regulation.

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Author Profile

Raphiou Maliki is an Agronomist, with a PhD in Natural Resource Management and Conservation in West Africa. He is Coordinator of Research and Development (R-D) in INRAB (National Agricultural Research Institute of Benin). Interim Director of CRA-Centre (Agricultural Research Center) of INRAB, and Administrative and Technical Chief of CRA-Centre. ICRA Expert 1999 (International Center in Agricultural Research for Development), National consultant FAO (Food and Agriculture Organization of the United Nations) of the Project TCP/BEN/3002 (A). Winner of The national Energy Globe Award Benin 2014 awarded to the project ("Solar Systems for Energy Self-Sufficient Households"), member of PAEPARD and CGIAR networks. Roots and Tubers Expert for the Green Innovations Center (CIVA) of AfricaRice/IITA Benin (International Institute of Tropical Agriculture). Worked in close relationship with CIRAD (International Centre for Cooperation in Agronomic Research for Development). Author of several articles in the Integrated Soil Fertility Management and Conservation, Adapted agriculture to climatic changes, speaks French and English. Fields of research (agroforestry systems, sedentary-based cropping systems, cover cropping systems, organic/biological/ecological agriculture, cashew plant breeding and management systems, Agro pastoral conflicts prevention and management, Climatic Changes, Green/Renewable Energy, Value Chains Productivity).

Denis Cornet, Ecophysiologist agronomist and researcher at CIRAD. For 10 years. He has been working on the understanding and improvement of yam based farming systems. He was in post for nine years at the International Institute of Tropical

Agriculture (IITA) in Benin as head of the Yam Research Coordination Unit. Since August 2010, he is hosted by INRA (UR Astro) as a CIRAD researcher on yam ecophysiology. My research focuses on the design of sustainable cropping systems and the analysis and modeling of the operation of these systems.

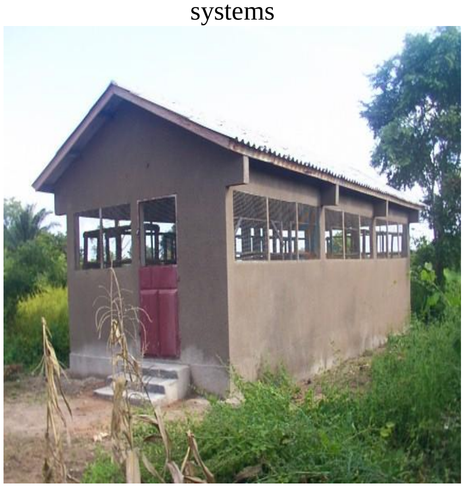
Brice Sinsin is a Beninese academic born March 3, 1959 in Djidja, in the Zou department in the south of the country. Engineer agronomist training, teacher-researcher specializing in natural resources conservation, crowned "best African scientist" in 2017, he was rector of the University of Abomey-Calavi from December 30, 2011 to December 18, 2017. The author of several scientific publications, his areas of expertise are: Development of natural pastures, Management of fodder resources, Agroforestry based on local or exotic species, Multipurpose management of protected forests, Protected Areas Management (State or Village Forests, National Parks, Game Zones, Community Management Areas), Wildlife Enumeration, Participatory Wildlife and Habitat Management (Bio-monitoring), Environmental Impact Assessment of Projects rural development. Several awards have been awarded: 2012: World Quality Commitment Award in Paris in the Gold category, 2013: World Quality Commitment Award in Paris in the Platinum category, 2014: The New Era Award for Technology, Innovation and Quality, 2014: West and Central Africa Council Award for Agricultural Research and Development (CORAF / WECARD), 2014: "Best Practices 2014" Award, 2015: "World Leader Business Person", 2017: Best Scientist Award Africa for the year 2017.

Picture 1: Slash and burn, shifting traditional yam-based cropping systems

(a) Maize+*Aeschynomene histrix* +*Gliricidia sepium*-yam rotation with early fire of shrubs (TMAGB). The *Gliricidia* coppice regenerates after shrubs incineration with around 97% rate.

(b) *Andropogon gayanus* natural fallow +*Gliricidia sepium*-yam rotation

Picture 2: Smallholders' adapted sedentary agroforestry systems



Picture 3: Partial view of storage barn for yam

Picture 4: Evaluation before pounding

Picture 5: Evaluation during pounding

Picture 6: Evaluation by tasters

Table 1: Tasting test result at different sites

Variety	Miniffi site November 29, 2005	Miniffi site November 30, 2005	Akpero site December 1er 2005
Laboco	Easy to pound, very good pounded yam	Very elastic crushed Yam very elastic, very appreciated	Good yam crushed elastic and very well
TDr 747	Easy to pound; good elastic crushed yam	Good crushed yam elastic	Crushed yams of average quality; good; takes little water
TDr 205	Good to pound; but less than (Laboco and TDr 747)	Good pounded yam; close to Laboco	Very good elastic pounded yam
TDr 95/18544	Less good crushed yam; not elastic; best for boiled yam	Bad yam pounded	Yams pounded quality less than acceptable
TDr 95/19158	Bad yam crushed; not elastic; do not take hot water	Passage pounded; does not take enough water	Good classic pounded yams; takes enough hot water

Picture 7: Partial view of yam processing activities in dried tubers (chips)