Sustainable Production and Utilization of Underutilized Nigerian Vegetables to Enhance Rural Food Security

Project Number 106511 (001-004)

Location of Study: Nigeria

Research Institutions:
Obafemi Awolowo University, Ile-Ife, Nigeria,
Osun State University, Osogbo, Nigeria
Cape Breton University, Sydney, Canada
University of Manitoba, Winnipeg, Canada

Final Technical Report

March 2011 – August 2014

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Names of Team Members: See Annex 1

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List of acronyms

1. UIV or UIVs= Under-utilized indigenous vegetable(s)
2. BMP= Beneficial Management Practices
3. NICANVEG= Nigeria-Canada Vegetables Project
4. OSU= Osun State University, Osogbo
5. OAU= Obafemi Awolowo University, Ile-Ife
6. UofM= University of Manitoba, Winnipeg, Canada
7. CBU= Cape Breton University, Sydney, Canada

1.0 EXECUTIVE SUMMARY

Nigeria, with approximately 174 million citizens, is the most populous country in Africa and the seventh most populous country in the world. The South western region of Nigeria with about 45 million inhabitants is mostly agrarian with about 65% resource-poor population living in rural areas and depending on under-exploited indigenous edible vegetables (UIVs) for daily supplies of nutrients, vitamins and other nutraceutical. Since these indigenous vegetables had not been a subject of organized research, this research project was initiated with the goal of developing new technologies to improve farming practices, post-harvest handling and value addition for these indigenous vegetables which offer great opportunities for food security and economic empowerment of the poor rural population, especially the resource-poor women farmers.

During the last 42 months our team (NICANVEG – Nigeria-Canada Vegetable Project) has conducted innovative research and public awareness and is pleased to present the following Key "take-away" messages from this study (Project 106511):

1. More than 1405 farmers (~51% women) in southwest Nigeria have adopted many innovative farmer-friendly agronomic technologies developed by this project for growing UIVs.
2. Yields of UIVs have increased by 30-50% and the cultivated area has expanded from 1.4ha to 30.6 ha during the 42 months of this project.
3. Consumer demand for UIV's has increased greatly as a result of our Radio and TV programmes which are estimated to reach about 4.0 million listeners daily. Supply of UIV cannot meet the demand and prices in the market place are high.
4. Incomes have increased for marketers and farmers who are now reporting incomes of as much as US$ 4531/year compared to US$ 1994/year pre-project and they are adopting a new savings culture to manage this additional income.
5. New and innovative food products such as UIV-fortified cookies have been developed and a prototype portable charcoal heated dryer has been tested providing value added processing options and potential new jobs and market opportunities.
6. Farmers, concerned about sustaining UIV production have formed associations and registered as 22 cooperative groups, with some 1405 members (50% women) to facilitate better access to credit, inputs and opportunities for collective marketing.

The Research Task Teams, partners and collaborators have achieved all of the milestones established for the project and have made significant progress towards the intermediate outcomes of awareness, value addition; agronomic beneficial management practices (BMPs) and market analysis.

The Baseline Survey provided a platform for identification of under-exploited indigenous vegetables in four target States (Oyo, Osun, Ondo and Ekiti) where researchers successfully interacted with 1,800 gatherers, 1,440 marketers and 3,600 consumers, in 72 locations. Eighteen (18) under-exploited indigenous vegetables were identified in the survey, from which 6 high premium vegetables were eventually selected for detailed agronomic and food quality studies. Field studies were conducted at 16 locations on farmers' land. The six (6) UIV species selected were: *Telfairia occidentalis* (Ugu), *Solanum macrocarpon* (Igbagba), *Amaranthus viridis* (Tete atetedaye), *Solanum nigrum* (Odu), *Solanum aethiopicum* (Ogunmo), *Solanecio biafrae* (Woorowo). Farmers have readily adopted newly recommended agronomic practices (BMPS for both rainy and dry seasons) such as raised rectangular

seed beds, seed drilling, a seeding rate of 4 teaspoons of seed per 6 m^2 plots, shading for *woorowo*, staking for *ugu*, split applications totalling 80 kg/ha Urea N fertilizer for most UIVs, multiple harvesting options for *igbagba*, *ugu*, *ogunmo* and *woorowo*, seed treatment, staking technology, dormancy breaking technology for *igbagba*, and botanical pest control. Throughout the field studies, the research team engaged the services of FADAMA, an extension agency of the Federal Government Ministry of Agriculture in each of the four States.

The land area seeded to UIVs has increased from 1.4 ha at project inception to 30.6 ha at project end after 42 months. This is largely due to the increase in number of participating farmers from ~200 at project inception to ~1405 (50% women) in July 2014. The total production of *Ugu*, *Igbagba*, *Tete atetedaye*, *Woorowo*, *Ogunmo* and *Odu* has increased significantly by 62%, 67%, 60%, 100%, 64% and 100%, respectively as a result of cumulative effects of the recommended BMPs, extension expertise and the physical and financial resource inputs provided by this project. The farmers are now reporting increased incomes of as much as US$ 4531/year compared to US$ 1994/year pre-project. They are also adopting a new savings culture to manage this additional income. The rate of adoption and expansion of land area under cultivation are strong indicators that scaling up of UIV production has very good potential. We estimate that during the course of the project, hundreds of farmers and urban dwellers have contacted our team by phone or in person for information, vegetable seed, training and/or seeking to join the research project.

Integrated research between agronomy and food science has documented the nutrient qualities of UIVs, developed processing and treatment options, and produced cooking and food preparation recipes for optimum retention of nutrients. This research has also resulted in "value-addition" with the introduction and testing of vegetable-fortified cookies with 2.5% to 4.5% sundried leaves of *Igbagba*. "Taste panels" consisting of both women and men farmers and their families, found that consumers would eat re-constituted sun-dried chopped green vegetables as part of their traditional daily dishes and even rated them as being better than the cookies made from plain wheat flour. Production of "UIV-fortified cookies" represents a potential new economic income option for commercialization and job creation either directly on the farm or in the local communities.

The project has also succeeded in strengthening the capacity and capability of the technical and scientific staff at both Nigerian and Canadian Institutions. Researchers from local governments as well as international universities have attended workshops, seminars and field days organized by members of our project team. As part of our communication strategy, our Team has produced an Outcome Story titled: "**Stories of Change: Nigerian women reap benefits from indigenous vegetables.**" This document was produced through the training on "**Communicating Research for Impact and Influence**" which was organized by IDRC in Pretoria South Africa (November 2013). Numerous invitations to publish and present our results and outcomes have been received from international institutions in South Africa, Kenya, Germany, Ghana, Ethiopia and Canada.

Our project has also achieved high-profile awareness at the local and regional policy levels as managers and government administrators in each of the four States have at one time or another attended field days, meetings and presentations showcasing the activities, results and recommendations derived the project. In addition to the project implementation workshop at OAU 2011, productive annual project review workshops have been hosted at Cape Breton University 2012, University of Manitoba 2013, and by the Osun State University, 2013, which gave opportunities for University and provincial administrators and researchers to attend and learn about the project. A total

of 294 farmers and scientists attended the OSU workshop along with Team members from the project, and Policy makers, including the Governor (Represented by the Special Adviser on Agriculture), the Chairman of the Governing Council, the Vice-Chancellor, the Director-General of National Biotechnological Development Agency (NABDA) and top FADAMA Officers from Osun, Oyo, Ondo and Ekiti States.

Our popular radio program, *Ramo Elefo* continues to air on four (4) FM Radio Stations which have signals that reach the inner communities of the savannah in Oyo, Ogun and Kwara States as well as the rainforest of Lagos State. An estimated 4.0 million people in southwest Nigeria listen to these programmes on daily basis. In addition, videos on BMPs have been produced for use as TV programs at Nigerian Television Authority, Osun Television and Oyo Television Service, and for farmer training in rural communities. For the wider public, we have developed 3 internet web sites as well as an on-line tool using Google maps to show the locations of project research. The map can be viewed at https://mapsengine.google.com/map/viewer?mid=zcxWntXGzW4Y.k_Db3XcZdeEc.

The original goal of this NICANVEG project was to investigate the Sustainable Production and Utilization of Underutilized Nigerian Vegetables to Enhance Rural Food Security and Incomes for Resource Poor Women Farmers. The UIV story extends from "Plot to Plate" (Plate 1). We have researched the resource and production issues, provided new beneficial management practices, developed new food products, changed farmer and consumer attitudes to growing, cooking and consuming UIVs through training and gender equity analysis, and assessed new marketing and proposed potential new agri-business and job opportunities through this IDRC-DFATD sponsored project. Collectively the Teams have provided a conclusive "proof of concept" that UIVs can be economically and sustainably produced, processed and marketed to improve the diversity of foods and nutrition as well as incomes for resource poor women farmers, their families and rural communities in Southwest Nigeria.

Plate 1. Summary of NICANVEG project, "From Plot to Plate", UIVs for food and income security.

2.0 THE RESEARCH PROBLEM

In Nigeria the majority of those who produce the country's food are the 65% small scale rural farmers who depend on natural resources. They comprise mostly women who play a major role in the production, processing and marketing of food crops. Information on global food production shows that Nigeria, at the current level of population growth and food consumption, will have to increase food production by 300% to provide "minimally" adequate diets for the more than 300 million people projected by 2050. Most small scale farmers in Nigeria are poor and lack the resources to purchase highly nutritious food items (egg, meat and milk), thus many rural dwellers resort to the gathering of indigenous vegetables, leaves and fruits for food and nutrient supplies. Most of these indigenous vegetables gathered from the wild remain largely unknown because organized research systems have not recognized or given these species priority for crop development as a source for improving human nutrition and enhancing farmers' income. It is widely acknowledged that the poor rural women are the custodians of gathering, utilization and preservation of the underutilized vegetables.

In southwest Nigeria, farmers, marketers and consumers of under-utilized vegetables have identified numerous production constraints that militate against the cultivation of several of these indigenous vegetables. These constraints include lack of planting materials, lack of production information, lack of government support, the psyche of consumers that discourage promotion of indigenous species, lack of awareness of the food value of the species and difficult production and maintenance techniques such as staking. The target singular goal of this project (2011-2014) is to profitably bring the wild under-utilized indigenous vegetables into cultivation. In this context, the CIFSRF project on "*under-utilized indigenous vegetables of southwest Nigeria"* aims to unleash the shackles that have prevented sustainable cultivation of selected indigenous vegetables. We initiated this project based on the broad hypothesis that under-utilized indigenous vegetables production and utilization will be a major stake in improving income; enhancing nutrition and technically boosting food security in the rural communities dominated by women farmers in southwest Nigeria. This funded research has addressed each of the above limitations for domestic production of UIVs. The objectives of this study were to develop science based recommendations and innovative technologies which will have wide application to Southwest Nigeria and beyond. Our results have confirmed that underutilized indigenous vegetables are rich in nutrients and nutritionally useful minerals and that cultivation and consumption of these UIVs is economically viable and will help alleviate the persistent problems of food insecurity and poor nutrition in the nation. This Final Report summarizes the progress, results and basic outcomes over the last 42 months of the research.

3.0 PROGRESS TOWARDS MILESTONES:

It can be noted that although the achievement of milestones did not always follow according to the original schedule, all project milestones have now been completed and are highlighted as follows. A list of science output publications is provided in Appendix 1 and the comprehensive documentation of milestones and accomplishments is presented as Appendix 1b.

Major Milestones	Key Accomplishment	Deliverables	Final Action
1. Report of the Inception workshop	Project Inception Workshop (PIW) was successfully held on the campus of Obafemi Awolowo University, Ile Ife, Nigeria between March 15 and 17, 2011.	A summary report was submitted to IDRC.	Report was submitted to IDRC on Oct. 17, 2011
2. Performance Measurement Framework (PMF) for the study	A description of the project Logic Model and Performance Measurement Framework was prepared based on the information provided in the original proposal to IDRC.	Submitted to IDRC.	Final revised version submitted to IDRC.
3. Monitoring and Evaluation Plan	M&E plan based on Logic model and PMF - The M & E was developed and was submitted to IDRC in March 2012.	Formulated and submitted	Submitted to IDRC
4. Research Implementation Plan	The Research Implementation plan was developed and was attached to March 2012 report.	Submitted with March 2012 report.	Submitted to IDRC
5. Gender Equity Assessment Framework	The gender equity assessment framework (GEAF) was developed. The gender gap principles was utilized to determine and place the role of women in project implementation.	Report submitted to IDRC	The GEAF was submitted to IDRC
6. Communication strategy	The communication strategies were put in place in order to enhance extension of the project and its results to a wider audience.	A communications strategy was developed.	Submitted to IDRC
7. Agronomic study site selection	-Four field sites were selected per State -for the agronomic trials. Two sites were selected for advanced agronomic studies.	Name and location of sites identified.	Table of sites submitted in First Interim report Oct 17, 2011.
8. Purchase of Equipment	All equipment listed for laboratory and field investigations were purchased by respective research components.	All the equipment were delivered, installed and calibrated and used.	Report submitted to IDRC
9. Baseline data collection on UIVs	Baseline data collection was achieved through the use of a structured questionnaire, focus group discussions and on – site	Baseline report was submitted to IDRC	Baseline report was submitted. Journal

	assessments. The team successfully interacted with 4,600 respondents made up of gatherers, marketers and consumers.		publications have been produced.
10. Development of GIS-linked database on UIVs	Data of the baseline study were organized and uploaded into a standardized GIS-linked database.	A structured database is available-.	GIS linked database is completed
11. Gender disaggregated baseline databank on the management of UIVs	A gender disaggregated databank on the occurrence, geographical distribution, socio-cultural factors influencing the consumption and cultivation of UIVs was produced.	Data bank available for query and data mining.	Database completed and launched
12.Recruitment and training of Graduate students/scientists:	10 Nigerian scientists and students actively involved in the study visited the University of Manitoba and Cape Breton University in April 2012 and May 2013.	Activity completed.	Report of the completion of visit was submitted to IDRC.
13. Training of Nigerian researchers in two Canadian Universities	This scheduled training was temporarily delayed due to logistics of availability of trainees, accessing travel visas, and accommodation arrangements in Canadian Institutes		All scheduled training was competed in 2013.
14. Dissemination and uptake of research Results. Communication strategy	Daily radio programmes tagged Ramo Elefo was aired on FM Radio Stations (89.5, 98.5 FM) at 8.30-8.33 am. Three internet sites were launched and populated with project activities.	DVDs, posters, journal publications, monographs, newsletters and briefs were produced.	A comprehensive communication strategy submitted to IDRC was developed and implemented.
12. Annual meeting to review progress for 1st year of studies.	We held the first year meeting at the Cape Breton University to review the progress made in year one of the project.	First year technical report.	Documentation submitted to IDRC after Year 1.
13. Selection of 5 UIVs using standardized criteria, multi-dimensional analyses.	Using some rigorous criteria, the following six (6) UIVs were selected as high premium species: *Telfairia occidentalis* (Ugu), *Solanum macrocarpon* (Igbagba), *Amaranthus viridis* (Tete atetedaye), *Solanum nigrum* (Odu) , *Solanum aethiopicum* (Ogunmo), *Solanecio biafrae* (Woorowo).	BMPs, journal articles. Outcome story, Factsheets.	Basis of selection was submitted to IDRC as Annexe to interim technical report.
14.1st on-farm trials on seeding population, seeding method, cutting length etc.	A total sixteen sites (16) were selected in the rainforest and savannah zones of four States (Oyo, Osun, Ondo and Ekiti) for the investigations.	BMPs, factsheets, VegNews, journal articles. Outcome story, Factsheets.	Factsheets and Vegnews were published and submitted to IDRC.
15. Production of extension monographs and factsheets	Fact sheets describing the agronomic beneficial management practices (BMP's) for the selected UIVs were produced and distributed.	Factsheets, VegNews, internet information. Journal articles	Report submitted to IDRC.

16. Training of farmers (50% women) on BMPs of UIVs	The farmer training component was completed.	Farmers have confirmed the positive effects of our training.	Documentation submitted to IDRC.
17. Training of Nigerian researchers in Canada	Training of 10 Nigerian researchers in Canada Universities was successfully completed.	Trainees contribute more to project.	Trainees contributed more to research
18. TV and radio drama series and jingles to create awareness of UIVs	The communications strategies implemented are: (a) 3 internet web sites, (b) multimedia – daily radio and weekly TV broadcasts, (c) publications (d) direct interaction.	Awareness creation for community involvement.	Radio and TV jingles continued.
19. Mid-term meeting to review progress and results,	The second annual progress review workshop was held between the 13th and 16th May 2013 in Winnipeg Manitoba. Hiring of a Project Manager, to manage the Project from July 2013 to 2014.	Revised budget and new MGC was produced and signed.	All of the decisions implemented.
20. Development of agronomic package for ten (10) underutilized vegetables of Nigeria.	We developed a suite of comprehensive beneficial management packages (BMP) for the ten (10) UIVs.	Full report submitted to IDRC.	Publications submitted to IDRC
21. Value-addition for the underutilized vegetables	Production of a video describing the preparation and processing of UIVs for consumption was used to inform women farmers, on methods of drying, cooking and preserving nutrients. Cooking trials and taste panels were conducted.	Cooking video available. Also, posters and papers have been prepared	Training successfully completed.
22. Increased awareness	Daily radio jingles/programs continued and a new TV program was initiated. A “pin-wheel” map of site locations is now available on Google maps.	All programmes fully implemented.	Documentation submitted to IDRC.
23. Mid-term review of the project and third annual meeting	A productive annual project review workshop was hosted by Osun State University, Dec 1-8, 2013.	Workshop report	Submitted to IDRC.

4.0 SYNTHESIS OF RESEARCH ACTIVITIES AND RESULTS

To view a comprehensive pictorials of all the project activities that are discussed and described under this section, the reader can access https://www.flickr.com/gp/92096525@N04/gJ8p11/ . The IDRC coordinated the photo-shoot which produced all photographs in the photo gallery.

4.1 Baseline information: Assessment of the pre-project conditions and farmers capacity for growing under-utilized indigenous vegetables

Baseline data (collected in 2011) indicated that the UIVs were rarely routinely grown for several reasons including lack of planting materials, lack of production information, lack of access to resources, lack of government support, the psyche of consumers that discourage promotion of indigenous species, lack of awareness of the food value of the species and difficult production and maintenance techniques such as staking. Thus UIVs were infrequently consumed since it meant gathering them from the wild. At commencement (2011), the apathy shown towards the project was reflected in the few numbers of farmers (148) interested in participating in the project (Table 1). However, by the end of the fourth year (2014) a total of 1405 farmers (51% women) had become active participants and readily organized into 22 registered and functional Cooperative Associations. In 2011 (pre-project baseline data) a total of 0.3ha, 0.2ha, 0.6ha, 0.0ha, 0.32ha and 0.00ha (totalling 1.4ha) were planted to *Ugu*, *Igbagba*, *Tete atetedaye*, *Woorowo*, *Ogunmo* and *Odu* respectively, whereas in 2014 (4th year), we recorded 10 ha, 6.8 ha, 6.3 ha, 2.3 ha, 2.8 ha and 2.4 ha (totalling 30.6ha), respectively, representing 20-fold increase in land area (Table 2). The comprehensive distribution of farmers by gender and land area under UIVs at each location is presented as Appendix 1c. Details of the impact of farmer-friendly project technologies on total productivity of the UIVs as shown in Figure 1and fully discussed in our publication Alao *et al.* (2014).

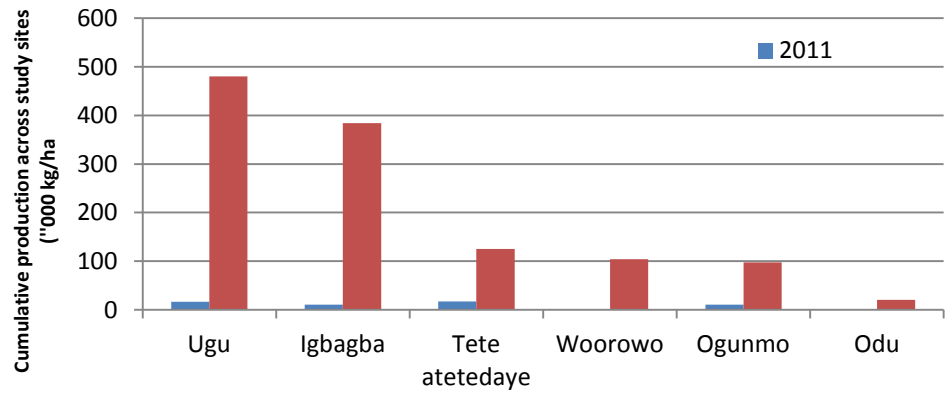

Fig 1: Total production of the vegetables at project commencement (March 2011) and present (July 2014)

4.2 Enhanced productivity of under-utilized indigenous vegetables through development of beneficial management practices

4.2.1 Basic Agronomic Trials:

In late 2011- late 2012 Research on optimum seeding density, seeding method, cutting length, staking technology and shading option were conducted at 16 locations (8 rainforest sites and 8 derived savannah sites) in Oyo, Osun, Ondo and Ekiti States. The studies were conducted during the rainy

season and repeated during the dry season. On one variant of *ugu*, we investigated the effects of seasons and intra-row spacing (Spacing 1 =0.5 m x 1.0 m, Spacing 2= 1.0m x 1.0 m and Spacing 3=1.0 m x 1.5 m) in combination with staking/non-staking in a factorial combination as a randomized complete block design (RCBD). Results (Figure 2) showed that in both seasons, staked plants produced significantly higher leaf yield compared to unstaked plants at all the spacings. Field observations showed incidence of leaf infection on unstaked plants resulting in poor leaf quality and this had negative effect on total marketable yields. In a situation of *ad libitum* water supply through irrigation, the leaf yield during the dry (late) season is numerically comparable to the leaf yield in the wet (early) season. Pronounced location-specific differences were recorded in the leaf yield of *ugu* as shown in Figure 3. It is also noted that the first harvest gave the highest leaf yield across the sites followed by successive declining harvest (Figure 4) but harvesting could continue for 8 months, taking place fortnightly. Details of our finding are published in Adebooye *et al.* (2014) and Idowu *et al*. (2014). Farmers claimed during baseline survey that they were not interested in planting *igbagba* because it took 30 days between planting and emergence. Our team conducted research on how to break dormancy in *igbagba* and found that soaking the seeds in water (40 °C) for 12 hours followed by immediate planting resulted in germination at 9 days after planting. This is a reduction of 66% of the time between planting and germination – resulting in quicker yields, earlier harvest, better use of moisture, and earlier sales in the market, and quicker incomes.

For *Tete* and *Ogunmo* we investigated the effect of seeding density, season and seeding method (drilling/broadcasting) on leaf yield. Our analyses showed that a spoonful of seed of *Tete* or *Ogunmo* contains approximately 280 seeds. Also during the baseline study we found that farmers were planting equivalent of 8 spoonfuls/6m^2 of land. On the farmers' farm at the 16 project locations, we studied drilling/broadcasting and two seeding rates (4 spoonfuls and 8 spoonfuls) in factorial arrangement using randomized complete block design. Results showed that a seeding density of 4 spoonfuls/6m^2 in combination with either drilling or broadcasting (Figures 5, 6) produced significantly higher leaf yields. Drilling or broadcasting differed only marginally but did not significantly affect the total leaf yields. However, drilling could be advantageous in terms of management of the field e.g. ease of harvesting, ease of pest and diseases control, ease of fertilizer application and ease of irrigation. We demonstrated that, given good water and fertility supply, there is no significant difference between leaf yield during the early and late season. Location did not affect the leaf yield of the *Tete* and *Ogunmo*.

Table 1: Number farmers and total land area under UIVs cultivation in each State

State	Total number of farmers * engaged at project commencement	Present total number of farmers growing UIVs	Total number of women UIVs growers	Total Area (m^2) of cultivated UIVs	
				Project commencement	Present
OSUN:	25	480	251	5500	80580
ONDO:	49	220	122	8060	76900
OYO:	49	570	264	420	80500
EKITI:	25	135	80	240	68160
	148	**1405**	**717 (51.0%)**	**14220 (1.42ha)**	**306,140 (30.6ha)**

Table 2: Current extent of each vegetable under cultivation at each of the States.

State	Ugu	Igbagba	Tete atetedaye	Woorowo	Ogunmo	Odu	TOTAL
	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)	(m^2)	
OSUN	32650	19050	17950	7800	9500	6000	92950
ONDO:	19500	17600	15900	6600	7300	5330	72230
OYO:	34750	18675	17975	5725	5725	8525	91375
EKITI:	13500	12500	11550	3250	5700	4500	51000
	100400 (10.0ha)	**67825 (6.8ha)**	**63375 (6.3ha)**	**23375 (2.3ha)**	**28225 (2.8ha)**	**24355 (2.4ha)**	**30.6ha**

*Limited cultivation of (ugu, igbagba, tete and ogunmo) before our project. There was no science backing the cultivation in terms of spacing, density and general management.

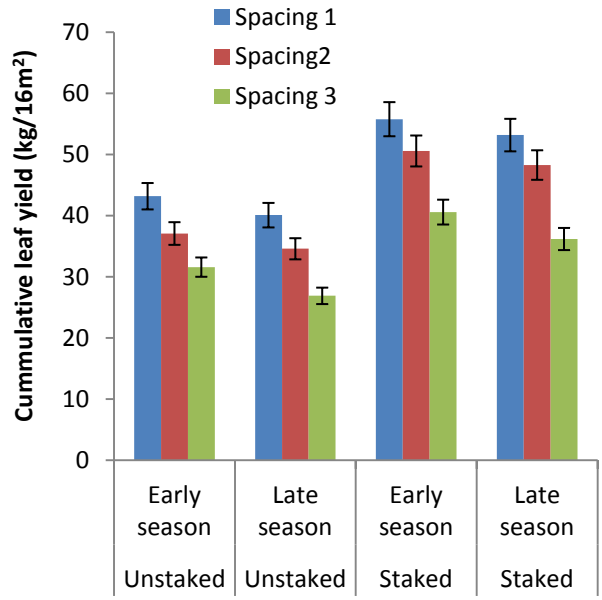

Figure 2: Cumulative leaf yield of *ugu* over 10 successive harvests

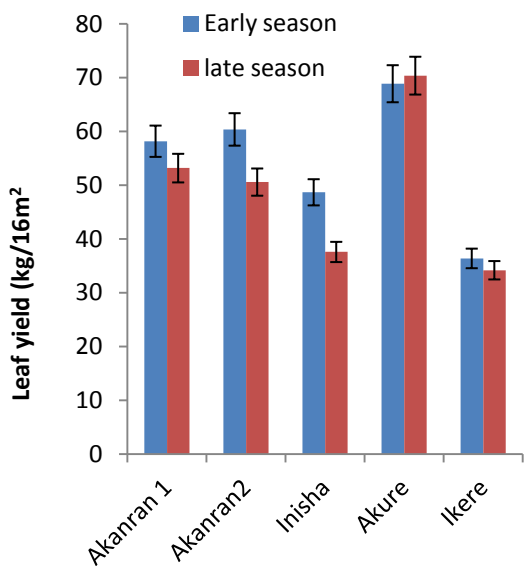

Figure 3: Selected location-specific cumulative leaf yield of *ugu*

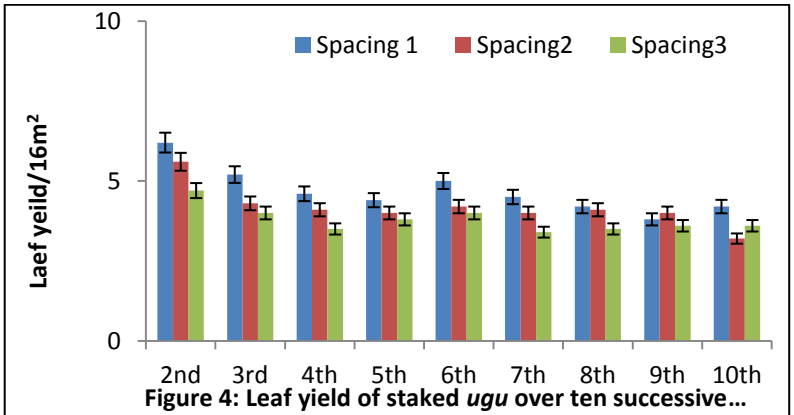

Figure 4: Leaf yield of staked *ugu* over ten successive…

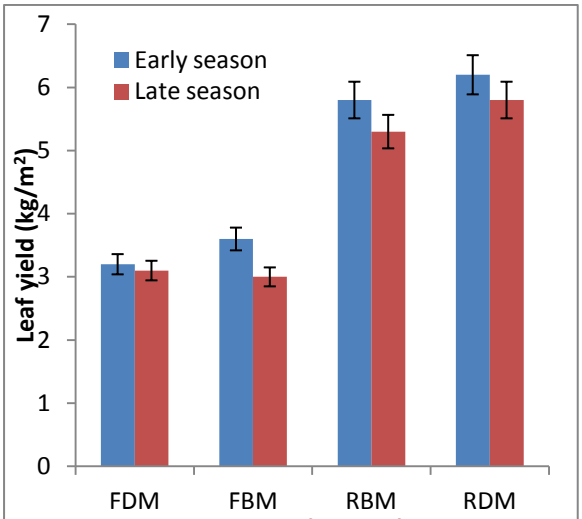

Figure 5: Leaf yield of *ogunmo* in the early and late season

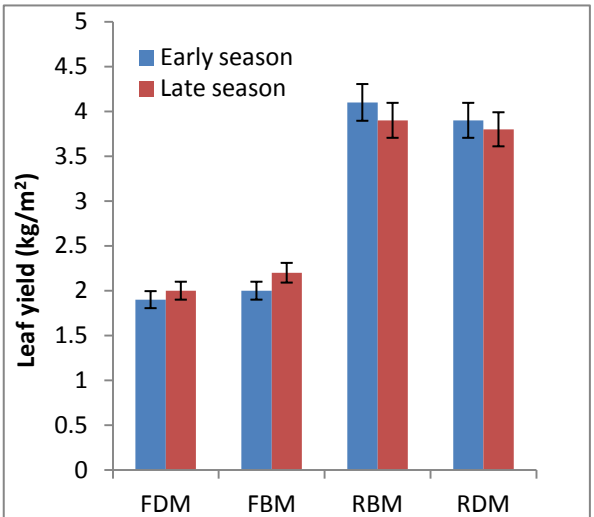

Figure 6: Leaf yield of *tete* during early and late season

The notations used in the Figures are FBM=Farmers seed rate planted by broadcasting, FDM= Farmers seed rate planted by drilling, RBM=Researcher seed rate planted by broadcasting and RDM= Researchers seed rate planted by drilling.

During the early and late seasons, at the 16 project locations, we showed that 4 spoonful seeding density/6m^2 is the optimum for *Igbagba* both in the early and late season (Figure 7) and that it is possible to harvest *Igbagba (and ugu)* repeatedly on fortnightly intervals (Figure 8) for up to 6 months with high quality retention but in real practice harvesting continues for up to 2 years during which the quality declines. The repeated harvesting schedule developed by this project, guarantees regular fortnightly income (Figure 9) for the farmers though income declines as the plant ages. This means that repeated harvesting is sustainable over a period of 6 months. As shown in Fig 7, cumulative leaf yield of *igbagba*, over the 10 successive harvestings was up to 40 kg/m^2 when we used Project 106511 seeding density (4 spoonful/6m^2) while under farmers' method (8 spoonful/6m^2) cumulative leaf yield was ~7.0 kg/m^2. The extremely poor yield from farmers seeding rate was due to overcrowding. We observed adverse physiological response of *igbagba* to overcrowding on the field.

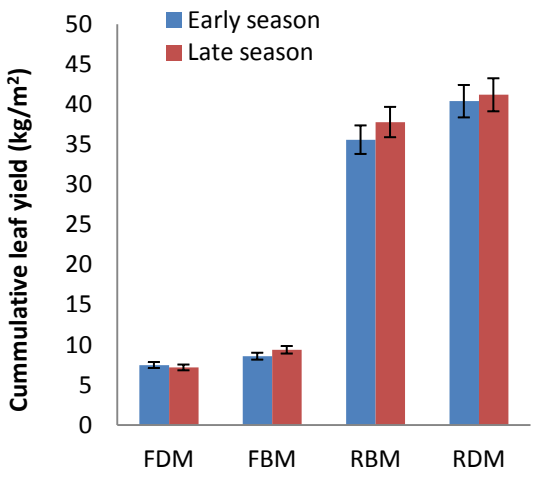

Figure 7: Cummulative leaf yield of *igbagba* over 10 successive harvests (kg/m²)

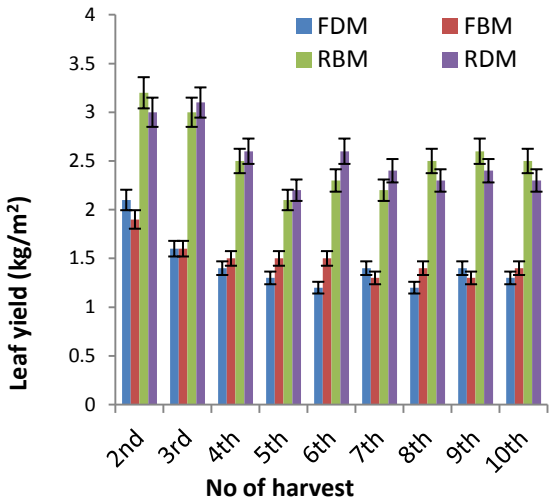

Figure 8: Leaf yield of *igbagba* over ten successive harvestings on fortnight basis.

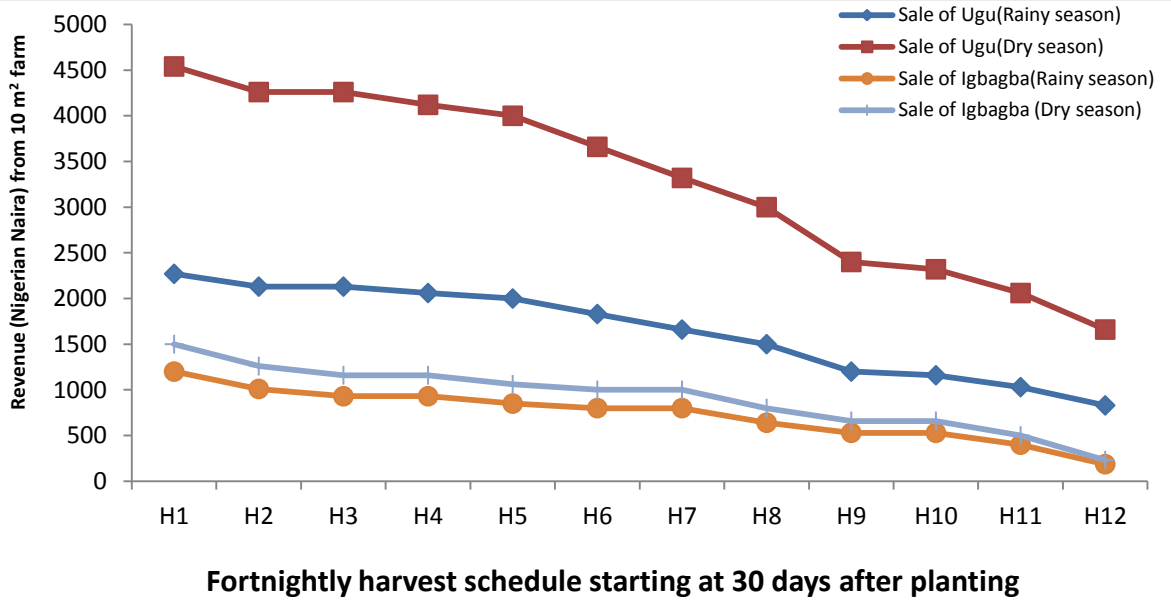

Figure 9*:* Revenue generated from sales of *Ugu* and *Igbagba* based on fortnightly harvesting over a six month period

On-farm studies showed that *Odu* produced a leaf yield of ~3 kg/m^2 at 5cm x 5cm (Spacing 1), ~4.5 kg/m^2 at 5cm x 7.5 cm (Spacing 2) and ˜4.7 kg/m^2 at 5cm x 10 cm (Spacing3) with no significant difference between leaf yields during the early and late season (Figure 10).

In the early and late seasons, we experimented with the possible propagation of *Woorowo* investigating the use of stem cuttings (10cm and 15cm long) and two spacings (50 x 50 cm and 50 x 60 cm) in two shade regimes (Shade 1 and 2) on leaf yield of *Woorowo*. The studies on woorowo, were conducted at six locations (Ilode, Inisha, Akure, Ogbomosho and Akanran). We used 1m x 4m beds and the experiment was a randomized complete block design in a factorial arrangement. We also carried 12 successive harvestings on fortnightly basis for 6 months. The cumulative leaf yield of *Woorowo* during the early season was significantly higher than during the late season (Figure 11)

across all the locations, even with irrigation. This therefore shows that early season weather favours the growth and performance of *woorowo* better than dry seasons. The leaf yields of plants under higher shade regime (Shade 1) in both seasons were higher than under lower shade (Shade 2). Leaf yield at cutting length 15 cm was higher than at cutting length 10 cm in both seasons. The work demonstrated that *woorowo* could propagated as against the old belief that *woorowo* could only be gathered from the wild in cacao plantation.

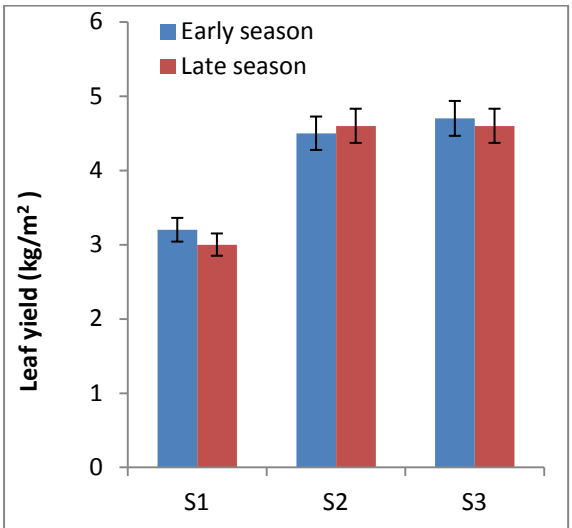

Figure 10: Leaf yield of *odu* across 16 locations

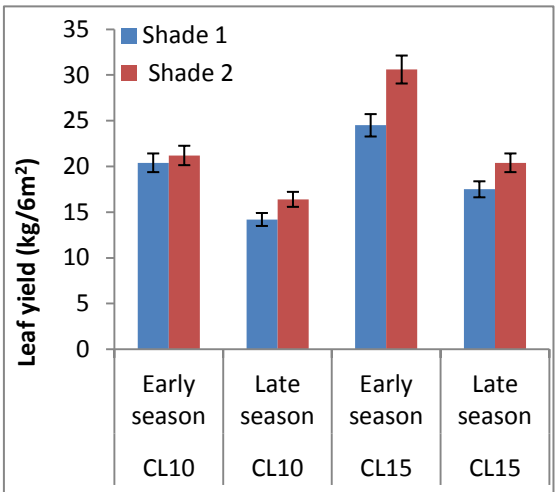

Figure 11: Cumulative leaf yield of *woorowo* over 12 successive harvest in two seasons

All these results are published as **Story of Change and can be accessed at (http://www.idrc.ca/EN/Documents/Nigerian-women-reap-benefits-from-indigenous-vegetables.pdf). It is also attached as Appendix 1a.**

4.2.2 Advanced agronomic trials

In the rainy and dry seasons of 2013, at eight locations (4 rainforest and 4 derived savannah), the Team conducted studies on the effects of Urea-N fertilizer rates on the leaf yield and SPAD chlorophyll index of six high premium UIVs (*Ugu*, *Tete atetedaye*, I*gbagba*, *Ogunmo*, *Odu* and *Woorowo*). The Urea-N fertilizer was applied at the rates of 0, 40, 80 and 160 kg N/ha in the rainforest and derived savannah locations. Biomass yield was optimum at 80 kg N/ha applied as split applications during the growing period for *Ogunmo*, *ugu*, *igbagba*, *Tete atetedaye*, *Woorowo* and *Odu* across all the locations. As shown in Figures 12-17 for *ogunmo*, *ugu*, *igbagba*, *odu*, *woorowo* and *tete atetedaye*, the Urea-N rate significantly affected the fresh leaf yield and chlorophyll index of all the vegetables with 80 kg N/ha recording significantly higher leaf yield which is about 20-60% higher than the control (0 kg N) and 25-50% higher than 40 kg N/ha, depending on the vegetable. Results showed sharp ecological differences in the yields of the vegetable crops in the rainforest ecology out-yielding the derived savannah ecology crops. The rainy season crop also numerically out-yielded the dry season crop irrespective of the ecology. Application of 160 kg N/ha has been shown not to improve the leaf yields of all the vegetables. The SPAD chlorophyll index which is directly related to leaf greenness increased with rate of N application, and peaked at 80 kg N/ha, in all the vegetables studied at both the rainforest and derived savannah ecologies. Since greener vegetables command better markets, an optimum N application rate to produce soil N content of 80 kg/ha is recommended for the studied UIVs. Our studies established 80 kg N/ha as the optimum for these indigenous vegetables in southwest Nigeria.

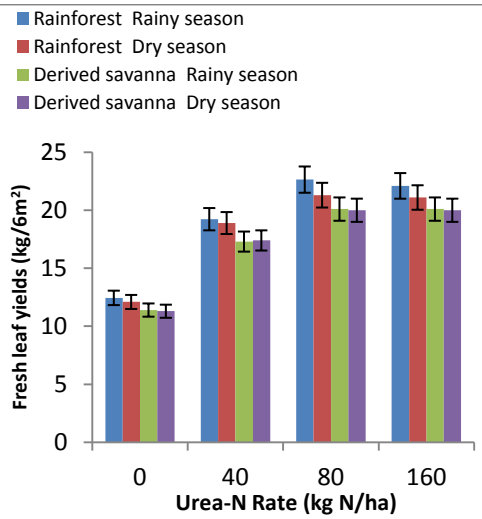

Figure 12: Cumulative fresh biomass yield of *Ogunmo* as affected by Urea-N rates across two agro-ecologies in southwestern Nigeria

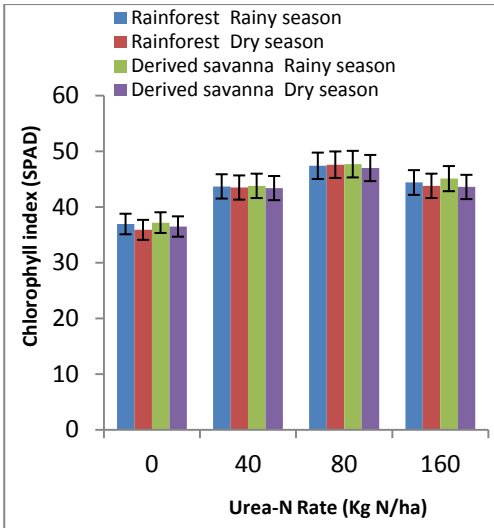

Figure 13: Chlorophyll index of *Ogunmo* as affected by Urea-N rates across two agro-ecologies in southwestern Nigeria

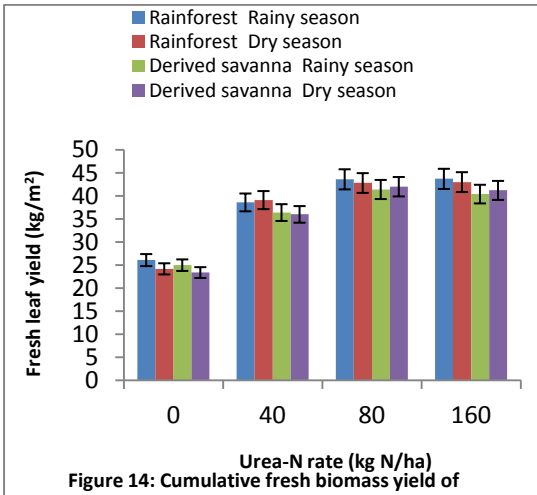

Figure 14: Cumulative fresh biomass yield of *ugu* in relation to Urea-N rates in two agro-ecologies in southwestern Nigeria

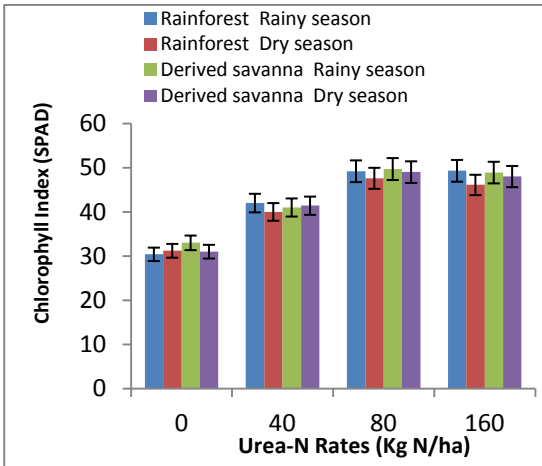

Figure 15: Chlorophyll index of *ugu* as affected by Urea-N rate across two agro-ecologies in southwest Nigeria

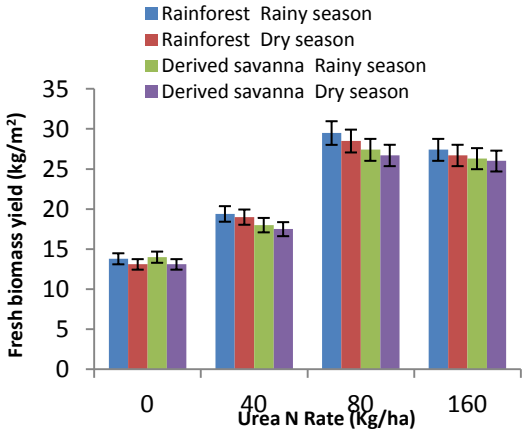

Fig 16: Fresh biomass yield of *igbagba* as affected by Urea N across rainforest and derived savannah ecologies

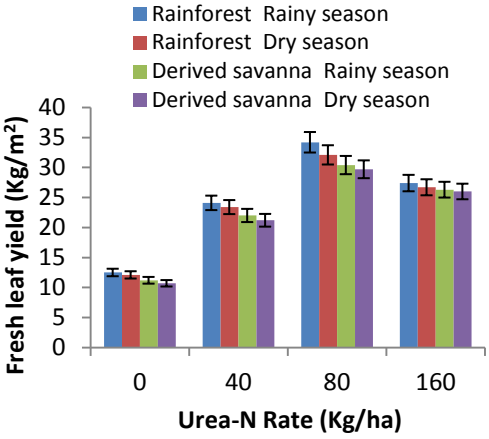

Figure 17: Fresh leaf yield of *woorowo* as affected by Urea-N rate acrosss two agroecologies in southwest Nigeria

4.2.3 Impact of the BMPs on cumulative revenue from UIVs

As a result of the development of BMPs and extensive training of the 1405 target farmers on seed bed preparation, optimum N fertilizer rate, optimum seeding population, seeding method, breaking of seed dormancy, staking option, seed treatment and botanical pest control, the project now has a total of 10 ha planted to *Ugu*, 6.8 ha to *Igbagba*, 6.3 ha to *Tete atetedaye*, 2.3 ha to *Woorowo*, 2.8 ha to *Ogunmo* and 2.4 ha to *Odu*, across southwest Nigeria (Table 3). The most popular of the vegetables across southwest Nigeria are *Ugu*, *Igbagba* and *Tete atetedaye*, which are consequently allocated largest land areas. As shown in Table 3, significantly higher leaf yields are recorded for the UIVs compared to the leaf yields at project commencement. Our results also show that the prices/Kg of the fresh leaves of UIVs increased by 36-56% within the first three years of project implementation. In 2013 and confirmed again in early season 2014, based on the total productivity of UIVs in southwest Nigeria (Table 3), we recorded a total sales of N84m (US$509090) for *Ugu*, N53.6m (US$324848) for *Igbagba*, N16.6m (US$100606) for *Tete atetedaye*, N13.9m (US$84242) for *Woorowo*, N7.5m (US$45454) for *Ogunmo* and N1.64m (US$9939) for *Odu* compared to pre-project sales records of N19.2m (US$116363), N10.1m (US$61212), N3.5m (US$21212), unknown, N1.7m (US$10303) and unknown, respectively. Details are discussed in Alao *et al*. (2014).

The Table 4 shows the influence of the project's seeding rate compared to farmers' seeding rate on total cost of seeds and productivity of the UIVs. Results show that the projects' seeding rate for *Ugu* increased by 58% while for *Igbagba*, *Tete atetedaye and Ogunmo* the rate reduced by ~50% and for *Woorowo* and *Odu* there was no information on the seeding rates because, farmers had never planted them and are both primarily gathered from the wild. The planting spacing developed by our project for *Ugu* is 0.25m x 0.5m (for leaf yield only) to give a population of 80,000 plants/ha while for *Igbagba*, *Tete atetedaye and Ogunmo* we recommend 250 plants/m^2 which is equivalent to one teaspoonful and this rate translates to a seed rate of 12 kg seeds/ha. The projects' seeding rate produced significantly higher leaf yields (36-100%) for all the UIVs compared to the previous farmers' seeding population. It is also noteworthy that prices of seeds have increased markedly between project commencement and now with *Ugu*, *Igbagba*, *Tete atetedaye Woorowo*, *Ogunmo* and *Odu* increasing by 62%, 57%, 57%, 100%, 42% and 100%, respectively. Experience has also shown that seed supply has not been able to meet the demand. As shown in Table 5, the use of botanical control of insects has significantly reduced losses suffered by farmers on the leafy vegetables. The project developed the use of Neem leaf extract which is applied as foliar sprays to control insect pests which has increased the yield, quality and acceptability of the UIVs especially *Tete atetedaye*, *Ogunmo* and *Igbagba*. The monthly income benefit realized from the use of this pest control method ranged between ₦352,000 and ₦2,352,000 per ha per month (Table 5).

Table 3: Comparative areas of land in cultivation, cumulative leaf yields and total production, price change and total sales for the six UIVs since project commencement March 2011 and the November 2013 - January 2014 period.

	Area Planted (ha)		**Cum. Leaf Yield (`000 kg/ha)$^+$**	**Total Production (`000 kg)$^+$**		**Price/kg (Nigerian Naira)**		**Total sales (`000,000 Nigerian Naira)**	
	March 2011	**Jan 2014**		**March 2011**	**Jan 2014**	**March 2011**	**Jan 2014**	**March 2011**	**Jan 2014**

Ugu	~0.30	7.56	55.5	16.5	420.0	120	200	1.98	84.0
Igbagba	~0.20	7.00	52.0	10.4	364.0	100	170	1.04	53.6
Tete atetedaye	~0.60	5.64	28.9	17.3	107.0	80	155	1.38	16.6
Woorowo	000	1.90	52.6	Unknown	99.9	90	140	Unknown	13.9
Ogunmo	~0.32	2.83	33.2	10.64	93.9	50	80	0.53	7.51
Odu	000	0.72	25.3	Unknown	18.21	40	90	Unknown	1.64

[+]*Woorowo* and *Odu* were not deliberately planted before the project intervention, therefore previous data are unknown.

Table 4: Impact of optimum seeding rate on cumulative yield returns of the UIVs.

	Seeding rate (weight of seed planted kg /ha)[+]		**Cost of seed (₦/unit seed)**		**Total cost of seed (₦ `000)/ha**		**Total Leaf Yield (`000 kg/ha)[+]**	
	March 2011	**Jan 2014**	**March 2011**	**Jan 2014**	**March 2011**	**Jan 2014**	**March 2011**	**Jan 2014**
Ugu	50	120	2500	6500	125	780.0	17.8	51.0
Igbagba	25	13	1500	3500	37	45.5	17.4	42.5
Tete atetedaye	25	12	1500	3500	37	42.0	18.2	28.5
Woorowo	Unknown	60	Unknown	2000	Unknown	120.0	Unknown	42.4
Ogunmo	25	12	2000	3500	50	42.0	15.6	39.8
Odu	Unknown	12	Unknown	5000	Unknown	60.0	Unknown	28.2

[++]*Woorowo* and *Odu* were not deliberately planted before the project intervention, therefore previous data are unknown.

Table 5: Impact of use of Neem extract for control of pests of UIVs

Vegetables	Leaf Yield (kg/ ha/month)		Improvement in revenue on use of Neem extract per ha (Nigerian Naira)		
	March 2011	January 2014 (with Neem)	March 2011	January 2014	Difference
Ugu	2,600	4,400	528,000	880,000	352,000
Woorowo	unknown	21,400	unknown	3,210,000	3,210,000
Igbagba	8,160	13,600	1,224,000	2,040,000	816,000
Ogunmo	9,000	15,000	1,350,000	2,250,000	900,000
Tete atetedaye	5,880	29,000	588,000	2,940,000	2,352,000
Odu	unknown	27,400	unknown	2,700,000	2,700,000

4.3 Value-addition of under-utilized indigenous vegetables

4.3.1 Nutraceutical and nutrient composition of the vegetables

We carried out comprehensive nutraceuticals analyses on the ten (10) UIVs that were used for preliminary agronomic evaluation. We analysed the plants using the basic methods of Association of Agricultural Chemist (AOAC) (2003) with several modifications. On the nutraceuticals studies, we established the amounts of different anti-oxidative, anti-nutrients and bioactive components (Table 6) that make up the different UIVs. Comprehensive report of the nutraceuticals can be found in our published work Adebooye *et al.* (2014). Indeed, comparison with available literature data on routinely cultivated species showed that the UIVs contain higher amounts of nutraceuticals and bioactive components that can contribute immensely to food, nutritional and health security in a

developing country such as Nigeria. All the vegetables (Table 7) were also found to be rich in Mg, Ca, P, Fe, Mn, Cu and Zn. It is significant to report that *ugu* and *woorowo* had higher Fe content than the other vegetables. Also *Igbagba* was found to be very rich in Mn and Zn which are essential micro-nutrients required for normal functioning in humans.

Table 6: Antioxidative, Antinutrient and Bio-active contents of some under-utilized vegetables

Vegetables	Total carotenoids (mg/100g DM)	Total Phenolics (GAE/100g DM)	Tannins (mg/100g DM)	Flavonoids (CE eq. /100g)	Phytate (mg/100 DM)
V. amygdalina (bitter leaf)	31.2	43.4	48.5	61.2	3.6
C. crepidoides (Ebolo)	24.1	38.6	55.6	54.3	4.2
T. occidentalis (ugu)	26.4	42.6	60.4	66.5	3.2
S. biafrae (woorowo)	22.4	50.4	58.4	44.6	2.4
S. macrocarpon (igbagba)	36.8	66.4	53.6	50.6	2.0
C. pepo (Elegede)	46.2	38.1	55.3	59.2	4.0
A. viridis (tete atetedaye)	24.2	61.8.	49.4	40.4	3.1
S. nigrum (odu)	20.0	70.4	64.3	50.7	2.6
S. scabrum (ogunmo)	23.2	63.2	54.2	45.6	1.2
T. cucumerina (fruit) snake tomato	252.1	504.2	253.1	107.2	1.4

Table 7: Macro- and micro-nutrient contents of some under-utilized vegetables (mg/ 100g dry weight).

Vegetables	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
S. biafrae	2745	300	2300	2230	750	81.1	36	4.71	1.2
S. macrocarpon	2047	675	1892	544	592	30	33	7.96	1.61
S. nigrum	2165	687	2146	2145	663	32	37	3.81	1.85
A. viridis	3284	496	2348	4864	1252	36	23	5.41	2.21
Telfaria occidentalis	2755	636	2032	396	1065	65	18	0.85	1.90
Solanum scabrum	2439	831	4555	860	380	28	36	5.3	2.24

4.3.2 Vegetables processing and preservation

Our team investigated the influence of pre-treatment methods on the nutrient and anti-nutrient composition of i) bitter leaf, ii) *igbagba* and iii) *ugu*. The pre-treatments evaluated were boiling, blanching and squeeze washing with or without salt or trona (kaun). The products were analysed for

Ca, Mg, Mn, Fe, K, P, Cu, Vit B (1-12), Vit C, Protein and anti-nutrients – oxalate, tannins and total phenol. Results on Bitter Leaf (*Vernonia amygdalina*) showed that untreated bitter leaf had mineral contents of 1081 mg/100g Ca, 4123.1 mg /100 g K, and 250.94 mg /100 g Mg, 302.19 mg /100 g P, 40.29 mg /100g Fe, 14.37 mg /100 g Mn, 36.72 % Protein, 16.38 mg / kg vitamin B1, 27.43 mg/kg B2, 8.72 mg / kg B6, 14.03 mg/kg B12 and anti- nutritional content of 29.21 mg/g Tannin, 46.69 mg/g of total phenol and 4.6 % oxalates. The mineral content of the vegetable was significantly decreased ($p< 0.05$) by various pre-treatments and time of processing with the exception of Ca which showed an increase of 7.3 % to 25 % with the boiling treatments. Percentage reduction was minimal on K content of the vegetables boiled with trona (25.7 to 35.1%) compared with (44.8 to 55.7%) reduction in other pre-treatment. However, the various pre-treatments caused a significant decrease of 15 - 40 % in the content of vitamin B1, B2, B6 and B12 with highest reduction of 50 to 80 % in the sample boiled with trona. The result of anti-nutritional content followed the same trend with vitamin B complex. Comparatively, blanching without the addition of substances appeared to be the best pre-treatment that ensured minimum nutritional loss. Various pre-treatment methods and times of processing caused a significant decrease ($P<0.05$) in the nutrient and anti-nutrient of *Vernonia amygdalina*.

Significant summary of the findings are:

- For all the mineral elements studied, blanching resulted in the least percent loss while squeeze washing gave the highest mineral losses.
- For the treatments, the effect of time was not highly significant on nutrient loss, even though trends indicated more nutrient loss at longer times.
- The addition of salt or trona more than doubled protein losses.
- Squeeze washing achieved the highest reduction in the anti-nutritional contents.
- The results suggest that blanching with salt reduces bitter causing compounds by about 50%, while minimizing nutrient losses.
- The addition of salt, and especially trona, during pretreatment increased vitamin losses significantly.

4.3.3 Cooking trial and sensory evaluation of products.

The cooking trial and sensory evaluation was done with the objective to determine the acceptability of rehydrated vegetables in local soup preparation. Fresh and dried samples of the 3 vegetables were used in stew preparation in two forms *efo riro* and *egusi* and were subjected to taste panels. All the samples were delicious to taste but the dried leaves were darker in colour while fresh leaves retained their green colour. The dried leaves also had tougher texture unlike fresh leaves that were softer thus requiring minimal chewing. The presence of melon (*egusi)* masked the ability of tasters to differentiate between vegetable stews prepared with fresh leaves from that prepared with dried leaves. Thus, inclusion of *egusi* in sauce preparation was discontinued in further testing. Field trails were thereafter conducted using the same methods but with the exclusion of *egusi*. The objective of the field trials was to sensitize the farmers to the possibility of using dried leaves in food preparation and also teach them different hygienic cooking methods for dry and fresh vegetables. The trials were conducted in **5** locations Ogbomoso, Akaran, Omi-Okun and Ilode (both at Ile-Ife) and Iludun Ekiti. Panellists (farmers and the locals) were able to differentiate the sauces with fresh vegetable leaves from those with rehydrated leaves. Fresh vegetable stews scored higher marks than dried vegetable although the difference in scores was not statistically significant ($P>0.05$). About 25% of the panellists could not tell the difference and indicated that the difference was not noticeable. Thus it was concluded that using the right recipe (with condiments), dried vegetable leaves can be used in the preparation of vegetable stew. The implication of this is that surplus vegetable leaves may be

preserved by sun-drying and reconstituted for later use. (Research report in Appendix 3). To further promote the use and adoption of UIVs in the daily diet of more consumers, a booklet of recipes has been produced and will be made widely available (Appendix 3).

4.3.4 Development and testing of farmer-friendly drying facility for UIVs

This Project designed and constructed a charcoal operated oven, which was tested for drying UIVs. The oven requires little charcoal, completes drying of 50 kg of fresh vegetables within one hour. It is affordable, mobile – on wheels and enhances colour retention and produced under hygienic conditions.

4.4 Economic and marketing potential of under-utilized indigenous vegetables (A comprehensive report is attached as Appendix 2)

This economic and marketing study provided the basic economic features for the underutilized indigenous vegetables which were not previously available in the study area. The study determined the production function and established the costs and returns to selected UIVs; characterised the features of marketing channels, and determined the factors promoting the consumption of the selected UIVs. Stratified random sampling procedure was utilised to select 254 producers, 323 marketers and 330 consumers of UIV in the study area. The data were subjected to standard econometric and marketing analytical procedures to achieve the set objectives of the study. Results indicated that UIV production has been made popular in the study area to the extent that the respondents now consciously allocate portions of farmland (an average of 0.4ha) to vegetables that were mainly previously gathered from the wild. Marketers are mostly young educate females with small household size of four, who travels an average of 3.8 kilometer (female) and 2.5 kilometer (male) to market their product. The cost structure analysis shows that all the selected UIVs were profitable with Ugwu giving the highest rate of returns to capital of 44.5% and Tete Abalaye with 22.5% rate of returns. Six main channels of marketing UIVs were identified, with major actors being producers, primary wholesalers, retailers and ultimate consumers. Production function analysis shows that labour is a critical variable, and, that for one additional man-day of labour, the output of UIV will increase by 38%. Also if one unit of land is made available to cultivate the UIV an additional 72% increase in output will be realised. While if the waste can be reduced, (possibly through value addition) 38% of UIV will be added to the production. As regards the consumers of UIVs, these were also young (mean age (38.5 years) mostly female (65%) with household size of six. The analysis further revealed that those who prefer Ugwu, Woorowo and Tete Abalaye would likely be rich educated elders, while Igbagba is preferred by younger married educated households. Incidentally, for all the UIVs, their consumption depends on their availability. Further analysis reveal that, the products will still be consumed at high prices, indeed for Woorowo a unit increase in price will provoke 85% increase in demand, while Ugwu will only command 6% increase in demand for a unit increase in price. The results of the cross price elasticity of demand shows that the UIVs are essentially complementary products that are consumed alongside other food products. The results show that there is a high potential for the selected UIVs to turn around the economy of the rural households if given the necessary enabling environment. The potential for making huge business enterprises is high especially for the young elites (nouveau rich) with interest in consuming the products.

4.5 Gender equity and impact of crop diversification on the environment and resource-use-efficiency

4.5.1: Gender Analyses: (Extract from Full Endline/Project Impact report Appendix 2)

Gender distribution of the NICANVEG Project beneficiaries: Results show that 51.0% project members were female while the remaining 49.0% were male. This complies with the project objective that more than 50% of the beneficiaries should be female indigenous vegetable farmers. Poor indigenous vegetable female farmers and marketers were encouraged to join the group in order to benefit from the capacity buildings and farm inputs both in cash and in kinds. They were also, encouraged to be members of cooperative groups and be part of the cooperative officers. Hence, in some of the groups women held vital positions like chairman, secretary and treasurer. This has improved the leadership potential of the female indigenous vegetable farmers. Distance to inputs: Figure 18 shows the distance in kilometers covered by the beneficiaries. Most (85.2%) female and majority (74.6%) male covered less than 10 kilometers (Km) to access their farm inputs, while very few (7.1%) female and few (15.6%) male covered between 10 and 19.9 Km to access their farm inputs. The average input distance covered by females was 5.43 Km while that of male was 12.77 Km. This indicated that the beneficiaries covered long distance to access their farm inputs. The distance covered by the male to access their input was longer than their female counterparts.

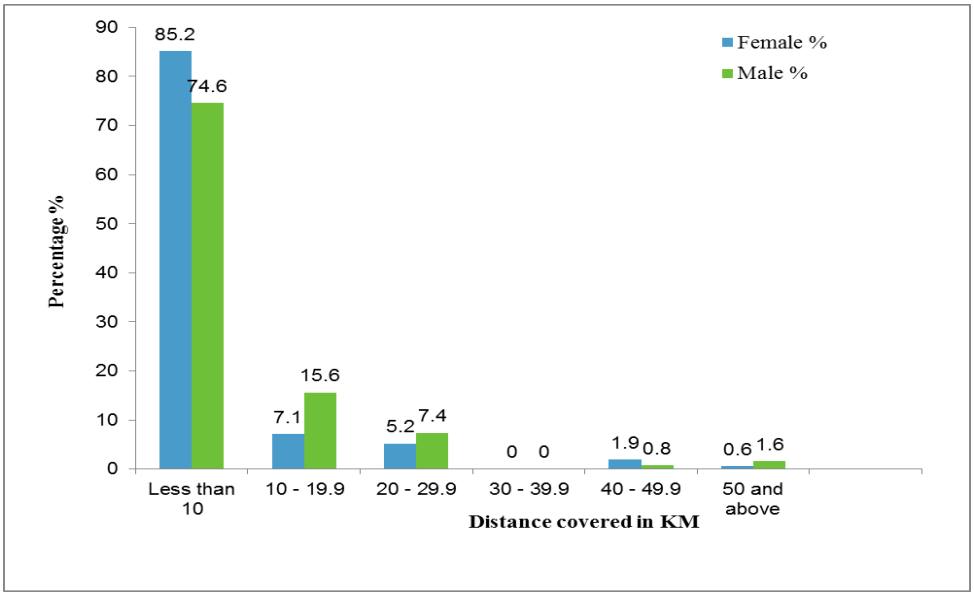

Figure 18. Distribution of beneficiaries according to input distance covered

Gender distribution of source of Information: Figure 19 revealed that 46.45% female and 36.07% male source their information through other farmers while 30.97% female and 27.87% male source information through radio. Only very few (1.64%) male and none of the females source their information from television. These revealed that female farmers shared information among themselves and listen to radio more than their male counterparts. None (both male and female) of them sourced their information through television. This may be as a result of inability of the farmers to purchase Television sets coupled with unavailability or epileptic supply of electricity in the rural areas. Furthermore, Figure 20 showed that 94.84% female and 87.70% male listened to the project jingle tagged 'Ramo Elefo' on the radio. These findings revealed that female are more regular radio listeners than male.

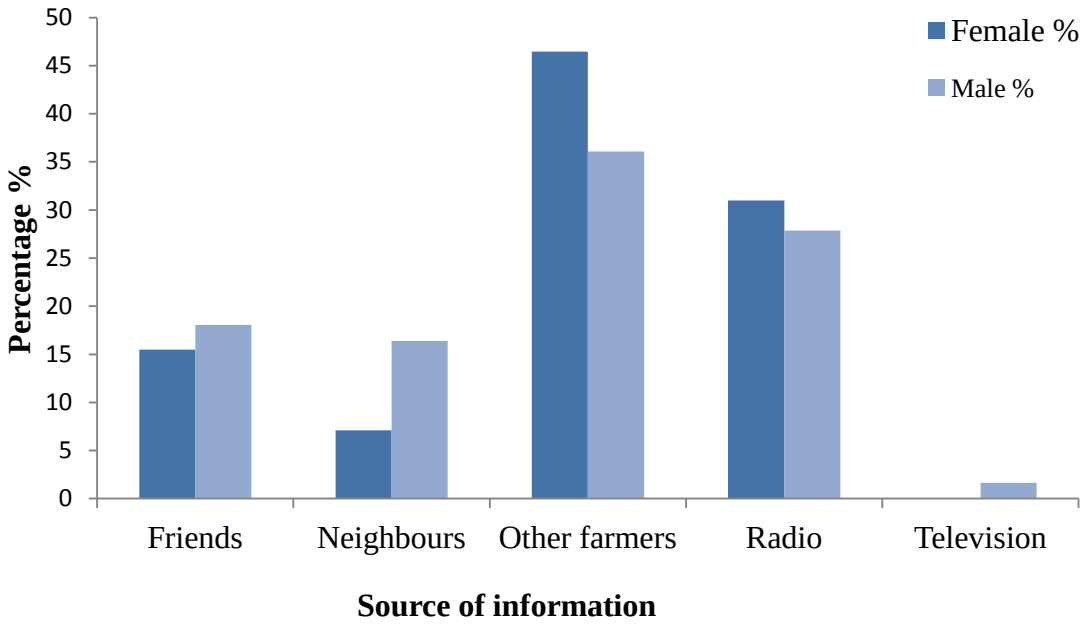

Figure 19: Distribution of the beneficiaries according to their source of information…

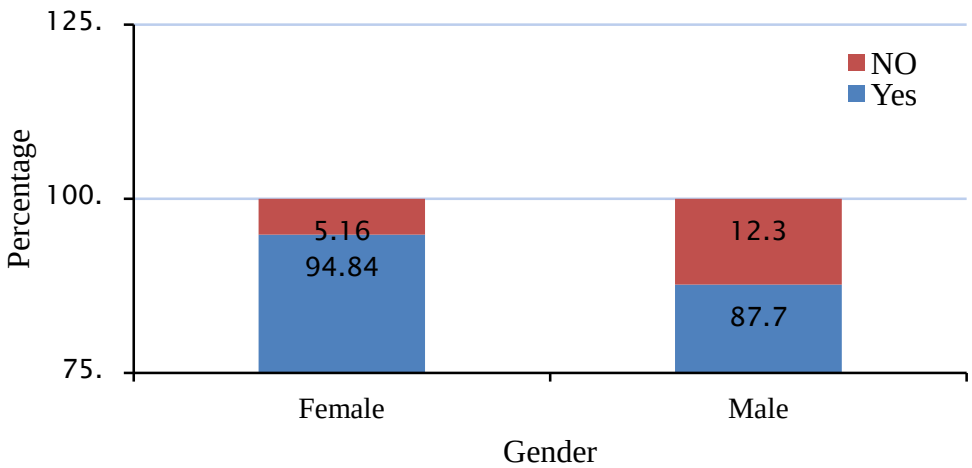

Figure 20: Distribution of gender according to their listening to radio jingle (Ramo Elefo)

Gender distribution of Project Awareness on production and consumption of indigenous vegetables:
Quantity of Vegetables Consumed Annually:

Figure 21 shows that quantity of indigenous vegetables in bundles being consumed annually by both male and female increased during their involvement in the project. The pre-project average indigenous vegetable consumed by the male and female were 328 and 269 bundles but increased to 455 and 416 bundles respectively during the project (weight of 1 bundle is 1 kg ~ 60% is edible). This indicated that female consumed more bundles of indigenous vegetable than male during the project. The quantity consumed by male was almost double during the project. We posit that this is the result of our rigorous awareness campaign on the nutritious values of the vegetables, increase in indigenous

vegetable output and the roles of women as homemakers. This may also be as result of workshop held on value addition to vegetables. Our results show that few male (15.07%) and female (16.1%) consumed 500-999 bundles of vegetables before the project but increased to 24.14% female and 22.95% male during the project. Also, very few male (5.48%) and female (3.39%) consumed between 1000 and 1499 bundles annually but increase to 9.66% male and 11.8% female.

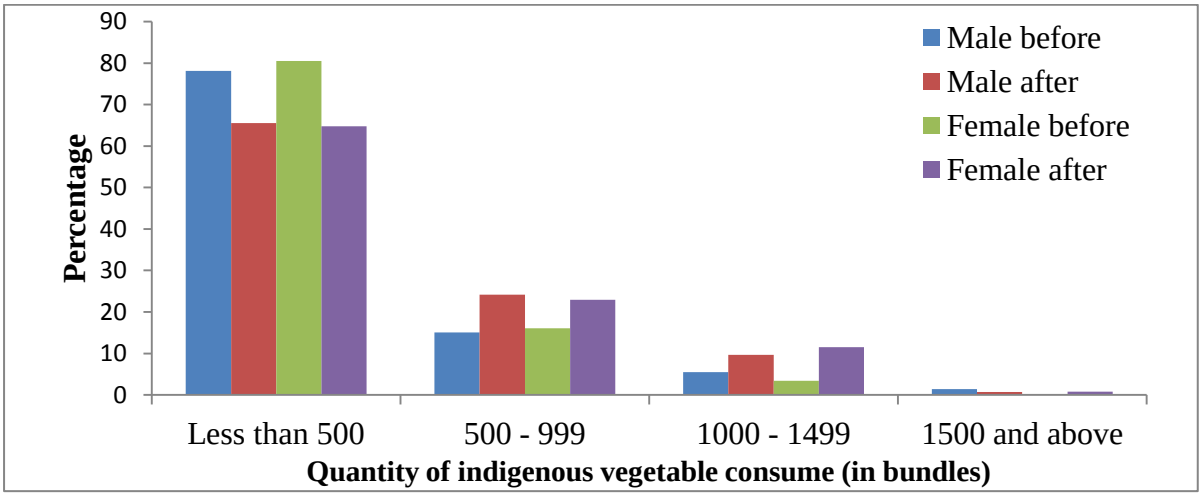

Figure 21: Distribution of the beneficiaries according to the quantity (bundles) of vegetable consumed annually.

Quantity of Vegetable in Bundles Sold per week: The quantity of bundles of vegetable being sold by the beneficiaries increased during the project (Figure 22). Only 9.73% of the female sold between 1000 and 1499 bundles before their involvement in the project but increased to 27.87 percent during their participation in the project. Also, few (12.69%) male sold above 1500 bundles per week before, but increased during their involvement in the project to 22.38%. The mean quantity of indigenous vegetable sold by male was 4,492 bundles and increased to 5,077 bundles during the project. While that of their female counterpart was 8,327 bundle before, but increased to 8,433 bundles during the project. The study revealed that female sold more bundles of indigenous vegetables before and during the project implementation than male. This is in agreement with the baseline survey that female harvest wild indigenous vegetables for sale.

Amount of Money (NGN) Saved annually: Savings per annum of the beneficiaries increased during the project (Figure 23). At the beginning of the project, 17.82% and 14.55% female and male, respectively saved between 100,000 and 199,999 Nigeria Naira (NGN) while 42 months into the project it increased to 21.6% and 14.94%, respectively. It is noted that 4.6% male saved between 200,000 and 299,999 NGN before the project but increased to 10.91% during the project.. Only very few (6.93%) female and (1.15%) male saved above 500,000 NGN annually before the project but increased to 9.6% and 6.36%, respectively during the project. The mean annual savings for female and male was 164,239.20 and 134,850 NGN before, but increased to 393,501.60 and 384,171.20 NGN, respectively during the project. This revealed that female savings culture is better than male before and during the project. It also, revealed that savings of both male and female was doubled during the project. This may be as a result of capacity building in savings education organised by the project.

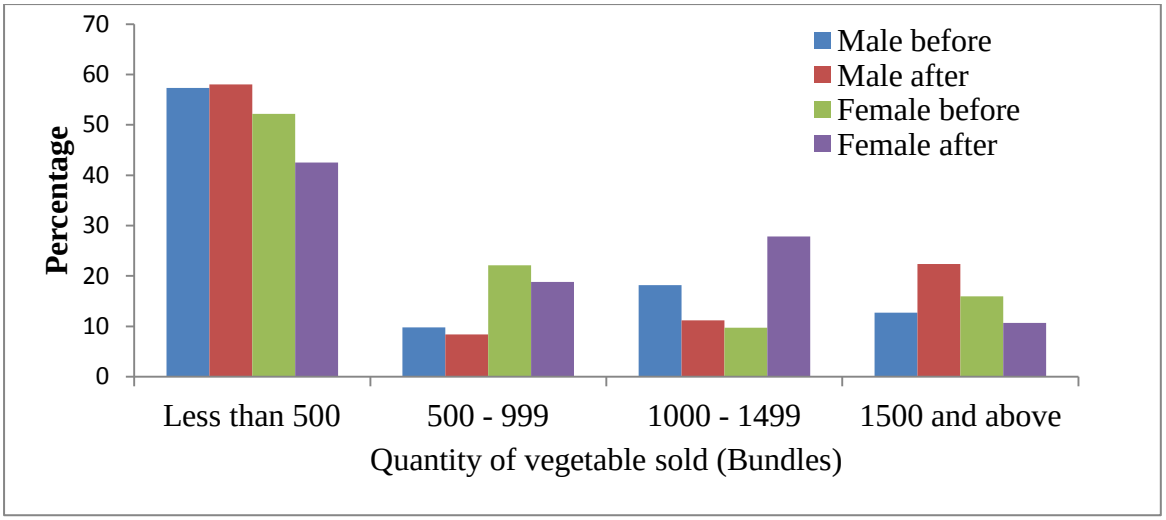

Figure 22: Distribution of the beneficiaries according to the quantity (bundles) of vegetable sold per week

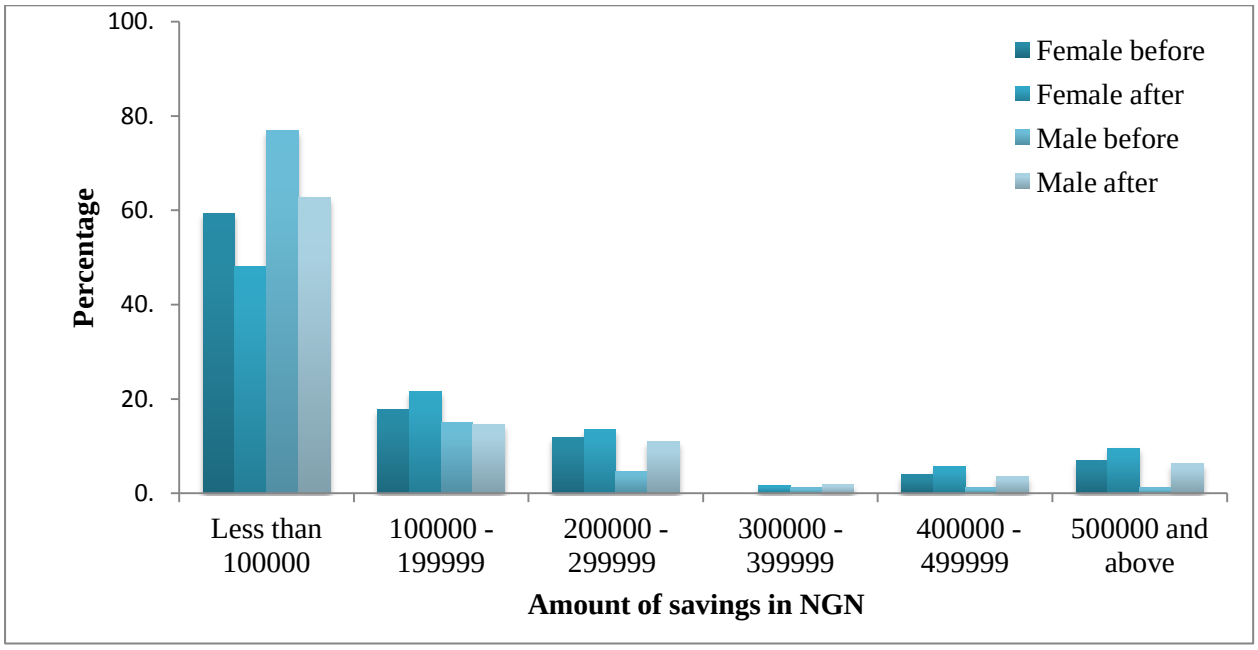

Figure 23: Distribution of the beneficiaries according to the amount of savings per annum in NGN

Expenditure on education: As shown in Fig 24, before the inception of the project, few female (15.96%) and male (17.72%) spent between 100,000 and 199,999 NGN on children education but increased to 18.09% and 18.82%, respectively, during the project. The mean educational expenditure for female was 229,094.70 NGN pre-project, but increased to 250,315.8 NGN during the project while the mean education expenditure for male was 240,200 NGN but increased to 441,783.70 NGN during the project. This revealed that male spent more on education of their children than the female; this may be as a result of improvement in the beneficiaries' income from indigenous vegetables and their value for education.

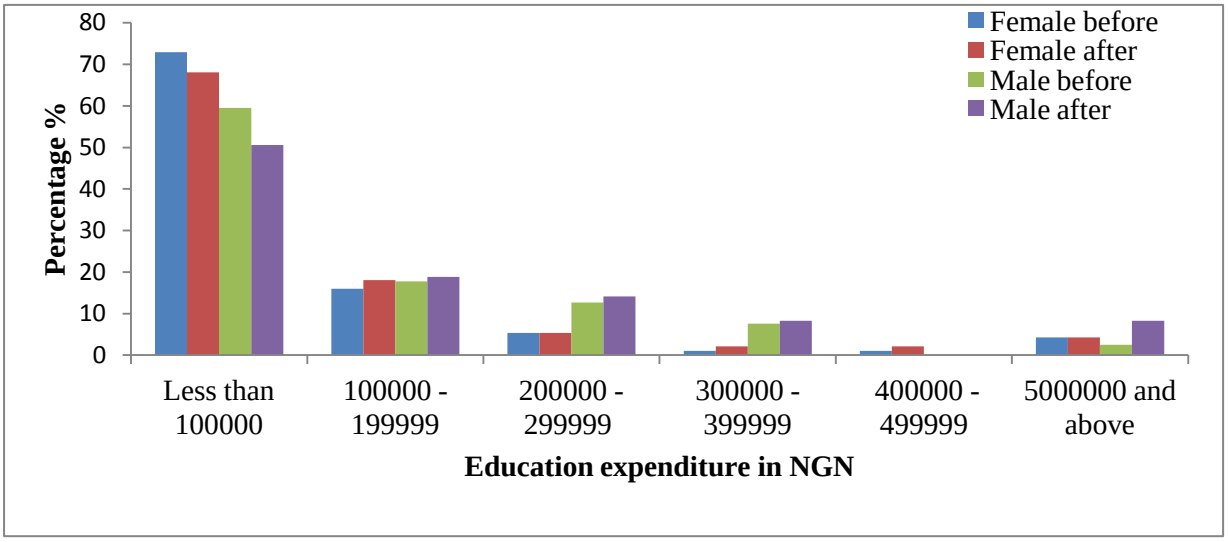

Figure 24: Distribution of the beneficiaries according to the amount spent on education of their children per annum in NGN

Gender and health of Beneficiaries: Comprehensive analyses show the impact of the project on the beneficiaries' health (Appendix 4).. The finding revealed that the project had made impact on both male and female health. The number of family members, between 4 and 6, that fell sick annually before the project reduced from female (27.4 %) and male (25.3 %) to 10.7% female and 20.8 % male, respectively. The mean number of family members that fell sick before the project for female were 3.43 and male were 3.6 but reduced to 2.1 female and 2.3 male during the project. This indicated that number of female family members that fell sick during the project was lower than that of male family members. This may be a result of an increase in the amount of nutritious food being consumed by the family members. The mean number of times the females visited hospital during the project was 1.84 while that of male was 2.06. This indicated that more male members visited hospital than female members during the project. The number of family members between 4 and 6 that visited hospital reduced from 20.6% to 11.1% for female and from 24.3 % to 10.3% for male during the project. The mean number of female family members that visited hospital during the project were 1.86 while that of male were 2.1. This indicated that number of male family member that visited hospital during the project was more than the female. The amount of money, between 5000 and 9,999 NGN spent by females declined from 18.2% to 11.2%, while the money spent by males declined from 21.5% to 11.2% over the duration of the project. Only about 15.9% female and male spent between 10,000 and 19,999 NGN before project but this increased slightly to 20.4% for female and 23.5% for male during the project. The mean amount spent in the hospital before the project by the female was 7861.67 NGN and male was 8530.8 NGN but reduced barely after 42 month to 4036.22 NGN for female and 4827.6 NGN for male. The hospital bill of the beneficiaries was reduced by 50%. This may be as a result of improved nutritious food being consumed. This indicated that both male and female members spent less in the hospital during the project but female spent lesser than male.

Additional information on Gender Savings Training and an MBA thesis derived from these activities is provided in Appendix 4.

4.5.2 Overall project impact assessment

The following abstract provided by the Economics Task Team – (See full report in Appendix 2)

"The study was conducted to ascertain the extent to which the NICANVEG project met with the expected outcomes in its execution. Using scientifically valid methodology we established the facts that: The project succeeded in encouraging more than 80 % of the beneficiaries to cultivate and market the selected UIVs to generate much needed income. More than 51 % of the project beneficiaries were women who, listen to and share information about UIVs with their friends more than their male counterparts, increased their consumption of UIVs by 40 % relative to the baseline and sold about 113 % more bunches than baseline, and also saved over 117 % more. Beneficiaries earn more from UIV cultivation, non-farm activities, and ultimately had more household income at the end of the project than non-beneficiaries and as such are more food secure. Participation in the NICANVEG had a positive and significant impact on the beneficiaries at the 5 % level. The quantum of the impact made the beneficiaries about 20 % better than the baseline condition, while the counterfactual situations (both conventional and clean) were neither better nor statistically significant. Nominally, the beneficiaries made about 210 % increase in income relative to 167 % obtained by non-beneficiaries".

5.0 SYNTHESIS OF RESULTS TOWARDS AFS OUTCOMES:

This project was structured and implemented in phases with 4 tangible outcomes as goals: 1) develop agronomic practices for growing UIVs, 2) publicize the value of growing and consuming UIVs, 3) develop technologies to increase the value of UIVs, and 4) document the economic options and opportunities for women farmers to be derived from producing UIVs. Full achievement of these goals is still a work-in-progress never-the-less, at this stage after 42 months, production of UIVs has gained wide acceptance in both the farming community and the general public and provides tangible support to the following AFS outcomes.

5.1. Generation of new technologies and/or farming systems and practices.

New agronomic technologies and management practices - One of the first and perhaps most important outcomes of this project was the development of numerous innovative farming technologies designed for and adopted by both women and men farmers that enabled them to successfully grow between 6 to 8 previously uncultivated indigenous vegetables. A comprehensive list of beneficial management practices was developed and provided to FADAMA for further extension to the farming communities. It was also uploaded to the UofM web site. (Appendix 5). These new technologies combined with new sources of foods and nutrition (UIVs) were a major goal of the project. They have resulted in notable changes in attitudes and activities in the participating farming communities; farmers now grow vegetables which previously they only gathered from the wild or grew in limited quantities (*woorowo* and *odu* had never been deliberately planted). They have converted fallow and unused lands to provide additional areas for UIV production and they now see UIVs as additional sources of food and income from the sale of excess vegetables to marketers and consumers. We also noted that *Odu* was not popular at most of the locations while *Woorowo* and *Ogunmo* were not popular at only a few locations and therefore were only allocated small areas of land for production. The most popular of the vegetables across all study sites are *Ugu*, *Igbagba* and *Tete atetedaye*, which were consequently allocated the largest land areas.

Total production of *Ugu*, *Igbagba*, *Tete atetedaye*, *Woorowo*, *Ogunmo* and *Odu* have increased by 62%, 67%, 60%, 100%, 64% and 100%, respectively as a result of cumulative effects of the

recommended BMPs, extension expertise and the physical and financial resource inputs provided by this project. We have also found that prices/kg of the fresh UIVs leaves have increased by 36-56% mostly in the past 36 months due to increasing demand largely attributed in part to the publicity from this project.

New tools and equipment - A second major outcome accomplishment for our project was the development and demonstration of new and innovative post-harvest tools and technologies to extend the harvest period (sequential cutting), preserve the nutrient quality (chopping, drying and packaging) and prolong the shelf life of these indigenous vegetables. As an example, we designed and fabricated a charcoal driven portable dryer that has the capacity to dry 50 kg of fresh vegetables in an hour. These new techniques were eagerly adopted and enabled farmers, particularly the women, to extend the period of available food stocks during the dry season in both the farm level and in the market place. Marketing of dry packaged vegetables has only recently been available and is still in the early stages of evaluation, although preliminary results from community taste-test panels showed that dried vegetables are very acceptable to consumers. A video demonstrating prescribed food handling, preparation and cooking methods for optimum nutrient retention of fresh vegetables was produced and used in training sessions for the benefits of women, children and households. We also distributed five dryers to farmers in selected locations and trained women farmers on their use. Taste test panels consisting of both women and men farmers and some family members, confirmed that consumers would eat re-constituted sun-dried chopped green vegetables as part of their traditional daily dishes.

On the research side, this project facilitated the design, construction and testing of an 8-channel data-logging device and also soil moisture testers for measuring soil water capacity using locally available materials. These devices were used to monitor soil water depletion on the field and in the laboratory to estimate crop water requirement and irrigation needs. Both devices are currently being considered for patent.
A more discussion on development of technologies is provided in Appendix 5.

5.2. Dietary diversity and nutrition

Increased variety of nutritious foods - In addition to improving and increasing the quantity of UIV food production, we also investigated the nutritional quality and nutrient composition of selected UIVs. Food processing studies were conducted to improve the taste of Bitter Leaf (*Vernonia amygdalina*) and preserve the nutrient content of Ugu (*Telfairia occidentalis*). Blanching is recommended for nutrient and mineral preservation, while squeeze washing achieved highest reduction in anti-nutritional contents in bitter leaf. Data on nutrient and food quality was discussed in section 4 above.

New food products - Production of new innovative recipes for cookies fortified with 2.5% to 4.5% sundried leaves of *Igbagba* were generally well accepted by taste panels as being better than the cookies made from plain wheat flour. Further studies are ongoing to determine nutritional value of the cookies after which rural women farmers will be trained on how to produce these as an alternative source of income. Production of "UIV cookies" represents a potential new economic income option for commercialization, and job creation either directly on the farm or in the local communities.

5.3. Engagement of Canadian researchers with southern research organizations

Canadian researchers and expertise were intimately linked with their discipline counterparts in OSU and OAU in Nigeria. Collaboration with Canadian expertise in food science, soil science, gender equity, environmental sampling and monitoring, and economic analysis and evaluation was very instrumental in the implementation of all phases of the project. Wole Akinremi (Soil Science UoM) contributed 6 months of his sabbatical leave to this project at OAU conducting field studies on soil fertility requirements for the 6 UIVs; Prof. Martin Scanlon (Food Science UoM) visited the project during research collaboration on food processing for nutrient retention; Mrs Rachael Alao of Helping Hands Canada, (third party UoM) visited Nigeria to participate in cooking trainings for women farmers and taste-test panels in Ilode, Omi Okun and Iludun; Bob Eilers (Soil Science UoM) visited Nigeria on several occasions to participate in field activities and advise on project management and coordination; Prof. Cathy Conrad (Geographer, St. Mary U) representing CBU - visited two of the project sites in Nigeria where she held training for farmers and children on the importance of monitoring water quality and safe use of water for agriculture and drinking. Thomas Bouman (PI, Ecologist CBU) organized research capacity training workshops (total of 9 weeks between April 2012 and June 2013) for Nigerian team members at CBU; organized three missions of Canadian team members to project sites; and, trained Nigerian team members in project management, design and analysis of agricultural field experiments, and taxonomy of UIVs. Richard Watuwa (Economist CBU) contributed training and expertise to the Economic Task Team and made presentations based on project out-comes to several international meetings. Dana Mount (Gender, CBU) was instrumental in implementing gender equity assessment training for project team members, mentoring graduate research on gender equity assessment, kicking off gender equity field research in Nigeria, and presenting on gender equity assessment at program-level meetings. In addition, two MBA students from the CBU visited Nigeria in June, 2013, where they cooperated with UNIOSUN and OAU to train farmers on savings and efficient use of resources. They also administered questionnaires to the farmers on managing household finances as a portion of their graduate research and training. Research team members from Nigeria received training at the U of M where they participated in the setting up of new trials, writing of factsheet and analysis of plant and soil samples and analysis of baseline data and the linking of baseline data to GIS. Benefits to Canadian Institutions included improved international recognition, exchange opportunities, as well as graduate student recruitment and training (Appendix 5. Benefits to Canadian Institutions).

5.4. Research groups

During the development of project proposal, the principal investigators adopted a TASK TEAM approach to organizing and coordinating the various science disciplines required to implement the project Each TASK TEAM consisted of members from each of the 4 collaborating partner Universities. The various teams have struggled at times to coordinate activities and reports, but "team work" takes work, patience and persistence to function fully. The project has adopted the slogan TEAM WORK MAKES THE DREAM WORK as a mantra to encourage closer cooperation and coordination. The frequent visit of the Canadian partners to Nigeria to participate in the activities and outputs of these various TASK TEAMs has resulted in a fuller awareness of project progress, especially the conduct of the field work, farmer training, gender issues and general project coordination. The project has embraced the concept of mainstreaming gender equity in agronomic research to facilitate reaching out to rural women as project beneficiaries. During the 42 months of the project, it has become evident that stronger research groups are emerging which should result in improved decision-making and better food security policies. Communications within and between research teams is a major challenge for any project. However, the exchange visits between Canada and Nigeria, technical training sessions, national and international conferences and annual review workshops sponsored by the project have done much to promote and enhance collaboration. The

research groups are gradually getting stronger as they collaborate to publish the significant scientific and socio-cultural findings from the voluminous data obtained from this project.

5.5 Food distribution.

This project did not have food distribution as a goal in its work-plan and therefore no specific attention was devoted to this component. The focus of the project as describe in section 4 has been on production, processing and preservation.

5.6 Food processing and storage

Innovative approaches to food processing techniques such as drying and blanching of fresh green UIVs have resulted in new options for storage and nutrient retention thus ensuring more nutritious meals. Details have been discussed in section 4 above. Some direct outcomes of this research are new products (fortified cookies), new cooking and processing recipes (preservation of nutrients), increased shelf life for postharvest UIVs will extend availability of food in the dry seasons (potential to mitigate effects of climate change), and increased market opportunities (dry vegetable packets last longer and can be transported further and more cheaply on a cost by weight basis). All of these innovations which rely mostly on local resources and skill levels are aimed at empowering women farmers to better care of the health and welfare of their families.

5.7. Risk mitigation

Environment -

Erosion control: serious erosion problems to seed beds occurred at the Akanran site. The risk of erosion was reduced using a peg and bamboo terrace technique. This simple method has been adopted by most farmers to reduce erosion along pathways between seed beds. Reported in the 18 months interim report.

Disease control: About 70% of the first planting of *Amaranthus* (tete) at Ikere Ekiti and Inisha sites was lost to a damping off bacterium. The second planting used seeds treated with Apron Plus instead of Seedrex which seemed control the problem. Farmers have now adopted this practice with good success. (virology pictures Appendix 5)

Nematode control: About 80% of *Ugu* were lost in Ilode, Ile-Ife due to drought induced soil moisture stress in combination with high population of nematodes. A second planting with good moisture after rainfall and application of compounded organic fertilizer reduced the nematode population.

Insect control: Beetles holes on leaves of both *Elegede* and *Ugu* was observed at some sites, so liquid extracts from neem leaves were applied as foliar spray. Maximum protection occurred after two sprays. A research paper on the effectiveness of compounded organic fertilizer on control nematode in *ugu* farm has been accepted for presentation ISFAM Conference that will hold in Kenya in October.

Drying and packaging UIVs – Fabricated vegetable dryers have been constructed tested and distributed to farmers to preserve excess vegetables produced during the rainy season. Drying excess fresh UIVs retains the quality and greatly prolongs shelf-life of the product, thus extending the supply of a variety of nutritious food products well beyond the normal wet season.

Land shaping for water management (drainage and harvesting) - Severe inundations restricted cultivation of UIVs at Ilode and Omi-Okun which required construction of drainage channels which have made cultivation possible in both wet and dry seasons. Surface water management is a critical aspect for irrigation of UIVs during the dry season.

5.8 Access to resources

Our project has made giant strides in the area of enabling farmers' access to resources. The 1405 participating farmers have organized and registered as 22 cooperative groups with women included in top executive positions. These registered cooperatives have successfully negotiated the allocation of fertilizers and other farm inputs in Osun, Oyo, Ondo and Ekiti States. The UIVs farmers have since taken delivery of inputs such as water pumps, fertilizer, wheel barrows, irrigation hoses, vegetable dryers. These cooperatives also facilitate farmers' access to Bank credit, Federal Government Agric support and participation in other future vegetable-related projects. Project 106511 is in the process of developing a Memorandum of Understanding (MOU) with the Bank of Agriculture of Nigeria, for disbursement of soft loans to UIV farmers. Our team has included FADAMA, the extension component of the Ministry of Agriculture, and the Agricultural Bank from the onset. The FADAMA officers assisted with data collection, monitoring and coordination of participating farmers' at demonstration sites. As a result of the poverty level among the vegetable farmers the project provided an initial injection of financial assistance to empower UIV farmer cooperatives prior to completion in August 2014. This seed money is to be circulated on a revolving loans basis among the members of the coops.

5.9 Income generation

As previously discussed in section 4, the project has resulted in a significant increase in the number of UIVs planted and the total yield. Production of *Ugu*, *Igbagba*, *Tete atetedaye*, *Woorowo*, *Ogunmo* and *Odu* have increased by 62%, 67%, 60%, 100%, 64% and 100%, respectively. In addition, as a result of increasing consumer demand attributed in part to our promotional awareness programs, prices/kg of fresh UIV leaves has increased by 36-56% in the past 36 months. Details of income are provided in our published work Alao *et al*. (2014)

5.10 Policy options.

As a result of the ever-increasing interest in our project by the governments in Osun and Ondo States, a comprehensive agenda to support indigenous vegetables production, utilization and processing is being prepared. Necessary machineries are now being put in place to commence implementation of this policy which includes the provision of inputs to indigenous vegetable farmers in Osun and Ondo States. In Osun State, the government has concluded plans to donate some materials to the project, including a tractor with full implements. The Governor has also conceived of a meeting with our

project team, but the meeting is yet to be held. Most of our awareness documents have been officially delivered to the Nigerian Minister for Agriculture.

5.11 Information and Communication Technologies

From the onset, the Project established a communications TASK TEAM and adopted a multi-media approach to communications. The team has produced and used Radio programs the most often since radio likely reaches a larger percentage of the poorer rural audience. Articles have been published in the newspapers which are also widely available. In addition, three websites were activated relatively early in the project to inform the audience with access to more digital technology. And lastly, TV programs were used to highlight the food and nutrition values of UIVs as well as the recommended practices for production, post-harvest handling processing and marketing UIVs. The feedback on the websites has been very encouraging. Many people have been contacting us as a result of their contacts with the websites. (See analysis Appendix 2).

5.12 Gender

Gender equity has been a prime component of every aspect of this project from proposal development, to project consolidation, evaluation and conclusion. The project team has consisted of 40% women scientists and technical specialists, also key leaders from the FADAMA extension services were highly skilled women, training in Canadian Universities was targeted at 50 /50 but we eventually achieved 45% female/55% male, training in-field and rural communities targeted at least 50% women farmers, and all farmer cooperatives are well represented with women in responsible management positions.

Research design, site selection, training locations, information factsheets and leaflets were specifically designed and implement with gender in mind. For example, all trainings and cooking demonstrations were held on farms and in the communities so that women would be able to attend and participate without the cost of travel or child minding. Seed bed design in terms of dimensions and layout made access gender user-friendly for seeding, maintenance and harvest thus reducing some of the back-breaking drudgery of attending to vegetables. A proportion of selected UIVs grown varies between communities based on local preferences and has significantly increased and diversified the local diets for farm families. The excess production sold in marketplaces has been a new-found source of income. Women farmers and some men now have improved access to and control over this new income as a result of Gender sensitive saving exercises that were conducted in several target communities (see report in Appendix 4). An important unexpected outcome of this training and data gathering was the successful completion of MBA theses at CBU (see appendix 4). This knowledge of money management is new and is already being utilized by individual family households as well as for the financial management of the established farmer cooperatives. A comprehensive manuscript has been written on gender aspect in the access to vegetable production resources. The manuscript is already published in the African Journal for innovation, technology and development (Taylor and Francis). The Gender team is also publishing series of Gender Outlook publications. (see Appendix 1)

5.13 Environment

The agricultural practices proposed by this project (Appendix 4) have been designed to ensure minimal adverse effects on the environment at the farm and landscape level. In fact, the project has made farmers much more aware of the potential impacts that could occur. Farmers are now very aware of the risks of soil erosion which dissects fields, removes sediments and nutrients and clogs canals and natural water ways and they have adopted mitigation strategies proposed by the project. The project has also informed and trained farmers on the more broadly based need for adopting community-based environmental monitoring (CBEM). Special emphasis was given to knowing the quality as well as quantity of surface waters used for irrigation and post-harvest handling of UIVs as well as for direct household consumption.

On the science side, research has provided knowledge and characterization of the production and nutritional aspects of UIVs which has contributed to the conservation of plant genetic resources and biodiversity. Use of environmentally friendly organic amendments for soil fertility improvement (test soils for N levels) and nematode control is ensuring sustainable soil productivity. Alternative methods and material for packaging processed and dried UIV food products are currently being investigated because of the negative environmental effects that may accompany the use of polythene or plastics.

5.14 Concluding comments:

The following statements are taken from Chapter 5 of the impact assessment report (presented in Appendix 2).

"*The project had a bigger impact on the poorest beneficiaries and could have much greater impact in the future because of the time-lagged effect of the productive asset acquisition. Thus, a follow-up study is needed to capture the longer-term effects of productive assets and other changes that farmers experienced as a result of participation in the NICANVEG. This study was conducted at the first stage of the project and does not capture its time-lagged impacts, especially the long-term benefits of productive asset acquisition and rural infrastructure development.*

Key issues that need to be addressed in scaling up this success story include, among others, better targeting of poor and vulnerable groups, especially women; finding sustainable methods of promoting development of rural financial services; and conscious inclusion of capacity building of NICANVEG beneficiaries in efficient management of productive assets.

As regards appropriate targeting, recall that over the first three years that the project operated, the Gini coefficient of income for beneficiaries changed by about 16 percent, compared with a change of 11 percent for the conventional sites and about 6 percent for other categories of non-beneficiaries. This suggests that the project contributed to a reduction in income inequality, probably through targeting poor and vulnerable groups. Consistent with the objective of targeting women, the project was able to change the income distribution for women by about 10 percent. In addition, the project also succeeded in raising the incomes of the poor tercile more significantly than for the other terciles. The non-significance of the impact on income for the other two terciles suggests appropriate targeting of the poor and vulnerable groups".

The overall response to the project at the farm level, market level and consumer level has been exceptional. From the onset, the project has utilized a method of collaborative partnership and farmer participatory research and development. Detailed agronomy studies and farmer training were the focus of the original plan. A host of environmental friendly beneficial management practices were developed, tested and extended to some 1405 farmers (~50% women) in 16 farming communities. As a result of the natural evolution of the project, new initiatives were concluded by the Value-added Food and Nutrition Task Team who developed new processing techniques, packaging, and new food products. A community awareness initiative focusing on gender and environmental issues was presented to participating farm women and farm cooperative groups. To-date the research findings have been widely disseminated to the primary beneficiaries, the resource poor women farmers, as well as to other farmers, marketers, consumers, scientists and policy makers.

We contend that this project (IDRC 106511) has fulfilled the overall goals and achieved the majority of outcomes as conceived in the original proposal. Research, extension and participating farmers have demonstrated that UIVs can be successfully grown, harvested, processed, marketed and consumed thus reducing the risk of poverty and improving the nutritional quality and quantity of food stocks in rural SW Nigeria as confirmed by the end-line impact report. In addition, the study has identified potential opportunities for entrepreneurial and commercial development which intern could lead to new jobs in local communities. Potential opportunities might include commercial seed production, custom drying of excess UIVs, production of new food products such as fortified cookies, etc. To finally conclude we present a schematic summarizing our UIV production model for SW Nigeria (Figure 25) showing the integration and linkages of the various components investigated in this project. We content that this production model has good potential for application at a much broader scale to alleviate poverty and increase food security in SW Nigeria.

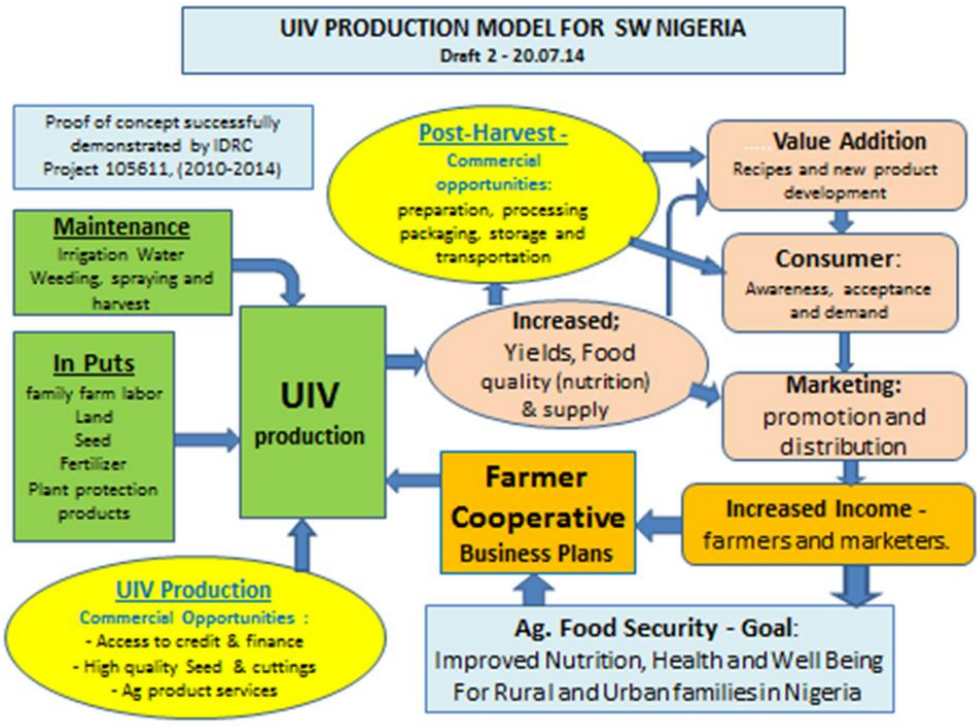

Figure 25. A UIV production model for Southwest Nigeria

6.0 PROBLEMS AND CHALLENGES

1. Government program activities for infra-structure maintenance - We lost substantial portions of our project locations at Inisha and Ilode and as a result of the extensive dredging of the waterways by the Government to solve the problem of flooding in Osun State. The dredging changed the hydrology of the land and made the land unsuitable for dry season UIV production. Also the heaps of rubbish that were excavated from the wide drainage channels were deposited onto our farms. This required unplanned time and resources to clear new land prior to UIV production.

2. Coordination between multiple institutes – pose important challenges for projects in common.

    a. Differences in Administrative structures and requirements for managing funds can result in problems for coordinating research activities in the field.

    b. Task Team collaborations – Inter-institute communications and jurisdictional differences between institutes can affect the functioning of research Task Teams – for example, - administration structures and regulations for travel and field expenses, can affect the efficiency, timeliness and coordination of joint field activities such as soil sampling, monitoring, training, etc., resulting in activities more specific to institutes rather than project.

    c. Integration of research outputs – clarification of publication protocols for research papers and authorship and publication, in addition to those required by the sponsor.

7.0 RECOMMENDATION:

The four principal partners in this project appreciate the timely assistance of IDRC at all times. We have witnessed the positive impact of a Project Manager in building a team approach in our project and helping with overall coordination and timely delivery of our report. We also recommend that any potential follow-up projects should include training and team-building exercises for collaborating scientist from various institutions to facilitate implementation, monitoring and evaluation; establishment and clarification of a project governance; and clearly defining the Institutional roles, flexibilities and responsibilities. We also recommend that IDRC should adopt the policy of having Project Managers appointed for its funded projects. The role of a Project Manager cannot be under-estimated in a multi-disciplinary research of this nature.

8.0 ANNEXES:

1. Team composition

9.0 APPENDICES

1a. Outputs and Publications
1b. Comprehensive documentation of milestones and accomplishments
1c. Gender distribution of farmers and land area allocated to vegetables (in two Tables)
2 Economics Team Reports
3. Food Science Team Reports
4. Gender Team Reports
5. Agronomy Team Reports