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Sensory Qualities of Bread

Ecosystem Services Provision

Highlights

Determinants of Conservation

Security of Farming Communities

Discovering Thoughts, Inventing Future

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Shades of Shade: Determinants of Conservation Practices in Coffee Plantations for Ecosystem Services Provision in Puerto Rico, a Preliminary Analysis

By Laura Villegas
North Carolina State University, United States

Abstract- Ecosystems provide society with a wide range of services—from reliable flows of clean water to productive soil, carbon sequestration and biodiversity conservation among many others. However, private landowners typically lack the incentive to manage their land to provide ecosystem services because many of these benefits accrue to third parties. As a result, land management effects on ecosystem services are often not incorporated into private decision-making, perpetuating suboptimal outcomes that may even harm both human well-being and the environment. To tackle this inefficiency, the use of market instruments and other forms of incentive programs that target resource conservation and provision of ecosystem services in private lands have become increasingly prevalent in environmental policy.

Keywords: *payments for ecosystem services, biodiversity conservation, puerto rico, coffee.*

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Shades of Shade: Determinants of Conservation Practices in Coffee Plantations for Ecosystem Services Provision in Puerto Rico, a Preliminary Analysis

Laura Villegas

Abstract- Ecosystems provide society with a wide range of services—from reliable flows of clean water to productive soil, carbon sequestration and biodiversity conservation among many others. However, private landowners typically lack the incentive to manage their land to provide ecosystem services because many of these benefits accrue to third parties. As a result, land management effects on ecosystem services are often not incorporated into private decision-making, perpetuating suboptimal outcomes that may even harm both human well-being and the environment. To tackle this inefficiency, the use of market instruments and other forms of incentive programs that target resource conservation and provision of ecosystem services in private lands have become increasingly prevalent in environmental policy. In this paper, I develop a micro-econometric model that examines the factors affecting land-owner participation in a variety of biodiversity conservation and agricultural-land management programs and the impacts of these schemes on the adoption of conservation practices among commercial coffee farmers in Puerto Rico. The empirical results indicate that participation in agricultural-landmanagement programs increases the probability of using conservation agriculture practices. In general, the results suggest that farmers who participate in conservation programs encouraging the cultivation of coffee under shaded canopies are "newer" farmers who take advantage of quality differentials in their product and sell it in specialty markets. In turn, the findings suggest that it may be "privileged" farmers who are more likely to adopt shade-management practices. Based on the studied sample, federal environmental agencies interested in improving the targeting of existing programs should be wary of displacing antagonistic state programs that favor a monocrop-type of coffee cultivation as these seem to be, paradoxically, the most important driver of the decision to adopt environmentally beneficial agricultural management practices.

Keywords: payments for ecosystem services, biodiversity conservation, puerto rico, coffee.

I. Introduction

Ecosystems provide society with a wide range of services—from reliable flows of clean water to productive soil, carbon sequestration and biodiversity conservation among many others. Individuals, companies, and communities rely on these services for raw inputs, production processes, food security, climate resilience and other benefits. However, private landowners typically lack the incentive to manage land to provide ecosystem services because many of these benefits accrue to third parties. As a result, land management effects on ecosystem services are often not incorporated into private decision-making, perpetuating suboptimal outcomes that may even harm both human well-being and the environment. To tackle this inefficiency, the use of market instruments and other forms of incentive programs that target resource conservation and provision of ecosystem services in private lands have become increasingly prevalent in environmental policy.

Several previous studies have examined the effects of incentive policies on carbon sequestration, biodiversity conservation, pollination services, habitat fragmentation, agricultural land prices, economic returns from different land-use patterns, provision of spatially dependent ecosystem services, and poverty amelioration in developing contexts.[1] In general, evidence of the effect of incentive programs on the adoption of conservation practices and the efficiency of conservation policies in accomplishing environmental and social development goals is mixed and context-specific. This study contributes to the existing literature devoted to this issue not only by adding another estimation testing the robustness of previous findings, but by exploring new linkages between competing policy instruments, adoption decisions and biodiversity conservation goals. In this paper, I develop a micro-econometric model that examines the factors affecting land-owner participation in a variety of biodiversity conservation and agricultural-land management programs and the impacts of these schemes on the adoption of conservation practices among commercial coffee farmers in Puerto Rico.

There is a broad consensus within the literature that adoption and diffusion of conservation practices are

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[1] See for example Lawler et al. (2014); Lewis and Wu (2014); Lewis (2010); Lin (2010); Polasky and Segerson (2009); Lewis and Plantinga (2009); Nelon et al. (2008); Lewis and Plantinga (2007); Kremen et al. (2007).

the result of a complex decision-making process, particularly when examined at the micro-economic level. Those decisions have been found to depend on a wide array of factors related to agro-ecological factors such as habitat fragmentation and spatial configuration of agricultural lands, farmer demographics and political, cultural and economic institutions of a particular social environment, among others.[2]In Puerto Rico, little research has been done about the status of coffee production, the influence of governmental policies on farming practices and the attitudes of farmers towards production practices that are beneficial to the environment. Therefore, a primary objective of this study is to investigate the factors that determine farmer participation in conservation programs and the impact of said programs on adoption of conservation practices in Puerto Rico.

The preliminary empirical results indicate that participation in agricultural-land management programs increases the probability of using conservation agriculture practices. In general, the results suggest that farmers who participate in conservation programs encouraging the cultivation of coffee under a shaded canopy are "newer" farmers who take advantage of quality differentials in their product to sell in specialty markets. In turn, the findings suggest that it may be "privileged" farmers who are more likely to adopt shade-management practices. Coffee producers in Puerto Rico face the decision to participate in federal incentive programs that encourage in situ biodiversity conservation or in antagonistic state programs that favor the use of monocrop-type-of coffee production methods that may be harmful for the environment. Based on the studied sample, federal environmental agencies interested in improving the targeting of existing programs should be wary of displacing antagonistic state programs, as these seem to be, paradoxically, the most important driver of the decision to adopt environmentally beneficial agricultural management practices.

This paper is organized as follows. Section 2 presents a short description of the agroecology of coffee production and introduces the concept of conservation agriculture and payments for ecosystem services (PES). Section 3 provides a brief review of the microeconomic literature on PES and biodiversity ecosystem services provision. Section 4 introduces and describes in detail the case of coffee farming and biodiversity conservation in Puerto Rico. In section 5, a theoretical framework is elaborated and key insights from this section are used to design and conduct the empirical work of this research. Section 6 presents the empirical methods followed in this study. Data description is followed by a discussion of the econometric methodology that was followed for estimation. This section ends with a presentation of the results from the econometric estimation. This paper ends with section 7 where conclusions and a short discussion of policy implications are presented.

II. The Agro-Ecology of Coffee Production

Coffee is an important commodity traded internationally. The commodity chain comprises growers, harvesters, processors, exporters, importers, shippers and roasters before the end product finally reaches consumers via supermarkets, specialist retailers and coffee shops. Coffee exporting alone is a USD $20 billion industry with tens of millions of people relying on coffee production as their primary form of employment around the world.[3]Coffee is produced and exported by approximately 55 countries, most of which are lower/middle income countries. The largest world producing region is Central and South America, with many of the leading world producers like Brazil, Colombia, and Mexico. Other important producers in the region are Peru, Guatemala, El Salvador, and Costa Rica. As far as production in North American countries goes, coffee plants grow commercially only in U.S. territories of Hawaii and Puerto Rico.[4]

The coffee tree is an evergreen tropical plant which grows in the tropics between latitudes 25°N and 25°S. There are over 60 species of coffee tree but only two dominate world production: Robusta and Arabica—which account for approximately 30% and 70% of world production, respectively. The world's largest producers of Arabica and Robusta coffee are, respectively, Brazil and Vietnam. Robusta coffee is a relatively resilient, high-yielding tree; highly resistant to disease but producing an inferior quality of bean.[5] Most of the global production of Robusta is used in the making of instant coffees.

Arabica, on the other hand, is a more delicate variety producing a more heterogeneous product, the quantity and quality of this bean varies significantly depending on soil, rainfall, altitude, temperature, amount of sunlight, and the cultivation practices followed by growers. Typically, Arabica beans sell for almost twice the price of Robusta beans in the market.

A typical coffee tree, Robusta or Arabica, takes about five years to yield a considerable crop and seven

[2] See the works by Page and Bellotti (2015); Greiner et al. (2009); Kauneckis and York (2009); Amsalud and De gRaffe (2008); De Graffe et al. (2008); Kumar (2007), Birol et al. (2006); Knowler and Bradshaw (2007).

[3] Cooper (2014).

[4] For more information visit the Wikipedia page on economics of coffee: https://en.wikipedia.org/wiki/Economics_of_coffee.

[5] Robusta has higher caffeine content than Arabica (almosttwice as much). Caffeine has a bitter taste butalsoserves as a chemicaldefense for the coffeeseed so that the quantity of caffeine in Robusta istoxic to insects.

to bear at full capacity (about a pound of coffee annually). Such rapid development of a tree that never becomes large suggests a short life. However, one coffee planting is typically unprofitable after 15-30 crops (more or less the same number of years, as coffee is generally harvested once a year).[6]There are four fundamental stages in coffee production: picking, processing (sorting), milling, and storing. Whenever coffee plantations are located in the mountains, which the most frequent case among Central and South American countries—except for Brazil, the picking of fruits (also called cherries) is mostly done by hand. There are two strategies for picking: (1) strip picking, where all coffee fruits are removed from the tree regardless of their maturation, and (2) selectively picking, where only ripe cherries are picked.[7] Selectively picking is very labor intensive because it requires pickers to visit the plantation every 8 to 10 days; therefore, it is only used for harvesting the finest Arabica beans.

A key feature of coffee production (and other fruit crops) is that the future yields from coffee plants decline (and maybe dramatically) when the plants are not maintained or when the coffee cherries are not harvested in a given year. If left unharvested, many "old" fruits will remain in place and limit the space for the formation of new flowers possibly causing significant damage to the tree's carrying capacity. In some cases, only significant investments can restore a coffee plantation where cherries have been left unharvested for a year.[8]

There are grossly two methods for managing a coffee plantation: farmers can produce coffee under a diverse and dense canopy of shade trees or grow the coffee trees without a shade cover. The coffee produced in a system with shade trees is called "shade coffee", its counterpart is called "sun coffee". In the past three decades, shade coffee cultivation has gained widespread attention for their crucial role in biodiversity conservation and ecosystem services provision.[9] Ecosystem services such as pollination, pest control, climate regulation, and nutrient sequestration are generally greater in shaded coffee farms. The botanical diversity contained in these systems provides shelter for a high biodiversity of other organisms—including birds and amphibians—and is therefore considered better for the environment. Other purported environmental benefits of shade management regimes include diminished crop exhaustion, improvement of soil fertility, and increased nutrient availability (due to fallen leaves).[10]

Despite the existence of positive environmental spillovers associated with shade cultivation, a recent trend in production in many coffee-growing regions is reducing the shade cover as this management practice proves economically unsustainable. Sun plantations are more economically attractive to coffee growers because, in the short run, sun-grown coffee trees are believed to produce higher yields than shade-grown trees. Additionally, as the forested structure of the farm makes it difficult to implement mechanized harvesting technologies, the harvesting shade plantations relies primarily on labor, therefore creating an additional dependence for coffee producers on the state of the labor market and the availability of complementary or substitutable inputs. Table 1 compares Sun and Shade Coffee production on various performance indicators. This information was obtained from a report on Mexican Shade Coffee presented to the WTO by Consumer's Choice Council in 2002.

[6] Perfec to and Vandermeer (2015).
[7]Unless climateisdry for anunusually long period of time, orunless some other stochastic in fluences that cause very heavy blossomingveryfast, there will be greenfruit of different ages on the tree at harvesting time.
[8] Batz et al. (2005).
[9] Jha et al. (2014).
[10] Borkhataria et al. (2012).

Table 1 : Comparison of shade and suncoffeeplantations

	Shade	Sun
Production		
Yield	Lower (~25-40%)	Higher
Plants/Hectare	1000-2000	3000-7000
Kg/Ha/Year	550	1600
Lifetime of Plants	24-30	12-15
Side Crops	High	
Flavor	Less Bitter	
Producers	Mostly, small-scale growers	Mostly, large-scale growers
Costs		
Weeding	Lower	Higher
Chemical Fertilizer	Lower	Higher
Pesticides	Lower	Higher
Irrigation	Lower	Higher
Labor*	Higher	Lower
Ecology		
Soil Erosion	Lower	Higher
Soil Acidification	Lower	Higher
Toxic Run-Off	Lower	Higher
Biology		
No. of Bird Species	150	20-50
Proportion Avifauna	2/3	~1/10
Mid-size Mammals	24 species	~0
Other	More species of ants, beetles, epiphytes, amphibians and other	Less species of ants, beetles, epiphytes, amphibians and other

** Not included in the original table.*
Source: Seattle Audubon Society Shade-Grown Coffee Project available here: http://dnr.wi.gov/wnrmag/html/stories/2004/feb04/shadechart.htm

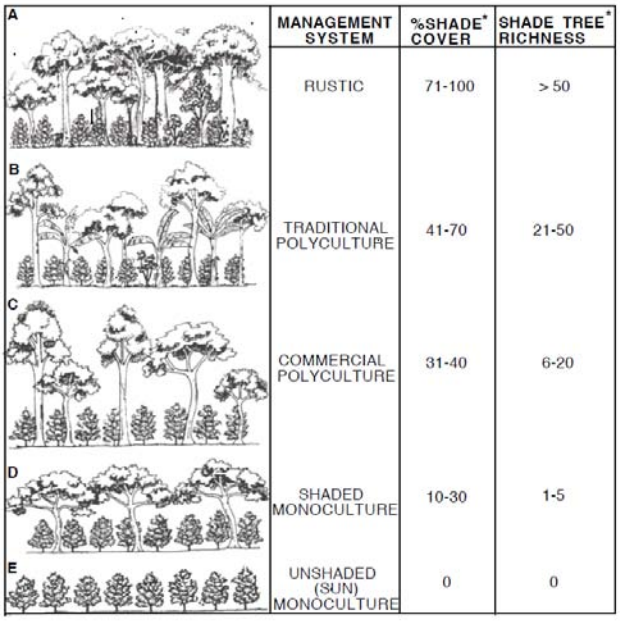
a) Institutional Approaches to Promote Conservation Agriculture

Given the economic, cultural and ecological importance of coffee in Latin America, the conservation/productivity trade-off presents an interesting opportunity to develop programs for sustainable development. Recently, several campaigns have been launched to promote the production and consumption of shade-coffee. One of the emerging strategies is shade coffee certification. Shade-coffee certification seeks to compensate farmers for the biodiversity conservation service provided by their shaded plantations. However, there is an important problem with the certification approach: a variety of shade management regimes exist in the coffee agro-ecosystem and it is not clear that all of them are necessarily good for maintaining biodiversity (see Figure 1). This is often called the "shades of shade" paradox. In general, there are three categories of agroforestry farms: rustic (coffee grown within the existing forest, the coffee plants have replaced some of the native plants); traditional polyculture (coffee is grown among native forest trees and intercropped with planted species that can generate additional income to farmers –like fruits and vegetables); and commercial polyculture (most native trees are removed to provide more space for coffee plants and coffee is mostly grown under planted timber and fruit trees). Such heterogeneity in performance would imply determining different premium prices for particular regions, or even particular farms—which is highly unrealistic and politically unpalatable.

Another policy instrument that is increasingly popular for the conservation and sustainable management of natural resources in Latin America are schemes of Payments for Ecosystem Services (PES). PES are economic incentives offered to farmers or landowners in exchange for managing their agricultural and forest lands to provide some sort of ecological service. PES programs circumvent some of the problems encountered by the certification approach. Explicitly, these conservation programs (whether they are governmental or non-governmental) provide funds or other form of payment (sometimes they are paid in the form of agricultural inputs), increasing the profitability of productive lands without passing on higher prices to consumers. Additionally, PES programs can be tailored as pro-poor development schemes, enabling low-income farmers to earn a reliable stream of income by adopting more sustainable land management practices.

PES programs are popular in Central America and in the Amazon region—particularly for addressing matters of agro-forestry and water management. Nevertheless, and in spite of the push by many international organizations to promote shade coffee production, little is known about how coffee farmers

make decisions about take-up, maintenance, harvest, and abandonment, and therefore about their responses to policies that promote this production practice. In this study, I seek to aid the design of sound policy instruments in the region and improve the scientific understanding of producers' decision-making process by carefully reviewing the particular case of Puerto Rican coffee growers that choose whether or not to participate in conservation programs offered by federal agencies and whose decision may help further broader conservation and environmental goals.



MANAGEMENT SYSTEM	%SHADE* COVER	SHADE TREE* RICHNESS
RUSTIC	71-100	> 50
TRADITIONAL POLYCULTURE	41-70	21-50
COMMERCIAL POLYCULTURE	31-40	6-20
SHADED MONOCULTURE	10-30	1-5
UNSHADED (SUN) MONOCULTURE	0	0

Modified from: Moguel and Toledo 1999; Rain Forest Alliance.

* Figures for percent shade and tree species richness are approximates based on studies cited by Moguel and Toledo, 1999 and our own research (Perfecto et al. 2003).

Figure 1 : Types of shade management systems with shadecover and shade tree richness. Source: Perfecto et al. (2007)

III. Literature Review

In neoclassical economic theory, the existence of market failures justifies regulatory intervention. In general, market failures are situations in which something prevents the market from reaching an efficient allocation of goods and services. In other words, there exists an alternative outcome where someone can be made better off without making someone worse off (in economics lingo, it is said there is an opportunity for a Pareto improvement). The coarse nomenclature of market failures includes externalities, public goods, imperfect information, and existence of market power. The study of the causes of market failures and the possible means of correcting it have important implications for public policy decisions. Policy interventions, such as taxes, price controls, and quotas, are often used to address market failures and reach a more efficient allocation of the resources in question. The case of ecosystem service provision in private lands is one of environmental externalities and impure public goods—goods that are neither wholly public nor wholly private.

The idea behind the PES concept is to provide additional incentives for private landowners to do more, or less, of the target activity in order to produce the socially optimal level of ecosystem services—the level that maximizes social value. In this sense, PES behave as a Pigouvian subsidy for providers of ecosystem services and biodiversity conservation.[11] Theoretically, if the level of payment is set correctly, private agents can reach a socially efficient outcome by means of engaging in otherwise undistorted market interactions. The microeconomic foundations of PES can be visually summarized in Figure 2.

The economic literature studying Pigouvian approaches to solve environmental problems is long, rich and sound. However, the application of Pigouvian approaches to integrate economics and ecology in the study of ecosystem services is a newer initiative and its interdisciplinary nature makes it a vibrant topic in the environmental economics field. Over the past decade, academic progress in the natural resources fields has improved the scientific community's understanding of how ecosystems provide services and how service

[11] A Pigouviansubsidy is a subsidy provided to anactivity that generate sexternal benefits. The logic behind this policy is to to incentivize the production of something whose producto on process generates benefits to third parties. For more detailsee https://en.wikipedia.org/wiki/Pigovian_tax.

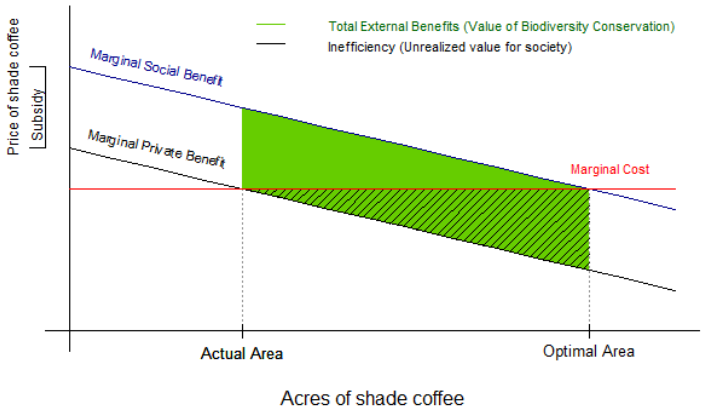


Figure 2 : Illustration of a Pigouvian Subsidy

provision translates into economic value.[12] Yet, there is much criticism over the approaches and assumptions used to study the relation between nature and economics. Common approaches to valuation often lack scientific foundation, or that lead to research that provides information that is largely irrelevant for answering complex policy question. Thus, moving from general pronouncements about the benefits nature provides to credible, quantitative estimates of ecosystem service values has been difficult.[13]

Nevertheless, recent advancements in computer technology and increased computer power has allowed researchers to incorporate more and more diverse information into scientific analysis, triggering an enormous amount of activity among focal natural resources researchers including environmental economists, ecologists, geographers, biologists and earth scientists. Between 2002 and 2015 the interdisciplinary literature examining ecosystem services provision and biodiversity conservation from a microeconomics framework grew rapidly. Recent studies have examined the effects of incentive policies on carbon sequestration, biodiversity conservation, pollination services, habitat fragmentation, agricultural land prices, economic returns from different land-use patterns, provision of spatially dependent ecosystem services, and poverty amelioration in developing contexts.[14] In general, evidence of the effect of incentive programs on the adoption of conservation practices and the efficiency of conservation policies to meet environmental and social development goals is not definite.

The problem of how to optimally allocate habitat for species conservation has been addressed previously.[15] The objective of these studies is to select reserves to maximize the number of protected species subject to a constraint on the total area of reserved land. Economists have also contributed to this literature.[16] Several authors have examined questions of optimal targeting of conservation incentives (including voluntary incentives) for furthering some environmental goal—such as reducing forest or habitat fragmentation, or enhancing the provision of ecosystem services like carbon sequestration and pollination.[17] However, few studies have developed methods to explicitly connect policy impacts on private land-use decisions and the resulting change ecosystem services provision.

Among the most complete and sophisticated works found in the recent literature, is the study conducted by Lewis et al. (2011) which addresses the efficiency of voluntary incentive-based policies in achieving biodiversity conservation objectives. In this study, researchers build off of their previous works on conservation planning and incentive-based policies.[18] The researchers develop a sound method that integrates an econometric model of private land-use decisions, landscape simulations, spatially explicit data, a biological model that estimates species persistence, and an algorithm that approximates a set of efficient solutions. The general result from this study is that voluntary incentive-based policies are often highly

[12] The field of research on topics of ecosystem services provision has benefited from support of large initiatives such as the EPA's establishment of the Science Advisory Board to study the valuation and protection of ecological systems and services in 2003, the 2005 UN Millennium Ecosystem Assessment, and joint ventures among private institutions like the Natural Capital Project which was launched in 2006.

[13] Nelson et al. (2009).

[14] See for example Lawler et al. (2014); Lewis and Wu (2014); Lewis (2010); Lin (2010); Polasky and Segerson (2009); Lewis and Plantinga (2009); Nelon et al. (2008); Lewis and Plantinga (2007); Kremen et al. (2007).

[15] See for example, Kirkpatrick (1993); Vane-Wright, Humphries and Williams (1991); Fischer and Church (2003); and Onal and Briers (2003).

[16] Ando et al.(1998); Wy, Zilberman and Babcock (2001); Polasky, Camm and Garber-Yonts(2001); Costello and Polasky(2004); Newburn, Berck and Merenlender(2006); and Polasky et al. (2008).

[17] Lewis and Plantinga(2007); Lewis et al. (2009); Lubowski et al. (2006); Kremer et al., 2007).

[18] see Lewis and Plantinga(2007); Nelson et al. (2008); Polasky et al. (2008); and Lewis et al. (2009).

inefficient in achieving conservation objectives with the inefficiency of incentives in improving biodiversity arising primarily from the inability of regulators to control the spatial pattern of landscapes with a voluntary payment mechanisms.

As for the literature examining adoption and diffusion of conservation practices, there is a broad consensus within the literature that these decisions are the result of a complex process, particularly when examined at the micro-economic level. Those decisions have been found to depend on a wide array of factors related to agro-ecological factors such as habitat fragmentation and spatial configuration of agricultural lands, farmer demographics and political, cultural and economic institutions of a particular social environment, among others.[19]

For the particular case of Puerto Rico, little research has been done about the status of coffee production, the influence of governmental policies on farming practices and the attitudes of farmers towards sustainable production practices. The most recent study on farming practices and attitudes towards conservation was conducted by Borkhataria et al. (2012). The findings in this paper suggest that farmers prefer to grow shade coffee but grow sun coffee in order to qualify for incentives established by Puerto Rico's Department of Agriculture. In the following section, the specific case of coffee farming and incentive programs for and against biodiversity conservation in Puerto Rico is explored in detail. As it is understood from reviewing the rich history of research and experimentation in the area of environmental policy, in conducting this study, I stand on the shoulders of giants. Nevertheless, as the field of environmental economics grows more dynamic and computer savvy, it becomes apparent that the present study is more than "new wine for old bottles". In incorporating new methodologies and tools into the sturdy foundations of neoclassical economic theory, this study contributes to the development of the fields of economics, ecology, and policy-making.

IV. The Case of Habitat Conservation among Puerto Rico's Coffee Producers

In 2013, the Puerto Rico Department of Natural and Environmental Resources (PR DRNA) published its new habitat conservation strategy, which seeks to ensure the long-term persistence of resident species of birds and amphibians. As part of the strategy, the DRNA requires an increase in the share of protected habitat area in the island from 8% to 15% (that increase would require another 62,250 hectares of land). The Department established a priority for targeting five of the eleven habitats in the island (the five habitats for which less than 15% their area is currently covered by the standing boundaries of official protected areas). These five habitats are, in essence, variations of the secondary wet forest habitat and share similar geographical location in the island, the central south west (see Figure 3).

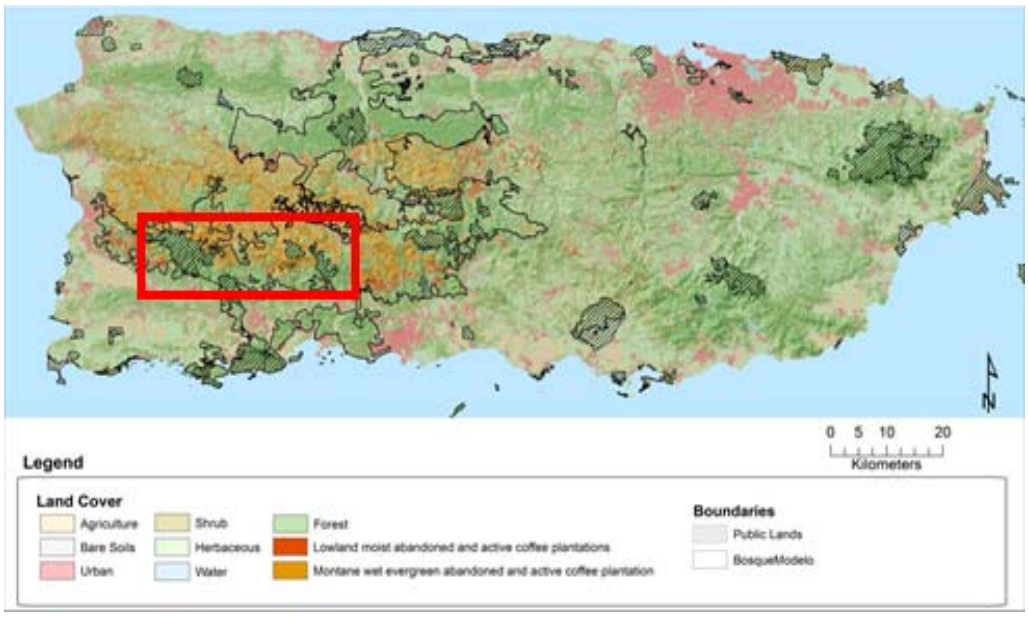


Figure 3 : General Target Area

[19] See the works by Page and Bellotti (2015); Greiner et al. (2009); Kauneckis and York (2009); Amsalud and De gRaffe (2008); De Graffe et al. (2008); Kumar (2007), Birol et al. (2006); Knowler and Bradshaw (2007).

Interestingly, the focal area of the conservation project, where these five priority habitats are found, overlaps with the strongest coffee producing region of the island. The DRNA has limited resources and is therefore interested in finding a way to reach the conservation target area without having to purchase private land. An attractive alternative is to take advantage of the ecological benefits that conservation agriculture practices offer. Thus, the DRNA has expressed interest in improving the efficiency of existing biodiversity conservation programs that target land-management practices among coffee growers.

In 2013, the DRNA selected an interdisciplinary group of researcher to conduct a comprehensive study to guide the Department's decisions regarding the allocation of funds and efforts to meet the agency's goal: to increase the conservation area from 8% to 15% in the region of the island where most of the secondary wet forest habitats are. The project involves state, federal, academic and NGO agencies, including researchers from North Carolina State University (NCSU), the South East Climate Science Center (SECSC), PR Department of Agriculture (PRDA), the US Fish and Wildlife Service (USFWS), the National Resources Conservation Service (NRCS), and Puerto Rico's Centro para la Conservación del Paisaje (CCP) and Casa Pueblo.

Between 2013 and 2015, a team of ecologist and geographers gathered data to determine the "optimal area of influence" of the project. Said area was defined as the patch of private land that performed best at meeting the following four conditions: maximizing the area within the "Bosque Modelo" (a political definition of certain zoning class in the island); maximizing the area of natural conservation areas already protected; hosting secondary wet forest habitats (priority habitats); and being located where the dominant economic activity is coffee agriculture. The final selection of land consisted of 44,174 hectares (18,076 short of the DNRA target). Based on the results of the geographical analysis, a socioeconomic survey was distributed to a random sample of coffee farmers within the selected area. The sample included 124 coffee farms in 12 municipalities. Figures 4-9 illustrate the process followed for finding the target area from which farmers were randomly selected.

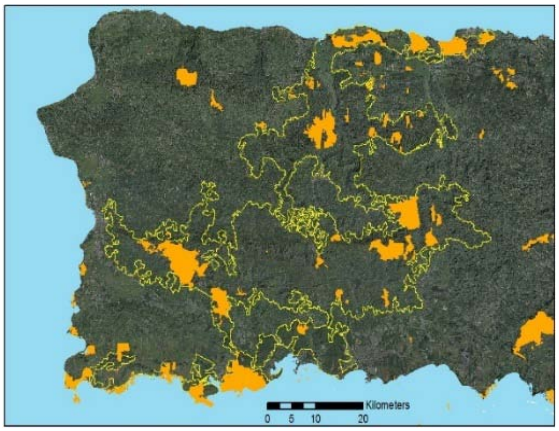


Figure 4 : Conservationzones (orange)

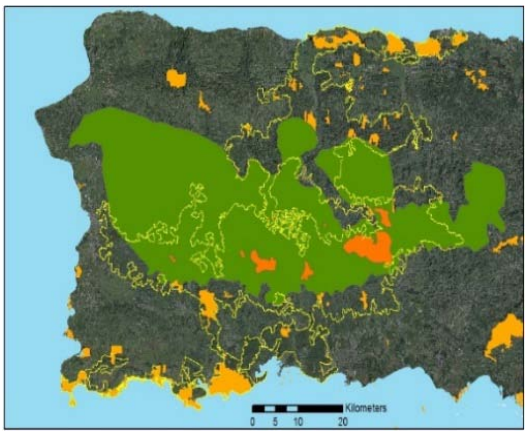


Figure 5 : Secondarywet forest

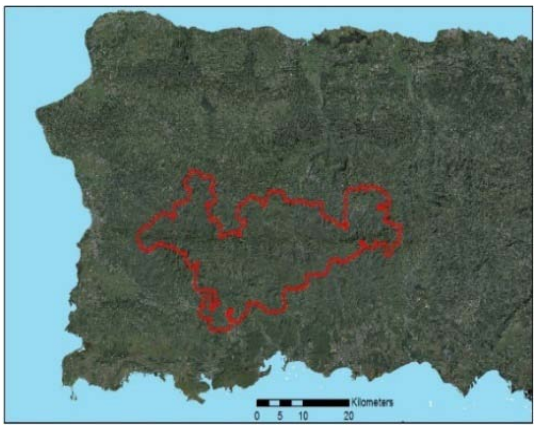


Figure 6 : Target Area

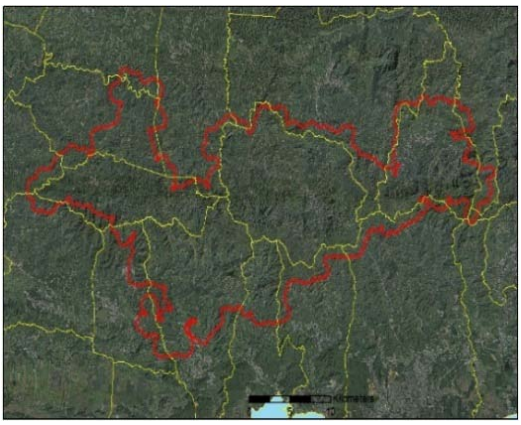


Figure 7 : Target Area and boundaries

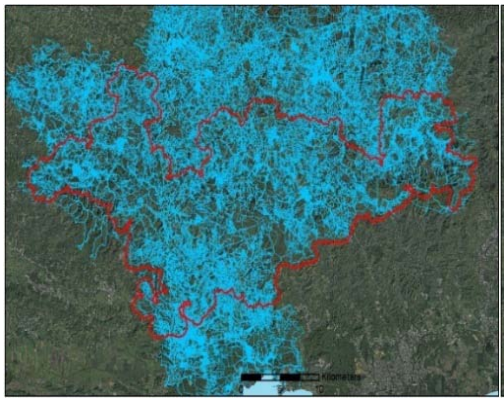


Figure 8 : Target Area and Properties

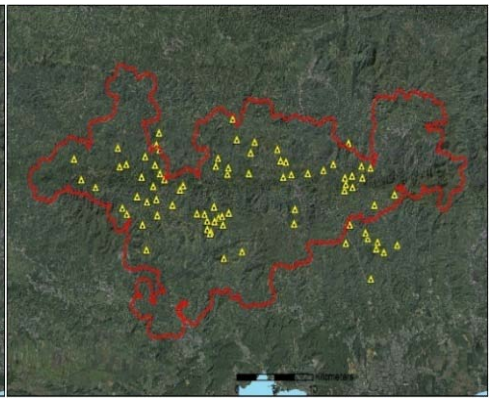


Figure 9 : Target Area and SurveySites

a) *The Economic Incentives of Coffee Farming in Puerto Rico*

As presented so far, the case of conservation agriculture in Puerto Rico seems entirely ecological. However, there are standing, and competing, economic institutions and incentives of both governmental and non-governmental nature, which can ultimately determine whether the DNRA's strategy to increase the conservation area succeeds or fails.

Traditionally, coffee has been an essential commodity for Puerto Rican consumers and producers, and coffee cultivation in the island has a long history of government involvement.[20] In the recent past, support for the crop has included guaranteed price floors to producers, protection against international competition though the imposition of high tariffs, crop insurance, extension programs, wage subsidies and direct government payments. Since the late 1960s, the Department of Agriculture of Puerto Rico (PRDA) has encouraged coffee farmers to take up intensive farming without auxiliary shade trees in the plot to increase yields. To encourage sun coffee cultivation, the government uses subsidy programs and conditional insurance terms.

Government subsidy programs involve conditional cash and in-kind assistance (farmers receive fertilizer or pesticides). They also include economic aid for investment in specialized machinery, distribution of fertilizers and pesticides, access to extension services, and wage subsidies to reduce the costs of labor to farmers. In turn, the PRDA offers insurance products that focus on ameliorating costs from catastrophic environmental events, like hurricanes. Producers of sun and shade coffee have access to insurance and at the same cost. However, the perception is that shade coffee is of high risk to the coffee plants during catastrophic events (for example, falling trees will damage the crop during a hurricane). Therefore, growers of shade-coffee face less attractive insurance terms; for instance, shade coffee growers receive less insurance money back in the event of a catastrophe and, in addition, the cost of replacing the shade trees is not covered by the insurance.

Government programs seemed to have had certain success. Figure 10 shows farmland devoted to shade and sun coffee between 1980 and 2007, and Figure 11 shows total number of coffee farms growing shade and sun coffee in the same period of time.

[20] Borkhataria et al. (2012).

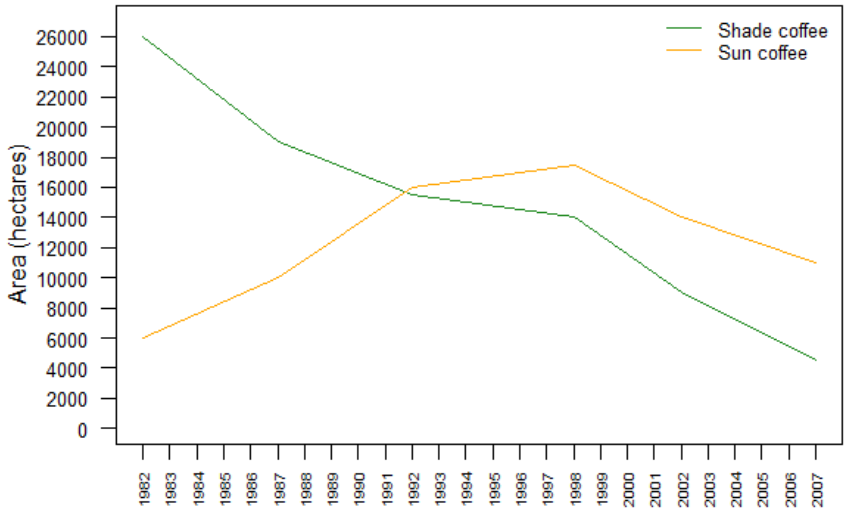


Figure 10 : Farmlandundershade and suncoffee. Source: USDA Census, 2012

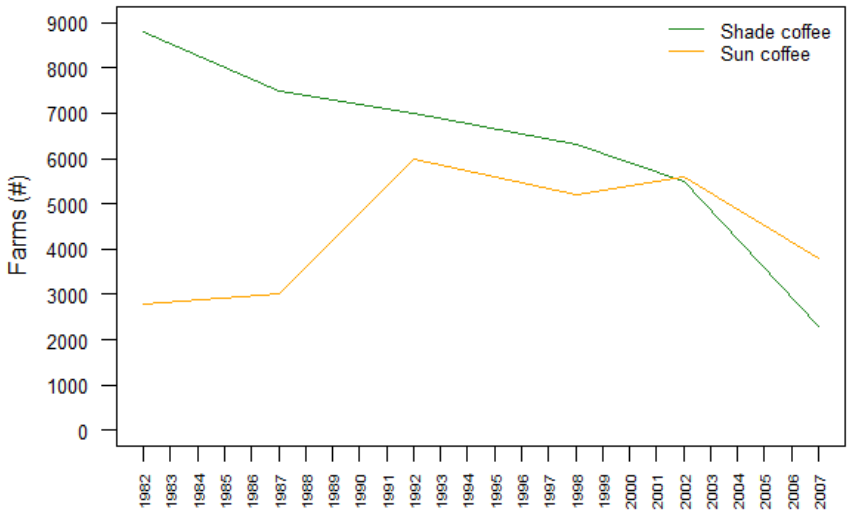


Figure 11 : Farms growing shade and suncoffee. Source: USDA Census, 2012

The apparent increase in farms practicing of sun monoculture has inspired concern among conservation agencies and since the early 2000 a consortium of organizations that include the NRCS and the USFWS has been involved in restoring the shading canopy in coffee plantations in the island. The restoration project in Puerto Rico focuses on promoting the transition from sun to shade coffee among farmers by providing the shade trees, funds and technical assistance. Under the NRCS and USFWS subsidy program, farmers are required to convert at least a third of their farm to shade. Beneficiaries receive the shade trees for free and some fixed amount of money ($8) per tree planted. The number of trees a farmer receives depends on the land that is converted to shade coffee. Also, the support is only offered once, upon adoption.

It is unclear whether federal programs targeting biodiversity conservation have been successful at nudging farmers to transition from sun to shade cultivation practices. There is a general lack of coordination between the agencies and the data collection and record is unorganized. Furthermore, there appear to be other incentive programs in place but their definition and function is rather unclear to farmers and researchers. An imperative threat to the validity of the findings resulting from the current investigation involves the confounding effect of these uncertain programs.

A preliminary review of the socioeconomic survey distributed by CCP in 2015, shows that 18% of farmers do not participate in any of the incentive programs (for sun or shade), 29% receive subsidies for cultivating both sun and shade coffee, 50% receive only PRDA (sun) incentives and 3% receive only federal (shade) incentives. According to this survey, the most popular incentive program is the PR Department of Agriculture's fertilizer subsidy program with 93% of

participants applying and receiving benefits from this program, followed by the wage subsidy program (53%), the assistance for new sun coffee farmers (48%), the NRCS shade coffee program (27%), and the DA's subsidy for returning sun farmers (13%). Table 2 shows the percentage of program participants that receive benefits from a particular agency involved in distributing incentives.

Table 2 : Program participants by provider agency. Source: CCP Surveys, 2015.

USFWS	NRCS	PRDA	NRCS+PRDA	USFWS+PRDA	PRDA+NRCS+USFWS
0%	1%	60%	30%	3%	6%

b) Coffee Markets in Puerto Rico

Puerto Ricans consume around 30 million pounds of coffee per year—that's nearly 8.3 pounds per person per year. However, the island only produces a fraction of what it demands. Once a strong coffee producer with large markets in both the U.S. and Europe, Puerto Rico's coffee sector has been in sharp decline in the last decades, with growers increasingly leaving the coffee business and abandoning coffee farms. Figure 12 shows a time series of area harvested, tons of coffee produced and coffee yield in Puerto Rico between 1961 and 2012. The contraction of the industry is undeniable. Since 1990, production has fallen by 63% and total land area devoted to coffee has declined more or less by half (from 32,114 ha to 15,144). In this time, the land devoted to shade coffee decreased nearly by 80% while cultivated sun coffee area increased by 65% (see Figures 10 and 11).

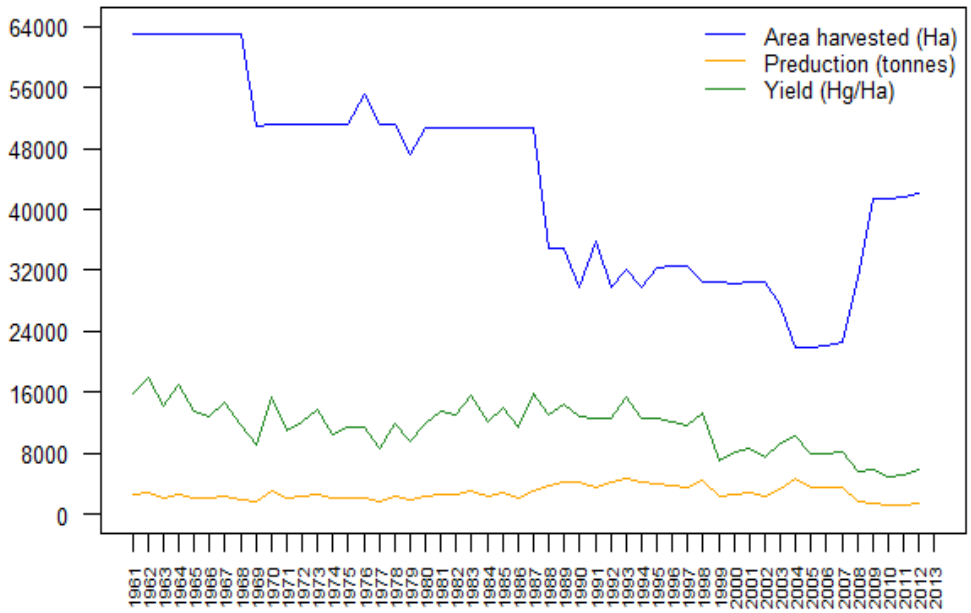


Figure 12 : Coffee Production in Puerto Rico (1961-2012). Source: FAO, 2015

The recent decline in coffee production may have something to do with the PR Department of Agriculture incentives programs (initiated in the 60s) and the conditional insurance; however, there is reason to suspect that many other more structural causes tightly related to Puerto Rico's economic model are behind the recent decline. Large up-front costs, a tight labor market, sluggish markets for fertilizer and seeds, pest emergence, and output market rigidities could be among the important obstacles that coffee growers face.

One of the main problems for Puerto Rican coffee growers is the lack of hirable "pickers". The harvesting/picking of coffee cherries is one of the most important stages in coffee production, not only because it determines current final output but because it has implications for future harvests.[21] In addition, Puerto Rico's coffee plantations are located in the mountains; therefore, the picking of fruits (cherries) is mostly done by hand. Informal local sources report that as much as 35% of the crop is lost every year because there are no workers to pick it.[22] To some extent, the shortage of coffee workers may be caused by rigidities in input markets and government price controls. More

[21] A key feature of coffee production is hat the future yields from coffee plants decline—may be even dramatically—when plants are not maintained or when the coffee cherries are not harvested in a given year.

[22] "Puerto Rico faces lowest coffee production ever". Jamaica Observer (May 24, 2013). Accessed April, 2016. Found here: http://m.jamaicaobserver.com/mobile/digicel/business/Puerto-Rico-faces-lowest-coffee-production-ever_14323278

specifically, the fact that Puerto Rico is a U.S. territory means that it is covered by US federal minimum wage laws, making a labor-intensive activity like coffee production uncompetitive relative to neighboring Caribbean nations and therefore unattractive as a business. The case may be even worse for growers of shade coffee as shade plantations require more labor than sun plantations—partially for maintenance of the canopy and partially because it is more technically challenging to implement mechanized harvesting technologies.

Lack of seeds, increases in the cost of fertilizer and emergence of pests are also blamed for the drop in production (not to mention the lack of workers to spray fields with pesticides and fertilizer). In the output market, other factors affecting the profitability of the coffee industry include regulations and government imposed rigidities. In Puerto Rico, coffee prices are fixed and are kept artificially low. Only growers producing a sufficiently high quality of bean are able to export their product and therefore receive higher prices that will keep them competitive.[23]

Shade coffee is of better quality than sun coffee and, in theory, growers of shade coffee should be able to sell their product for a premium. In practice, however, market failures like transportation costs and presence of monopsonistic power, prevent farmers from reaching high-value markets. Reaching the gourmet market almost certainly entails the farmer processing, grinding, roasting and certifying its own product. Becoming a certified coffee producer is an imminent hurdle for first time coffee farmers, and even though the industry has seen a trend towards vertical integration, the majority of farmers still simply sell bags of unprocessed mixed coffee beans.[24] Furthermore, in Puerto Rico there are few large coffee processing corporations with monopsonistic power that can "coerce" growers into selling their good quality coffee for low prices.[25]

Other relevant up-front costs keeping farmers from reaching high-price markets may be related to current management practices. For instance, if top soils are depleted due to the long-term use of sun cultivation practices, farmers may have to incur in large expenses to rehabilitate the land. Additionally, if farmers wish to transition from sun to shade coffee, they will have to wait around five years after the first planting to see the first useful harvest of coffee cherries (although it takes a plant 2-4 years to produce cherries that are ripe enough to harvest).

As described above, the reasons behind the recent drop in production are many and possibly inter-related. The data collected by CCP, together with commentary data from the USDA and other sources may offer an opportunity to explore the importance of these institutional factors in explaining the overall decline in coffee production at the macro-economic level and in explaining farmer behavior at the micro-economic level. The completion of this analysis remains a secondary goal of the current study but may be revisited in future research.

V. Theoretical Discussion

At the microeconomic level, the agents of interest in this problem of ecosystem services provision in Puerto Rico are coffee farmers. The fundamental assumption of economic theory is that the objective of coffee farmers is to maximize the value of their plantation for as long as they are in the business of coffee production—this is what economists call *rational behavior*. Coffee farmers choose what to do with their land in order to meet their economic goal: to maximize the stream of expected discounted profits their land can support. In a given year, coffee farmers consider current and historic values of net revenues in all alternative economic uses to their land to form static expectations of future returns. Every year, based on these expectations, farmers choose to continue their current practices, to change management practices, or to switch to different economic activities altogether.

The Puerto Rican coffee farmer problem can be modeled as an adoption problem in presence of environmental externalities. In this model, farmers choose whether or not to adopt the shade management regime or to abandon their plantation altogether based on expected market performance and government subsidies when available. In addition to predicting farmer behavior, this theoretical framework allows for the explicit characterization of the decision-making process, facilitating researchers to address questions of policy efficiency. With this simple model, the optimal level of PES can inferred—the level of payments that nudges farmers to grow the amount of shade coffee leading to the socially efficient provision of ecosystem services. Of course, the answering of this question entails knowing the ecological functions of coffee farm systems and the social value of the ecosystem services produced in coffee farms.

The strategy for answering the questions posed in this paper is to find the stream of expected discounted profits that makes a farmer indifferent

[23] In 2015, imported coffee was set at $3.22 per pound while prices for local coffee beans were $3.79 per pound.

[24] According to a Marketing study, Puerto Rican farmers mostly sold their products to local supermarkets (73%), ordirectly to the consumer (32%). Of those farmers selling to supermarkets, 54% were large farmers, 30% small farmers and 15% médium farmers. The majority (89%) of small farmers reported selling through other channels such as Internet sales ordirectly to the consumer in farmer markets (Alamo et al., 2006).

[25] Since 2013, the Puerto Rico Coffee Roasters company, a branch of Coca-Cola, owns around 85% of Puerto Rico'scoffeebrands ("Coca Cola and the Puerto Rico Coffee Industry: A Double-EdgedSword?" May, 2016.https://repeatingislands.com/2013/06/23/coca-cola-and-the-puerto-rico-coffee-industry-a-double-edged-sword/).

between cultivating shade and sun coffee. Having estimated the monetary difference, the goal is to derive an expression for the value of the external benefits from shade plantations that justifies different levels of a subsidy on low-yielding shade coffee. In what remains of this section I will formulate a simplified version of the coffee farmer's decision-making problem. In the design of the model I will assume separability between consumption and production decisions; complete labor, credit and insurance markets (although the latter may not be the case according to some anecdotal evidence); fixed output prices for coffee; and no quality differentials (see discussion on accessing premium price markets). Further, I will assume there are no distortions in the input markets (labor, land, fertilizer, pesticides and irrigation water).[26] I will also assume there are no land quality differentials between farmers and that once a farmer chooses to grow shade or sun coffee he devotes all his "coffee-land" to one or the other but not both. Finally, it will be assumed that shade increases longevity of coffee plants so that shaded plantations are profitable for more crops than sun plantations and farmers have a longer stream of expected profits; that the type of trees used for shade eliminate farmers' need for pesticides, fertilizer and irrigation water;[27] and that yields from shade plantations are 30% lower than those from sun plantations.

a) A simple Model of Adoption in Presence of Externalities

From the above discussion, it follows that a farmer adopts shade management practices if he considers this to be a more profitable practice over time. For illustration purposes, I will present the adoption of shade-management regime decision as a multiple stage problem where adoption occurs at the first stage. In this illustrative exercise, a farmer that uptakes the shade-plantation strategy foregoes 5 years of coffee revenues and once the plantation starts producing at full capacity, yields are lower than yields from an analogous sun coffee farm. However, the adopting farmer will receive a stream of profits that outlasts those of the sun plantation by up to $T + 5$ periods, where T is the lifespan of a sun plantation.

Take F to represent fixed costs of transitioning from sun to shade cultivation. Then, the expected, discounted, stream of profits from transitioning to a shade farm is:

$$E_0 \sum_{t=0}^{2T+5} \delta^t \pi_{sh} = -F + 0 + 0 + 0 + 0 + E[\delta^6 \pi_{sh} + \delta^7 \pi_{sh} + \cdots + \delta^{2T+5} \pi_{sh}] \quad (1)$$

And the stream of profits from a sun farm is:

$$E_0 \sum_{t=0}^{T} \delta^t \pi_{su} = \pi_{su} + E[\delta \pi_{su} + \delta^2 \pi_{su} + \cdots + \delta^T \pi_{su}] \quad (2)$$

A farmer will adopt the shade regime if (1) is larger than (2). In this case, the positive externality of the shade plantation is realized. The social benefit has two components: increased agricultural wealth via spill-over effects onto the productivity of other farms and the intrinsic value of biodiversity. On the contrary, if (2) is greater than (1) a farmer will cultivate sun coffee. It is under this scenario where it is relevant to address the question of what value of external benefits justifies different levels of subsidies nudging farmers to grow the less profitable variety of coffee.

The specific questions of interest in this study are the following:

1. When is (1)≦ (2)?
2. If (1) < (2), what level of subsidy will bring (1) to equal (2) plus a miniscule additional benefit that is enough for the farmer to prefer shade over sun coffee?

If some structure is imposed to the analysis, a brief pick at equations (1) and (2) may reveal useful insights. For instance, assuming that the yield differential between sun and yield coffee is of 30% and that this yield differential directly translates into a profits differential of 30%[28]; further assuming a discount factor of 0.99, and a lifespan of 15 years for coffee trees grown under a sun regime (T=15), then equations (1) and (2) are equal when:

$$-F + E_0 \sum_{t=6}^{2T+5} \delta^t \pi_{sh} = E_0 \sum_{t=0}^{T} \delta^t \pi_{su} \quad (3)$$

$$-F + 0.7 \cdot E_0 \sum_{t=6}^{35} 0.99^t \pi_{su} = E_0 \sum_{t=0}^{15} 0.99^t \pi_{su} \quad (4)$$

$$0.7 \cdot E_0 \sum_{t=16}^{35} 0.99^t = 0.3 \cdot E_0 \sum_{t=6}^{15} 0.99^t + \frac{F}{\pi_{su}} \quad (5)$$

$$10.85 = 2.7 + \frac{F}{\pi_{su}} \quad (6)$$

$$8.15\pi_{su} = F \quad (7)$$

[26] Although in reality there are wage subsidies to farmers, in the mean time, I will abstract from this fact to make the model more tractable.

[27] Depending on the trees used to create a dense shadecanopy, the shade trees can reduce farmers' costs. Certain trees can help fix nitrogen to the soil, reducing the need for fertilizer. Also, if the trees helpsoak more wáter in to the soil, farmers of shade coffee do not need to apply as muchwater to theirplots. Additionally, the trees can help reduce farmers' need for pesticides in two ways. First, the shade and fallen leaves help suppressw eeds and fungi; and second, by providing an enhanced habit at for ants, birds, and lizards the tree shelp decrease the abundance of insect pests in coffee plantations(Borkhataria et al., 2012).

[28] These parameters are taken from the literature documenting yields of sun and shade coffee plantations in Mexico (see Table 1).

According to this naïve arithmetic exercise, a farmer will be indifferent between growing shade and sun coffee if the annual profits are 8.15 times the costs the farmer bears for transitioning into shade coffee. Thus, a subsidy program looking to achieve this end would provide the farmer with lump sum payments with the present value of $8.15\pi_{su}$.

Of course, this is not an accurate result as it ignores changes in input choices and the substitutability between labor and capital inputs under different production regimes. To account for this differences, it is precise to find the optimal levels of labor and fertilizer a farmer chooses when growing sun or shade coffee. To derive comparative statics that pin down this substitutability between labor and capital inputs (fertilizer/pesticide/irrigation) and the change in costs, it is useful to set up the farmer's decision-making process as a standard profit maximization problem. A simple model of conservation practice adoption in presence of externalities is included in the Appendix section of this paper.

b) Insights from Modeling

If it were possible to parameterize and solve explicitly the model presented above, it would also be possible to compare the stream of profits a Puerto Rican farmer expects to attain by growing shade or sun coffee. In turn, the optimal level of subsidy for ecosystem services (improved soil fertility, increased habitat for wildlife, and decreased erosion) would correspond to the amount that would make a farmer indifferent between these two streams.

Under the highly restrictive model (included as an Appendix), the key to find the optimal level of subsidy is to pin down the change in production costs to a farmer that chooses to transition from sun to shade coffee. Specifically, the parameters that will allow the assessment of this transition are the elasticity of substitution between labor and the capital input in the production of sun coffee, and the size of the externality. If the reduction in capital input costs outweighs the increase in labor input costs that would be necessary to keep production of shade coffee on par with yields from a non-shaded plantation, and if the subsidy allows a farmer to cover the upfront fixed costs of planting the shade canopy and forgone profits of the first 5-7 years of production, then a Puerto Rican coffee farmer should find it lucrative to switch into a shade management regime. On the other hand, if increases in labor requirement translate into substantial increases in cost (particularly relevant given the scarcity of labor), a farmer would only choose to grow shade coffee is the subsidy not only covered the upfront cost and forgone profits of the first 5 years, but also the annual economic losses for the following 30 years.

On a final note, and looking ahead towards future research, it seems important to explore the role of potential income effects on production decisions. Apparently, Puerto Rican coffee farmers are increasingly willing and able to become small producers and processors of specialty/gourmet coffee.[29] This trend may be partially explained by the increased importance of non-farm activities as sources of household income. Said shift in livelihood orientation may impact attitudes towards risk and risky farming practices (such as growing shade coffee). If the impact to be positive, then we may find that the level of subsidy necessary to incentivize farmers to grow shade coffee is actually lower than anticipated. The opposite is true if non-farm wages are associated with tighter liquidity constraints and higher risk aversion among coffee farmers.

VI. Empirical Analysis

In this section a description of the datasets used for estimating the effect of policies on adoption of conservation practices. Data description is followed by a discussion of the econometric methodology that was followed for estimation. Finally, this section ends with a presentation of the results from the econometric estimation.

a) Data

For the preliminary empirical analysis of this project I use cross-section farmer data from a survey conducted by the Centro para la Conservaciondel Paisaje (CCP) in 2015. Ideally, in the near future I will complement this dataset with historical agricultural data from the USDA census and historical records of program participants and benefit receipts made available by the US FWLS, NRCS and PRDA.[30] Below I describe the survey data.

Between September and December, 2015, the CCP conducted interviewed 89 coffee farmers in 12 Puerto Rican municipalities in the west-central region of Puerto Rico—Adjuntas, Ciales, Guayanilla, Jayuya, Juana Diaz, Lares, Las Marias, Maricao, Ponce, Sabana Grande, Utuado and Yauco.[31]Farmers in the survey ranged in age from 12 to 86, with the average age being 59. About a third of respondents had a bachelor's degree or higher, another third high-school degrees, and the remaining third had below middle school attainment. The majority of them were land owners (82%) and although there was reasonable variance in length of ownership (fairly uniformly distributed between 0 and 40 years), the majority had substantial experience

[29] Alamo et al. (2006).

[30] Unfortunately, at the moment such data is unavailable. It turns out that finding "public" data in digital format for Puerto Rico is much more difficult than one would expect. Currently, there are no spreadsheets available containing PR Agricultural Census Historic data; the data is only available in pdf format of the original publications. In addition, permission is needed from the territory's officials to access the US FWLS and NRCS data.

[31] Information about the CCP's involvement in the DRNA's project can be found here: http://ccpaisaje.org/node/59.

with coffee growing activities with more than two thirds of the sample having grown coffee for more than 20 years.

The average farm size was 65 acres but farms varied between 2 and 750 acres. On average, 51% of total farmland was planted with coffee, the remaining land was forested land or was used for other purposes. About 34% respondents were growers of both sun and shade coffee, 28% only produced sun coffee, while the remaining reported producing coffee under shade or semi-shade conditions (22% and 16%, respectively).

Farmers in the sample were primarily producers for commercial purposes—74% of respondents sold coffee beans, and of those, 9.5% sold their coffee to gourmet markets; 19% of all interviewees had processing equipment; and 7% had equipment for coffee milling. The average price received per pound of coffee cherries of average quality was $0.52, but it varied according to buyers from $0.46 to $0.58.Most farmers planted a variety of other crops with their coffee trees. About 12% of respondents reported using all their farmland for coffee farming, but of those that planted

Table 3 : Characteristics of farmers in the CCP Survey by participation status

	Total Sample	Any Program	FWS incentives	NRCS incentives	PRDA incentives	PRDA wage-subsidy
Percentage of farmers involved		82%	5%	31.5%	80.9%	43.8%
Percentage growing sun coffee only	34.8%	35.6%	20%	21.4%	36.1%	38.5%
Av. land size (in cuerdas)*	67.14	72 cuerdas	91.6	116.42	71.77	90.13
Av. land holdings	70.67	76.3	120.4	123	75.72	97.42
Av. time as manager (years)	20.9	20.68	16	16.79	20.97	21.03
Av. area in coffee cultivation	22.53	26.16	76	39.68	25.414	36.43
Av. age	58.63	57.51	64	56.61	57.93	59.15
Av. Farm income (annual)	16,000	18,300	60,000	28,000	18,600	30,100
** 1 cuerda = 0.9 acres*						

other crops, the majority kept their produce for personal consumption.[32]

Farm incomes were low in general—below $30,000 for 82% of the respondents, and below $10,000 for 49% of respondents. Not surprisingly, respondents reported non-farm sources of income had become increasingly important for coffee growers. About 78% of the respondents were participants in local state incentives (favoring sun coffee), 32% participated in federal programs (favoring shade coffee), and 18% did not participate in any program. Around 29% of the simple received benefits from both federal and state program. Table 3 provides a summary of the profile of participant and non-participant farmers surveyed by CCP in 2015.

To complete building the profile of a typical coffee farmer in the coffee-producing region of the island, I will use results from a comparable survey from a recent study of 96 farmers in three Puerto Rican municipalities in the central region—Ciales, Utuado and Jayuya.[33] This study found that coffee growers relying mostly on coffee profits as their source of income had been in decline. Apparently, 34% of farmers in their study made the majority of their income from coffee in 1992; 16.8% did so in 2002, and 23.6% in 2007. Importantly for the project at hand is that for the majority of farmers (93%), family was an important source of labor. Of these 93%, 73% complemented family labor with hired labor during harvest. The remaining 9% had permanent employees.

Finally, responses in this complementary study, show that hurricanes were perceived as the most important obstacle to coffee production. Other obstacles reported as important included lack of capital, unavailability of workers, erosion, insect damage, nutrient deficiencies, and fungal damage. About half of the respondents had some crop insurance. More sun coffee farmers insured their crops than did farmers of shaded coffee (56% of sun growers against 34%of shaded coffee growers) but few farmers had difficulties finding insurance and the different impediments reported did not differ significantly between plantation types.

b) Econometric Methods

Participation in conservation programs (like the FWS or NRCS programs) and land management practices (like the use of a shade canopy) are likely to affect one another and be determined simultaneously. Thus, to evaluate the impact of participation conservation programs on land management practices, in this preliminary analysis, I follow the three-stage framework presented in Wissen and Golob (1990) and estimate a system of two simultaneous equations

[32] Commonly cultivated produce included oranges, bananas, plantains, rootplants, breadfruit, squash, pigeon peas, papayas, and avocadoes.

[33] Details of the survey are found in Borkhataria et al. (2012).

involving binary endogenous variables. I follow a bivariate probit estimation procedure and instrumental variables to correct for endogeneity.

The three-stage procedure is the following. In a first stage, the structural equation is expressed in reduced form—that is, it is expressed only in terms of exogenous variables and random disturbances. The reduced model is estimated to retrieve the predicted parameters via Maximum Likelihood Estimation. In the second stage, the structural equation is estimated by replacing the endogenous right-hand side variables with the continuous fitted latent instruments constructed in the first stage. The methodology described above provides consistent and unbiased estimates. However, given the use of instruments in the second stage, the reported standard errors are not accurate. Hence, the final stage of the procedure involves correcting the variance-covariance matrix of estimated disturbances to compute the adequate standard errors.

The structural econometric representation of the joint decision model is defined as follows:

$$P_{ij}^{*} = \delta_1 Shade_i^{*} + \sum_{k \neq j} \alpha_k P_{ik} + \alpha_0 + \alpha_1 X_i + \alpha_2 Y_i + \alpha_3 Z_i + \alpha_5 p_i^c + \varepsilon_{1i}$$

$$Shade_i^{*} = \delta_2 P_{ij}^{*} + \sum_{k \neq j} \beta_k P_{ik} + \beta_0 + \beta_1 X_i + \beta_2 Y_i + \beta_3 Z_i + \beta_5 p_i^c + \varepsilon_{2i}$$

The dependent latent variables are P_i^{*} and $Shade_i^{*}$. P_i^{*} is a binary measure of participation decision by farmer i in program j that takes on the value of 1 if the farmer is a current participant in the j^{th} incentive program available to Puerto Rican farmers. There are over 30 such programs, thus, for analytic convenience I bundle them by provisionary agency. In total there are 3 types of programs: FWS programs, NRCS programs and PRDA programs. The former two offer shade incentives, while the latter offers incentives to grow sun coffee. $Shade_i^{*}$ is also binary and it signals whether farmer i uses a shaded canopy in his coffee plantation. Variable p_i^c represents the price per pound of coffee received by farmer i.[34] P_{ik} are binary variables taking the value of 1 if farmer i participates in any of the alternative incentive programs available to him.

Vectors X_i, Y_i, and Z_i consist of exogenous variables and include farmer-specific attributes, farm-specific variables, and land farmer managerial characteristics, respectively. The variables included in vector X_i are age, gender, and indicator variables for different levels of educational attainment. Vector Y_i includes variables that characterize the production capacity of the farm. These include total land owned, area under coffee cultivation,[35] farm income, whether the farm is large enough to sell its produce by bulk (this is measured by an indicator variable that equals 1 if the farmer reports selling his product by the quintal—100 lbs.), and whether the farmers sells his product in specialty markets.

Vector Z_i includes variables that define farmers' managerial aptitues and attitutes. Variables included here are ownership status, number of years that farmer i has managed the farm, whether the farmer grows only coffee, whether the farmer intercrops, whether the farmer leaves land undeveloped for forest, the farmer's the farmer's current management practice (sun, shade, part sun and part shade, or semi-shade), whether the farmer has changed from sun to shade or vice versa, and whether the is also involved in any of the coffee processing stages. Lastly, ε_{ni} is the error term. Summary statistics of the variables included in the econometric estimation are presented in Table 4.

[34] Various important simplifying assumptions of this model are reflected in this price term. The first is that the coffee market is competitive and that consumers compete in prices for the product. Thus, a farmer with higher quality product can find a buyer that is willing to pay a premium for this specialty product. Also, it is assumed that the coffee industry is vertically integrated; meaning that all farmers are producers of an intermediary good. In other words, it assumed that coffee producers are not coffee processors, thus, any variation in received should only reflect differences in the quality of coffee cherries. In reality, these assumptions are highly questionable—at least in the case of Puerto Rico's coffee industry.

[35] In this analysis, I do not use actual productivity of the farm because that question was missing from the interviews. However, from the open-ended questions I induce that one cuerda of land (0.9 acres) can yield between 20-25 quintals (one quintal has 100 lbs. of coffee) of coffee. In this study, land area can be used as a proxy for productivity.

Table 4 : Variable Definition and SummaryStatistics

Varible	Description	Mean	Median	Std. Dev.
Participant	Binary variable equals 1 if respondent participates in any incentive program	0.82	1	0.386
FWS	Binary variable equals 1 if respondent participates in any FWS pro-shade incentive program	0.05	0	0.231
NRCS	Binary variable equals 1 if respondent participates in any NRCS pro-shade incentive program	0.3146	0	0.4669
PRDA	Binary variable equals 1 if respondent participates in any PRDA pro-sun incentive program	0.809	1	0.395
PRDA_wage	Binary variable equals 1 if respondent participates in PRDA's pro-sun wage-subsidy incentive program	0.4382	0	0.498
Age	Continuous, age of respondent	58.63	60	13.189
Gender	Binary, equals 1 if masculine	0.9438	1	0.231
Basic education	Binary, equals 1 if maximum educational attainment is middle school	0.3034	0	0.462
High school education	Binary, equals 1 if maximum educational attainment is high school	0.2697	0	0.446
College education	Binary, equals 1 if maximum educational attainment is a university degree	0.3146	0	0.4669
Graduate education	Binary, equals 1 if maximum educational attainment is a graduate degree	0.089	0	0.287
Farm size	Continuous, measures size of farm in cuerdas (1 cuerda = 0.9 acres)	67.14	25	109.76
# land holdings	Continuous, number of landholdings managed by respondent	1.1691	1	0.548
Total land managed	Continuous, area of landholdings managed by respondent	70.67	27	109.46
Annual farm income	Categorical, 1 if annual farm income is between 10,000-19,999; 2 if between 20,000-29,999; etc.	1.607	0	2.2744
Coffee area	Are of farm devoted to coffee cultivation measured in cuerdas	22.53	11	25.728
Sells in large scale[+]	Binary, equals 1 if farmer reports selling by quintal instead of almud.	0.1685	0	0.376
Sells in specialty markets	Binary, equals 1 if the farmer sells coffee in specialty markets	0.1236	0	0.33
Price per pound[*]	Average price received per pound of coffee	0.9853	0.5357	1.2144
Ownership status	Binary, equals 1 if respondent is owner, 0 if sharecrops	0.82	1	0.386
Years as manager	Continuous, time managing the farm	20.9	20	14.97
Main crop	Categorical, 1=coffee, 2=coffee and plantain or citrus, 3 = not coffee	1.281	1	0.62
Intercrop	Binary, equals 1 if farmer practices intercropping	0.8652	1	0.343
Forest land	Binary, equals 1 if farmer leaves uncultivated areas for forest	0.5506	1	0.5
Current management practice	Categorical, 1=sun, 2=shade, 3=part sun and part shade, 4=semi-shade	2.315	2	1.124
Change in management practices	Binary, equals 1 if farmer has switch from sun to shade or vice versa.	0.5843	1	0.49
Caficultor	Binary, equal 1 if farmer only grows coffee	0.7303	1	0.446
Beneficiado	Binary, equal 1 if farmer is involved in initial stage of coffee processing	0.191	0	0.395
Torrefactor	Binary, equals 1 if farmer is involved in all processing stages	0.0674	0	0.252

[*] *In Puerto Rico, the price of coffee is fixed by the Department of consumer affairs (DACO). However, in the data, we do observe variation in the prices received by farmers. The variation seems correlated with farm capacity and processing of the beans done in situ.*

[+] *The definition of these units used by the USDA is the following 1 quintal=100 lbs., and 1 almud=28 lbs. However, the use of these metrics may be an issue of concern. Therefore, this variable is left out from the regression.*

c) Results

Results from the simultaneous bivariate probit estimation procedure described earlier are reported in Tables 5—7. Table 5 shows the results of various regression on a subsample of the data where farmers are primarily coffee growers, while table 6 shows results of the same regressions on the entire sample. The differences between these two are minimal—particularly on the variables of interest; therefore, only the results corresponding to Table 5 will be discussed. The first two columns in Table 5 show the results of the bivariate simultaneous probit regression when participation in any

program (pro-sun or pro-shade) is considered. The third and fourth column show the results corresponding the analysis when only participation in conservation programs (offered by the FWS or NRCS) is considered. The last two columns show the similar results when participation in the DA's pro-sun incentive programs is analyzed. In turn, table 7 shows the transformed coefficients to reflect estimated marginal effects for the variables that were significant in the regressions explored and summarized in Table 5.

Based on the sample data, very little can be said with confidence about the determinants of farmer participation in any program. In general, it can be concluded that none of the explanatory variables examined is related to the decision of whether or not to participate in any sort of agricultural incentive program. On the other hand, farmers that do not leave undeveloped land for forest, who are involved in some stage of coffee processing and who have graduate-level education are significantly more likely to follow shade management practices in their coffee plantations. However, the effects are small—circling around a 25% increase in probability of adopting shade-management regimes.

When only participation in conservation programs is examined, the results are slightly different. As columns three and four of Table 5 show, a farmer is more likely to participate in conservation programs if he leaves some of his farmland undeveloped for forest, if he owns the farm, if he sells his product in specialty markets, if he has larger area of his land devoted to coffee cultivation, if he has basic rather than higher education (farmers with high-school degrees are 18% less likely to participate in incentive programs than farmers with basic education attainment), and, interestingly, if he has spent less time managing the farm (although this effect is very small). Not much changes in the adoption of shade-management practice equation when only participation in conservation programs is examined.

Finally, the results corresponding to the decision to participate in DA's programs favoring sun coffee management practices are more in line with economics intuition. In general, variables describing economic capacity of the farm, like farm income, whether the farmer sells by bulk (quintal), and whether he is involved in the processing of the coffee cherries, become significant determinants of the participation decision. In turn, education indicators, and whether the farmer leaves land undeveloped for forest are variables that remain related to the adoption of shade-management practices. Interestingly, in this analysis, participation in the incentive program examined is also significant. When the coefficient estimates are adjusted to reflect marginal effects, it turns out that the probability of adopting shade management practices increases by77% if farmers participate in DA's pro-sun incentive programs. This result is interesting and rather counter-intuitive as it suggests that farmers who participate in pro-sun incentive programs are also more likely to adopt a shade management practice. Although this result is somewhat surprising, it is well supported by the fact that 39% of the interviewed farmers receive both types of subsidies (see Table 2).

Age, college education, farm size, number of plots owned, and total land holdings, are never significant determinants of either of the two decisions. Surprisingly, neither are the dummy indicator of changes in management practice (from sun to shade or from shade to sun) nor the indicators of intercropping or high-level processing of the cherries (if he is a "torrefactor" who grinds his own coffee beans). Finally, shade cultivation is never significantly related with program participation.

Table 5 : Results simultaneous bivariate probit. Sumbsample of coffee growers (Maincrop==1)

	Any Incentive program					Conservation Program				DA's pro-sun Program			
Explanatory Variables	Participation		Shade Coffee Management			Participation		Shade Coffee		Participation		Shade Coffee	
	Coeff.	Std. error	Coeff.	Std. error		Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Shade	268.4	88240				2.257	2.1002			-0.800	2.805		
Participates			0.896	0.939				1.159	1.684			8.366	3.606 *
Intercept	-182.7	2.28E+07	-198	3.20E+05		2.123	14.407	-164.3	9.11E+05	2.977	4130	-336.9	2.29E+05
Age	3.38	818.1	-0.016	0.021		0.016	0.028	-0.025	0.022	0.000	0.037	-0.004	0.033
High-school	-22.38	5.05E+03	0.44	0.692		-1.46	0.85 .	0.12	0.63	-1.38	0.75 .	3.45	1.69 *
College	95.14	2.00E+04	-0.719	0.74		0.757	0.896	-0.834	0.7597	1.41	1.091	-1.29	0.88
Graduate	-105.8	4.75E+04	1.9	1 .		-1.642	1.470	1.674	1.004 .	-0.133	2.851	4.03	1.70 *
Farm size	19.23	2.31E+03	-5.57	519		-0.424	0.704	-4.665	531.4	0.1845	0.1245	-9.15	565.50
Plots owned	210.80	4.76E+04	-115	1.09E+04		-10.33	15.026	-96.52	1.12E+04	1.826	1.948	-186.9	1.18E+04
Land	-19.98	2.47E+03	5.57	519		0.428	0.704	4.672	531.4	-0.159	0.1275	9.15	565.50
Income	8.80	2.31E+03	0.105	0.20		0.19	0.16	0.06	0.19	1.12	0.55 *	-0.29	0.29
Area coffee	12.93	1.73E+03	-0.02	0.02		0.05	0.02 .	-0.02	0.02	0.00	0.03	-0.04	0.02
Sells specialty	203.00	2.11E+07	0.535	1.16		3.121	1.395 *	0.3339	1.174	8.493	4155	-1.43	1.63
Sells quintal	-24.98	2.34E+04	-33.5	3.19E+05		1.13	1.48	-29.02	9.10E+05	-10.37	3.89 **	-52.56	2.28E+05
Ownership	20.72	4.26E+03	-0.179	0.71		3.31	1.43 *	-0.15	0.81	0.23	0.78	-1.40	1.05
Time	0.94	1.08E+02	-0.007	0.023		-0.050	0.025 *	0.004	0.023	-0.010	0.021	0.01	0.03
Intercrops	-433	2.28E+07	313	3.21E+05		1.630	1.473	262.1	9.11E+05	-5.571	4130	518.60	2.30E+05
Forest land	72.98	3.38E+04	-1.81	0.70 **		3.21	1.01 **	-1.99	0.91 *	1.20	1.13	-4.43	1.57 **
Change	41.15	4.37E+03				-0.46	0.74			1.10	0.75		
Beneficiado	-2.22	1.65E+07	1.94	1.08 .		-1.44	1.37	1.77	1.08	11.62	3.95 **	3.20	1.46 *
Torrefactor	-191.7	2.11E+07	-8.81	2.00E+04		-2.643	1.932	-8.794	2.08E+04	-14.44	4155	-5.77	9665
N	82		82			82		82		82		82	
K	20		19			20		19		20		19	
AIC	40		77.224			75.839		77.815		73.469		65.323	
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1													

Table 6 : Results simultaneous bivariate probit. All farmers (Maincrop==1, 2 or 3)

Explanatory Variables	Any Incentive program											
	Participation		Shade Coffee Management		Participation		Shade Coffee		Participation		Shade Coffee	
	Coeff.	Std. error	Coeff.	Std. error	Coeff	Std. error	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Shade	268.4	8.82E+04	-186	3.42E+05	0.703	1.86			-0.269	2.149		
Participates			1.678	1.171			0.8098	1.613			6.386	2.473 **
Intercept	-198.1	3.20E+05	-185.6	3.42E+05	2.53	9.63	-156.3	4.84E+05	-2.79	3.31	-212.6	1.63E+07
Age	-0.02	0.02	-0.01	0.02	0.01	0.03	-0.03	0.02	-0.01	0.03	-0.01	0.03
High-school	0.44	0.69	0.58	0.70	-1.47	0.86 .	0.09	0.60	-1.52	0.76 *	2.18	1.07 *
College	-0.72	0.74	-1.17	0.79	0.80	0.80	-0.93	0.72	1.58	1.09	-2.32	1.01 *
Graduate	1.90	1 .	1.94	1.10 .	-0.45	1.05	1.18	0.99	-2.79	1.45 .	4.56	1.80 *
Farm size	-5.57	519	-5.17	478.90	-0.43	0.48	-4.41	499.20	0.18	0.11	-6.02	456.10
Plots owned	-115	1.09E+04	-106.4	1.01E+04	-10.2	10.3	-91.14	1.05E+04	2.25	1.69	-122.1	9.58E+03
Land	5.573	519	5.184	478.9	0.44	0.48	4.422	499.2	-0.176	0.111	6.028	456.1
Income	0.105	0.196	-0.262	0.210	0.32	0.15 *	-0.171	0.195	0.680	0.264 *	-0.799	0.335 *
Area coffee	-0.021	0.019	-0.028	0.022	0.04	0.02 .	-0.020	0.022	0.025	0.021	-0.040	0.024
Sells specialty	0.535	1.164	0.261	1.311	3.156	1.49 *	0.548	1.311	11.33	473.9	-1.545	1.966
Sells quintal	-33.47	3.19E+05	-32.84	3.42E+05	0.02	1.40	-28.04	4.84E+05	-6.48	2.14 **	-47.90	1.63E+07
Ownership	-0.179	0.706	-0.058	0.68	3.51	1.48 *	0.023	0.792	-0.203	0.784	-0.291	0.778
Time	-0.007	0.023	1.22E-04	0.022	-0.05	0.03 .	0.007	0.022	-0.013	0.021	0.014	0.025
Intercrops	313.4	3.21E+05	291.3	3.43E+05	1.96	1.46	248.4	4.85E+05	0.72	1.39	330.8	1.63E+07
Forest land	-1.81	0.70 **	-1.73	0.64 **	2.68	0.82 **	-1.59	0.78 *	1.95	0.94 *	-3.71	1.18 **
Change	1.94	1.08 .			-0.68	0.71			1.34	0.72 .		
Beneficiado	-8.81	2.00E+04	2.60	1.16 *	-0.91	1.34	2.10	1.10 .	9.04	3.31 **	4.21	1.52 **
Torrefactor	0.90	0.94	-7.79	1.93E+04	-3.65	2.37	-7.86	2.01E+04	-13.53	473.9	-6.31	1.85E+04
N	89		89		89		89		89		89	
K	20		19		20		19		20		19	
AIC	40		81.728		80.072		83.754		84.721		74.705	
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1												

Table 7 : Marginal effects significant variables in Table 5 (Only coffee growers)

Explanatory Variables	Participation in any incentive program	Shade Coffee Management Practice	Participation in conservation program	Shade Coffee Management Practice	Participation in DA's pro-sun-coffee program	Shade Coffee Management Practice
	Marginal effect	Marginal effect	Marginal effect	Marginal effect	Marginal effect	Marginal effect
Participates in program						0.770 *
High-school			-0.18 .		-0.15 .	0.32 *
Graduate		0.2545 .		0.226 .		0.37 *
Farm income					0.13 *	
Area in coffee			0.01 .			
Sells specialty			0.386 *			
Sells Quintal					-1.15 **	
Ownership			0.41 *			
Time managing			-0.006 *			
Forest land		-0.24 **	0.40 **	0.27 *		-0.41 **
Beneficiado		0.259 .			1.13 **	0.29 *

*Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

VII. Conclusions

As far as the decision to participate in conservation programs goes, the empirical analysis suggests that farmers are about 40% more likely to participate in conservation programs if the sell their product in specialty markets, if they leave land undeveloped for forest growth, and if the own their farm. There are other significant factors in this relation but their effect is rather small. For instance, participation in conservation programs increases by 1% as their area under coffee cultivation increases. Also, farmers with higher than basic education are 18% less likely to participate (probably because they do not need the additional economic assistance). Finally, as coffee growers spend more time managing their farm they become 0.6% less likely to participate in conservation programs.

On the other hand, variables related to participation in Department of Agriculture's pro-sun incentive programs are, in general, indicators of economic performance of the farm. For instance, as farm income increases, farmers are 13% more likely to participate in the DA's programs. Also, farmers that process their coffee cherries are 113% more likely to receive DA's assistance. However, if farmers sell by bulk they are 115% less likely to participate in pro-sun programs. These results are somewhat contradictory, but I offer the following interpretation. It appears that larger farmers may not need additional economic assistance, however, more vertically integrated farmers—those involved in some of the processing stages—may be more closely related to the DA.

In regards to the decision of shade-management practices, the results suggest that it may be "privileged" farmers who are more likely to adopt them. For instance, farmers with higher education attainment are consistently more likely to adopt shade management practices. Also, farmers that do not have undeveloped land are 41% more likely to grow their coffee under shade. Finally, what is perhaps the most interesting result from this analysis, is that vertically integrated farmers and farmers participating in pro-sun incentive programs are also more likely to adopt shade management practices. The main rationale behind vertical integration is to increase the overall efficiency and reduce costs of production. It is possible that farmers who control more of the production process and have access to additional farm income are more profitable and therefore can afford switching to practices to become producers of shade coffee.

a) Policy Implications for environmental services and biodiversity conservation programs

In 2013, the Puerto Rico Department of Natural and Environmental Resources (PR DRNA) published its new habitat conservation strategy which seeks to ensure the long-term persistence of resident species of birds and amphibians. The DRNA is interested in improving the efficiency of existing biodiversity conservation

programs that target land-management practices among coffee growers to increase the area of certain protected habitats in the island.

There is a broad consensus within the literature that adoption and diffusion of conservation practices are the result of a complex decision-making process, particularly when examined at the micro-economic level. In Puerto Rico, little research has been done about the status of coffee production, the influence of governmental policies on farming practices and the attitudes of farmers towards sustainable production practices. A primary objective of this study was to investigate the factors that determine farmer participation in conservation programs and the impact of said programs on adoption of conservation practices. A secondary goal was to explore new linkages between competing policy instruments, adoption decisions and biodiversity conservation goals. The empirical results indicate that participation in agricultural-land management programs increases the probability of using conservation agriculture practices.

Based on the studied sample, federal environmental agencies interested in improving the targeting of existing programs should be wary of displacing antagonistic state programs, as these seem to be, paradoxically, the most important driver of the decision to adopt environmentally beneficial agricultural management practices.

In general, the results suggest that farmers who participate in conservation programs encouraging the cultivation of coffee under shade are "newer" farmers who take advantage of quality differentials in their product to sell in specialty markets. In turn, the findings suggest that it may be "privileged" farmers who are more likely to adopt shade-management practices. The level of distortion in the Puerto Rican coffee market is striking; thus, it is possible, that simple income-transfer programs that allow farmers to afford switching from sun to shade coffee may be the less distortionary, and perhaps more efficient, way to promote biodiversity conservation practices. However, this proposition is not verifiable given the data or the estimation methods chose for this study.

b) Note from the author: Additional considerations and recommendations for policy design

In conducting my study, I ran into several inconsistencies in the data that raised my awareness of additional structural factors in a rather complex system of which coffee farmers are a small component. If the intention is to use agricultural policy to further environmental goals, the environmentalist agencies will need to gain much deeper understanding of institutional idiosyncrasies governing the microeconomics of coffee production in Puerto Rico. With the risk of overstepping, I will discuss two examples that illustrate how difficult it will be to successfully intervene in Puerto Rico's coffee sector in order to improve biodiversity conservation and environmental service provision in the is land.

The first issue is an example of what could be the prevalence of pernicious incosystency in monitoring, recording and measuring of economic performance in thecoffee sector. Coffee in Puerto Rico is sold by *almuds* or *quintals*. These are non-standard metrics that have different definitions—and indeed, are used to measure different properties (say volumen instead of mass) —across LatinAmerica and the Caribbean. The USDA defines these units as one almud equaling 28 pounds, and one quintal equaling 100 pounds. However, after speaking with officials and researchers, there is reason to believe that farmers, researchers, government agents, and consumers may have different ideas of what exactly these units constitute. The lack of transparency in the metric system itself may be enough reason to worry about some agents taking advantage of the system to exploit illicit profits. Although I have no evidence of illicit profiting, in the data I do find that average coffee prices vary drastically depending on whether the farmer sells by almud of quintal. The average price per pound that farmers selling by quintal received was $3.16 (with standard deviation of 1.37); on the other hand, the corresponding figure for farmers selling by almud was 0.54 (with standard deviation of $0.49). Although, theoretically those receiving $3.16 are "beneficiadores" (business that are in charge of processing the coffee at a comercial scale) selling coffee beans, while farmers receiving $0.5 are growers selling coffee cherries; there is no certainty over this issue and the data does not support this distinction entirely. This large discrepancy in prices is reason of concern, particularly for distributional considerations and compensatory public policy.

The second issue that clearly reflects the level of convolution in the system, shows how uncertainty as to the implementation of public policy by one state agency can escálate rapidly and affect the actions of other regulatory agencies and the industrial organization of coffee markets itself. In Puerto Rico, the Department of Consumer Affairs (DACO) sets the price of coffee. By law, since 1973, the DACO is supposed to review the price of coffee every 5 years and fix an increase based on recommendations by the Department of Agriculture and the University of Puerto Rico through the Agricultural Science Department and the Agricultural Extension Service. However, coffee prices have not been reviewed systematically.[36]

[36] It took 13 years since the enactment of the "Ley Organica del Departamento de Asuntos del Consumidor" for DACO to adjust coffee prices. In 1986 it set them to $3.12 per pound. In 1991, the price was adjusted to $3.64 per pound. Then, in 2005, prices were raised by 20%. The last time DACO reviewed coffee prices was in 2015. Then, DACO set the price of ripe coffee cherries to $0.52 per pound (and $0.35 for green cherries) and the price of coffee beans to $379 per quintal—or $3.79 per pound.

The DACO is also in charge of systematically setting import tariffs on coffee. Historically, imported coffee had been taxed heavily, keeping its Price artificially higher than that of local coffee. However, since 2015, DACO signed an order imposing a Price ceiling of $322 per quintal of imported coffee—making local coffee less competitive from a pricing standpoint. DACO's neglect and apparent favoritism for coffee consumers—local and multinational—over local producers has likely had an impact on subsequent political actions taken by interested parties such as the Department of Agriculture and certain large multinational companies operating in Puerto Rico. In turn, these actions may have spurred interactions with existing disruptions and inefficiencies of the market, making the situation for coffee farmer seven more complicated. I will elaborate on these thoughts to make their meaning more explicit.

With the objective of relieving some of farmers' financial pressures, since 2001, the Department of Agriculture has established a series of incentives programs in addition to the existing programs subsidizing seeds, fertilizer and labor. The effectiveness of these new programs is highly questionable based on anecdotal observations. Certain legal records document the flaws in these programs. Among them, high uncertainty as to the priority given by the administration to the appropriation of funds to said programs. Additionally, payments conceded by these new schemes are often received late, and sometimes never. Yet, with in the last year, DACO's failure to revise the prices systematically has risen legislation proposals to have the PR Department of Agriculture establish coffee prices instead.[37]

On the other hand, DACO's neglect is certainly not helping farmers who are facing higher input prices and a fiercer competition from abroad. However, anartificially low price of coffee may be disproportionally benefiting large consumers. Although I have no evidence and no way of showing that monopsonistic power is related to DACO's public policy, it is a worry supported by recent news and media analysis.[38]

The coffee industry in Puerto Rico has been struggling in the last few decades. The reasons behind this collapse are multiple and likely to be interrelated. From natural reasons (like pests and hurricanes) to shocks in the labor market to public policy initiatives to market organization, these reasons obscure the fundamental factors determining farmer behavior and thus, make matters ever more complicated for parties interested in targeting coffee producers to further environmental objectives. I want to conclude this paper with the following thought. Although much progress has been made in the areas of economics and ecology in terms of understanding the micro-economic foundations of human behavior and the interactions between humans with the environment in an economic setting, taking these lessons to action will ultimately depend on the functionality, reliability and transparency of political and legislative systems.

[37]"Sen. Ruiz Proposes Agriculture Department Set Coffee Prices." May, 2016. http://cb.pr/sen-ruiz-proposes-agriculture-department-set-coffee-prices/

[38] Since 2013, Puerto Rico Coffee Roasters (which is domain of Coca-Cola Co.) controls 80% of the coffee market.

References Références Referencias

1. Alamo, C.I., Monroig, M., Gonzalez, W., Brugueras, A. (2006). Manual para la producción y exportación de café de Puerto Rico. Agricultural Experiment Station, University of PR.
2. Amsalu, A., & De Graaff, J. (2007). Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. *Ecological economics, 61*(2), 294-302.
3. Batz, M. B., Albers, H. J., Ávalos-Sartorio, B., & Blackman, A. (2005). Shade-Grown Coffee: Simulation and Policy Analysis for Coastal Oaxaca, Mexico. *Resources for the Future Discussion Paper*, (05-61).
4. Bacon, C. (2005). Confronting the coffee crisis: can fair trade, organic, and specialty coffees reduce small-scale farmer vulnerability in northern Nicaragua?. *World development*, *33*(3), 497-511.
5. Barham, B. L., & Weber, J. G. (2012). The economic sustainability of certified coffee: Recent evidence from Mexico and Peru. *World Development*, *40*(6), 1269-1279.
6. Barham, B. L., Callenes, M., Gitter, S., Lewis, J., & Weber, J. (2011). Fair trade/organic coffee, rural livelihoods, and the "agrarian question": Southern Mexican coffee families in transition. *World Development*, *39*(1), 134-145.
7. Beer, J., Muschler, R., Kass, D., & Somarriba, E. (1998). Shade management in coffee and cacao plantations. In *Directions in Tropical Agroforestry Research* (pp. 139-164). Springer Netherlands.
8. Bellon, M. R., Gotor, E., &Caracciolo, F. (2015). Assessing the Effectiveness of Projects Supporting On-Farm Conservation of Native Crops: Evidence From the High Andes of South America. *World Development*, *70*, 162-176.
9. Birol, E., Smale, M., & Gyovai, Á. (2006). Using a choice experiment to estimate farmers' valuation of agrobiodiversity on Hungarian small farms. *Environmental and Resource Economics*, *34*(4), 439-469.
10. Blackman, A., Ávalos-Sartorio, B., & Chow, J. (2012). Land cover change in agroforestry: shade coffee in El Salvador. *Land Economics*, *88*(1), 75-101.

11. Borkhataria, R. R., Collazo, J. A., & Groom, M. J. (2006). Additive effects of vertebrate predators on insects in a Puerto Rican coffee plantation. *Ecological applications*, *16*(2), 696-703.
12. Borkhataria, R. R., Collazo, J. A., & Groom, M. J. (2012). Species abundance and potential biological control services in shade vs. sun coffee in Puerto Rico. *Agriculture, ecosystems & environment*, *151*, 1-5.
13. Borkhataria, R., Collazo, J. A., Groom, M. J., & Jordan-Garcia, A. (2012). Shade-grown coffee in Puerto Rico: Opportunities to preserve biodiversity while reinvigorating a struggling agricultural commodity. *Agriculture, Ecosystems & Environment*, *149*, 164-170.
14. Cerdán, C. R., Rebolledo, M. C., Soto, G., Rapidel, B., & Sinclair, F. L. (2012). Local knowledge of impacts of tree cover on ecosystem services in smallholder coffee production systems. *Agricultural Systems*, *110*, 119-130.
15. Chanakya, H. N., & De Alwis, A. A. P. (2004). Environmental issues and management in primary coffee processing. *Process safety and environmental protection*, *82*(4), 291-300.
16. Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., & Hyde, T. (2006). Valuing the diversity of biodiversity. *Ecological economics, 58*(2), 304-317.
17. "Coca Cola and the Puerto Rico Coffee Industry: A Double-Edged Sword?" Repeating Islands. N.p., 23 June 2013. Web. Accessed May, 2016. https://repeatingislands.com/2013/06/23/coca-cola-and-the-puerto-rico-coffee-industry-a-double-edged-sword/
18. Cooper, John C. (2014). The World Coffee Economy. *Interdisciplinary Journal of Economics and Business Law, 3*(4), 64-77.
19. DaMatta, F. M. (2004). Ecophysiological constraints on the production of shaded and unshaded coffee: a review. *Field Crops Research*, *86*(2), 99-114.
20. De Graaff, J., Amsalu, A., Bodnár, F., Kessler, A., Posthumus, H., &Tenge, A. (2008). Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. *Applied Geography, 28*(4), 271-280.
21. De Souza, H. N., de Goede, R. G., Brussaard, L., Cardoso, I. M., Duarte, E. M., Fernandes, R. B., &Pulleman, M. M. (2012). Protective shade, tree diversity and soil properties in coffee agroforestry systems in the Atlantic Rainforest biome. *Agriculture, Ecosystems & Environment*, *146*(1), 179-196.
22. Edmeades, S., Phaneuf, D. J., Smale, M., & Renkow, M. (2008). Modelling the Crop Variety Demand of Semi-Subsistence Households: Bananas in Uganda. *Journal of Agricultural Economics*, *59*(2), 329-349.
23. Ferraro, P. J., Hanauer, M. M., Miteva, D. A., Nelson, J. L., Pattanayak, S. K., Nolte, C., & Sims, K. R. (2015). Estimating the impacts of conservation on ecosystem services and poverty by integrating modeling and evaluation. *Proceedings of the National Academy of Sciences*, *112*(24), 7420-7425.
24. Garcia-Yi, J. (2014). Organic coffee certification in Peru as an alternative development-oriented drug control policy. *International Journal of Development Issues*, *13*(1), 72-92.
25. Geromel, C., Ferreira, L. P., Davrieux, F., Guyot, B., Ribeyre, F., dos Santos Scholz, M. B., & AndrocioliFilho, A. (2008). Effects of shade on the development and sugar metabolism of coffee (CoffeeArabica L.) fruits. *Plant Physiology and Biochemistry*, *46*(5), 569-579.
26. Gobbi, J. A. (2000). Is biodiversity-friendly coffee financially viable? An analysis of five different coffee production systems in western El Salvador. *Ecological Economics*, *33*(2), 267-281.
27. Goldstein, J. H., Caldarone, G., Duarte, T. K., Ennaanay, D., Hannahs, N., Mendoza, G., & Daily, G. C. (2012). Integrating ecosystem-service tradeoffs into land-use decisions. *Proceedings of the National Academy of Sciences*, *109*(19), 7565-7570.
28. Gordon, C., Manson, R., Sundberg, J., & Cruz-Angón, A. (2007). Biodiversity, profitability, and vegetation structure in a Mexican coffee agroecosystem. *Agriculture, ecosystems & environment*, *118*(1), 256-266.
29. Grau, H. R., Aide, T. M., Zimmerman, J. K., Thomlinson, J. R., Helmer, E., & Zou, X. (2003). The ecological consequences of socioeconomic and land-use changes in postagriculture Puerto Rico. *BioScience*, *53*(12), 1159-1168.
30. Greiner, R., Patterson, L., & Miller, O. (2009). Motivations, risk perceptions and adoption of conservation practices by farmers. *Agricultural systems*,*99*(2), 86-104.
31. Harmsen, E. W., Miller, N. L., Schlegel, N. J., & Gonzalez, J. E. (2009). Seasonal climate change impacts on evapotranspiration, precipitation deficit and crop yield in Puerto Rico. *Agricultural Water Management*, *96*(7), 1085-1095.
32. Heal, G. (2005). Corporate social responsibility: An economic and financial framework. *The Geneva papers on risk and insurance-Issues and practice*,*30*(3), 387-409.
33. Hein, L., Van Koppen, K., De Groot, R. S., & Van Ierland, E. C. (2006). Spatial scales, stakeholders and the valuation of ecosystem services. *Ecological economics*, *57*(2), 209-228.
34. Ibanez, M., & Blackman, A. (2015). Environmental and economic impacts of growing certified organic coffee in Colombia. *Resources for the Future Discussion Paper*, (15-03).

35. Ibañez, M., & Blackman, A. Does Eco-Certification Have Environmental Benefits? Organic Coffee in Colombia. *Unpublished working paper. Washington, DC: Resources for the Future*.
36. Jha, S., Bacon, C. M., Philpott, S. M., Méndez, V. E., Läderach, P., & Rice, R. A. (2014). Shade coffee: update on a disappearing refuge for biodiversity. *BioScience*, *64*(5), 416-428.
37. Kauneckis, D., & York, A. M. (2009). An empirical evaluation of private landowner participation in voluntary forest conservation programs. *Environmental management*, *44*(3), 468-484.
38. Kho, R. M. (2000). A general tree-environment-crop interaction equation for predictive understanding of agroforestry systems. *Agriculture, ecosystems & environment*, *80*(1), 87-100.
39. Kilian, B., Jones, C., Pratt, L., & Villalobos, A. (2006). Is sustainable agriculture a viable strategy to improve farm income in Central America? A case study on coffee. *Journal of Business Research*, *59*(3), 322-330.
40. Kitti, M., Heikkilä, J., &Huhtala, A. (2009). 'Fair'policies for the coffee trade–protecting people or biodiversity?. *Environment and Development Economics*, *14*(06), 739-758.
41. Knowler, D., & Bradshaw, B. (2007). Farmers' adoption of conservation agriculture: A review and synthesis of recent research. *Food policy*, *32*(1), 25-48.
42. Koellner, T., Sell, J., & Navarro, G. (2010). Why and how much are firms willing to invest in ecosystem services from tropical forests? A comparison of international and Costa Rican firms. *Ecological Economics*, *69*(11), 2127-2139.
43. Kremen, C., Williams, N. M., Aizen, M. A., Gemmill-Herren, B., LeBuhn, G., Minckley, R.,&Winfree, R. (2007). Pollination and other ecosystem services produced by mobile organisms: a conceptual framework for the effects of land-use change. *Ecology letters*, *10*(4), 299-314.
44. Kumar, C. (2007). Perceptions of incentives for participation: insights from joint forest management in India. *The International Journal of Sustainable Development & World Ecology*, *14*(5), 532-542.
45. Lawler, J. J., Lewis, D. J., Nelson, E., Plantinga, A. J., Polasky, S., Withey, J. C., &Radeloff, V. C. (2014). Projected land-use change impacts on ecosystem services in the United States. *Proceedings of the National Academy of Sciences*, *111*(20), 7492-7497.
46. Lewis, D. J. (2010). An economic framework for forecasting land-use and ecosystem change. *Resource and Energy Economics*, *32*(2), 98-116.
47. Lewis, D. J., & Plantinga, A. J. (2007). Policies for habitat fragmentation: combining econometrics with GIS-based landscape simulations. *Land Economics*, *83*(2), 109-127.
48. Lewis, D. J., & Wu, J. (2014). Land-Use Patterns and Spatially Dependent Ecosystem Services: Some Microeconomic Foundations. *International Review of Environmental and Resource Economics*, *8*, 191-223.
49. Lewis, D. J., Barham, B. L., &Zimmerer, K. S. (2008). Spatial externalities in agriculture: empirical analysis, statistical identification, and policy implications. *World Development*, *36*(10), 1813-1829.
50. Lewis, D. J., Plantinga, A. J., & Wu, J. (2009). Targeting incentives to reduce habitat fragmentation. *American Journal of Agricultural Economics*, *91*(4), 1080-1096.
51. Lewis, D. J., Plantinga, A. J., Nelson, E., &Polasky, S. (2011). The efficiency of voluntary incentive policies for preventing biodiversity loss. *Resource and Energy Economics*, *33*(1), 192-211.
52. Lewis, D. J., Provencher, B., &Butsic, V. (2009). The dynamic effects of open-space conservation policies on residential development density. *Journal of Environmental Economics and Management*, *57*(3), 239-252.
53. Lin, B. B. (2010). The role of agroforestry in reducing water loss through soil evaporation and crop transpiration in coffee agroecosystems. *Agricultural and Forest Meteorology*, *150*(4), 510-518.
54. List, J. A., Sinha, P., & Taylor, M. H. (2006). Using choice experiments to value non-market goods and services: evidence from field experiments. *Advances in economic analysis & policy*, *5*(2).
55. López-Gómez, A. M., Williams-Linera, G., & Manson, R. H. (2008). Tree species diversity and vegetation structure in shade coffee farms in Veracruz, Mexico. *Agriculture, ecosystems & environment*, *124*(3), 160-172.
56. Lubowski, R. N., Plantinga, A. J., &Stavins, R. N. (2006). Land-use change and carbon sinks: econometric estimation of the carbon sequestration supply function. *Journal of Environmental Economics and Management*, *51*(2), 135-152.
57. Martínez-Sánchez, J. C. (2008). *The role of organic production in biodiversity conservation in shade coffee plantations* (Doctoral dissertation, University of Washington).
58. Méndez, V. E., Gliessman, S. R., & Gilbert, G. S. (2007). Tree biodiversity in farmer cooperatives of a shade coffee landscape in western El Salvador. *Agriculture, Ecosystems & Environment*, *119*(1), 145-159.
59. Messer, K. D., Kotchen, M. J., & Moore, M. R. (2000). Can shade-grown coffee help conserve tropical biodiversity? A market perspective. *Endangered Species Update*, *17*(6), 125-131.

60. Murthy, P. S., & Naidu, M. M. (2012). Sustainable management of coffee industry by-products and value addition—A review. *Resources, Conservation and recycling*, *66*, 45-58.
61. Nelson, E., Mendoza, G., Regetz, J., Polasky, S., Tallis, H., Cameron, D., &Lonsdorf, E. (2009). Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment*, *7*(1), 4-11.
62. Nelson, E., Polasky, S., Lewis, D. J., Plantinga, A. J., Lonsdorf, E., White, D., & Lawler, J. J. (2008). Efficiency of incentives to jointly increase carbon sequestration and species conservation on a landscape. *Proceedings of the National Academy of Sciences*, *105*(28), 9471-9476.
63. Neupane, R. P., & Thapa, G. B. (2001). Impact of agroforestry intervention on soil fertility and farm income under the subsistence farming system of the middle hills, Nepal. *Agriculture, ecosystems & environment*, *84*(2), 157-167.
64. Ninan, K. N., & Sathyapalan, J. (2005). The economics of biodiversity conservation: a study of a coffee growing region in the Western Ghats of India. *Ecological Economics*, *55*(1), 61-72.
65. Page, G., & Bellotti, B. (2015). Farmers value on-farm ecosystem services as important, but what are the impediments to participation in PES schemes?. *Science of the Total Environment*, *515*, 12-19.
66. Perfecto, I., Armbrecht, I., Philpott, S. M., Soto-Pinto, L., & Dietsch, T. V. (2007). Shaded coffee and the stability of rainforest margins in northern Latin America. In *Stability of Tropical Rainforest Margins* (pp. 225-261). Springer Berlin Heidelberg.
67. Perfecto, I., Rice, R. A., Greenberg, R., & Van der Voort, M. E. (1996). Shade coffee: a disappearing refuge for biodiversity. *BioScience*, *46*(8), 598-608.
68. Perfecto, I., Vandermeer, J. (2015). *Coffee Agroecology: A new approach to understanding agricultural biodiversity, ecosystem services and sustainable development.* New York: NY. Routledge.
69. Perfecto, I., Vandermeer, J., Mas, A., & Pinto, L. S. (2005). Biodiversity, yield, and shade coffee certification. *Ecological Economics*, *54*(4), 435-446.
70. Pinto, L. F. G., Gardner, T., McDermott, C. L., & Ayub, K. O. L. (2014). Group certification supports an increase in the diversity of sustainable agriculture network–rainforest alliance certified coffee producers in Brazil. *Ecological Economics*, *107*, 59-64.
71. Plantinga, A. J., & Lewis, D. J. (2014). Landscape simulations with econometric-based land-use models. *The Oxford Handbook of Land Economics*, 380.
72. Plantinga, A. J., Alig, R., & Cheng, H. T. (2001). The supply of land for conservation uses: evidence from the conservation reserve program. *Resources, Conservation and Recycling*, *31*(3), 199-215.
73. Plantinga, A. J., Lubowski, R. N., & Stavins, R. N. (2002). The effects of potential land development on agricultural land prices. *Journal of Urban Economics*, *52*(3), 561-581.
74. Polasky, S., & Segerson, K. (2009). Integrating ecology and economics in the study of ecosystem services: some lessons learned. *Resource*, *1*.
75. Polasky, S., Lewis, D. J., Plantinga, A. J., & Nelson, E. (2014). Implementing the optimal provision of ecosystem services. *Proceedings of the National Academy of Sciences*, *111*(17), 6248-6253.
76. Polasky, S., Lewis, D. J., Plantinga, A. J., & Nelson, E. (2014). Implementing the optimal provision of ecosystem services. *Proceedings of the National Academy of Sciences*, *111*(17), 6248-6253.
77. Polasky, S., Nelson, E., Camm, J., Csuti, B., Fackler, P., Lonsdorf, E., & Haight, R. (2008). Where to put things? Spatial land management to sustain biodiversity and economic returns. *Biological* conservation, 141(6), 1505-1524.
78. "Puerto Rico faces lowest coffee production ever" Jamaica Observer (May 24, 2013). Accessed April, 2016. http://m.jamaicaobserver.com/mobile/digicel/business/Puerto-Rico-faces-lowest-coffee-production-ever_14323278
79. Ricketts, T. H., Daily, G. C., Ehrlich, P. R., & Michener, C. D. (2004). Economic value of tropical forest to coffee production. *Proceedings of the National Academy of Sciences of the United States of America*, *101*(34), 12579-12582.
80. Ruben, R., & Fort, R. (2012). The impact of fair trade certification for coffee farmers in Peru. *World Development*, *40*(3), 570-582.
81. "Sen. Ruiz Proposes Agriculture Department Set Coffee Prices." Accessed May, 2016. http://cb.pr/sen-ruiz-proposes-agriculture-department-set-coffee-prices/
82. Takahashi, R., & Todo, Y. (2014). The impact of a shade coffee certification program on forest conservation using remote sensing and household data. *Environmental Impact Assessment Review*, *44*, 76-81.
83. Tornquist, C. G., Hons, F. M., Feagley, S. E., & Haggar, J. (1999). Agroforestry system effects on soil characteristics of the Sarapiquı region of Costa Rica. *Agriculture, ecosystems & environment*, *73*(1), 19-28.
84. Valkila, J. (2009). Fair Trade organic coffee production in Nicaragua—Sustainable development or a poverty trap?. *Ecological Economics*, *68*(12), 3018-3025.
85. Vignola, R., McDaniels, T. L., & Scholz, R. W. (2012). Negotiation analysis for mechanisms to deliver ecosystem services: The case of soil conservation in Costa Rica. *Ecological Economics*, *75*, 22-31.

86. Wilson, A. P., & Wilson, N. L. (2014). The economics of quality in the specialty coffee industry: insights from the Cup of Excellence auction programs. *Agricultural Economics*, *45*(S1), 91-105.
87. Wissen, L. J., & Golob, T. F. (1990). Simultaneous-Equation Systems Involving Binary Choice Variables. *Geographical Analysis*, *22*(3), 224-243.

Appendix

The profit-maximization problem framework applied to Puerto Rican coffee farmers

In this appendix I develop a simple model of conservation practice adoption in presence of externalities. Here I introduce the definition of variables used in the mathematical expression and describe the relevant equations in the system that the model represents. Then, I make explicit certain simplifying assumptions. A discussion of the model's insights for guiding the empirical work in found in the theoretical section of the main text.

Variable Definition

Define the variables in this model as follows:

Q_t: Coffee production, this is the state variable of the model
X_t: Non-coffee crop production
A: Area of the farm devoted to shade-coffee
A_j: Area of an adjacent farm devoted to shade-coffee
$\sum A_j = \overline{A}$: Total area of adjacent farms devoted to shade-coffee.
Z_t: Composite technology/capital inputs (fertilizer, pesticides and irrigation water)
L_t: Labor input, this is the control variable of the model
L_t^f: Household's farm-labor
L_t^{nf}: Household's non-farm labor
L_t^h: Hired labor
π_t: Net revenues at time t
B_t: Borrowings at time t
M_t: Income at time t
Y_t: Cash at hand at time t
γ_t: A penalty term that reduces output at time t depending on the level of previous produce that was left unharvested and the area of plot that was not maintained.

I_t: Indicator variable, it takes the value of 1 when a farmer grows shade coffee, and of zero otherwise.
D_t: Dividend term that represents benefits to any farmer from the environmental spill-overs generated by the group of farmers growing shade-coffee. This term depends on the total area devoted to shade-coffee plantations that is adjacent to a particular farmer's land.

β_{PES}: Subsidy provided for growing shade-coffee
w: Wage in the labor market[39]
w_z: Price of a composite technology input
P_q: Price of coffee (assumed to be constant)
P_x: Price of non-coffee crop (also assumed to be exogenous and fixed)
i: Interest rate
F: Fixed cost of transforming a sun plantation to a shade plantation
δ: Discount rate
ω: A binary outcome that takes the value of 1 when a particular plot with shade coffee is adjacent to the farmer's land.
ε_t^L: Exogenous shock to labor market (for example, out migration changes amount of hirable labor).
ε_t^N: Exogenous shock to natural conditions (for example, a hurricane).

Model Equations

The model developed here is best represented by a system of equations relevant for each farmer i. For notational simplicity the index i is left out. The equations that characterize this system are the following:

Coffee production function

$$Q_t(L_t, Z_t, \gamma_t; A, \overline{A}) = \gamma_t \cdot f_i(L_t, Z_t; A, \overline{A}) \,, \qquad (8)$$

Coffee production depends on labor, capital inputs, fixed land, the amount of land devoted to shade coffee in adjacent farms, and a penalty term that depends on previous produce was left unharvested and the area of plot that was not maintained. The hypothesis is that $f_i(L_t, Z_t; A)$ will be different for shade than for sun coffee (thus, i = shade, sun), but that for the same level of inputs $f_{shade} = 0.7 f_{sun}$.

Equation for penalty γ_t

$$\gamma_t = \gamma(Q_{t-1}(L_{t-1}, Z_{t-1}, A), L_{t-1}, Y_{t-1}) + \varepsilon_{t-1}^N,$$
$$\text{with} \qquad \gamma_t \in (0,1) \text{ and } \varepsilon_t^N iid \sim N(0, \sigma^2), \qquad (9)$$

The level of fruits that is left unharvested and the size of the plot that is not maintained is determined by the amount of labor available, available liquidity to pay cherry pickers, and an exogenous shock to natural conditions (like hurricane or landslide).

Non-Coffee crop production function

$$X_t(L_t, Z_t, I_t; A, \overline{A}) = g_i(L_t, Z_t; A, \overline{A}) + \xi g_i(L_t, Z_t; A, \overline{A}) I_t, \quad (10)$$

Non-Coffee production depends on labor, capital inputs, fixed land, adjacent land devoted to shade-coffee, and a term that captures the increased productivity of the non-coffee crop by virtue of growing shade coffee (captures the spill-over benefit on own farm).

[39] US Federal mínimum wage applies in Puerto Rico. Although the government offers a wage subsidy to ameliorate labor costs to coffee farmer, this distortion will be ignored for the moment.

Profit equation

$$\pi_t = P_q Q_t(\cdot) + P_x X_t(\cdot) - wL_t - w_z Z_t + wL_t^{nf} + I_t\beta_{PES}A + D_t(\sum \omega A_j) \quad (11)$$

Profit is the revenue from shade coffee production, net the costs, plus off-farm income, plus whatever subsidy is provided for growing shade-coffee, plus a dividend term that represents benefits to any farmer from the environmental spill-overs generated by the group of farmers growing shade-coffee in adjacent land. The transfer benefit is zero for farmers growing sun coffee. This term depends on the total area devoted to shade-coffee plantations that is adjacent to a particular farmer's land (ω denotes when a particular plot with shade coffee is adjacent to the farmer's land).

Income equation

$$Y_t = \pi_t + B_t - (1+i)B_{t-1} \quad (12)$$

Income equals cash at hand equals profit plus borrowings minus payments on standing debt.

Labor supply equation

$$L_t = (L_t^f + L_t^{hired})\varepsilon_{t-1}^L, \text{ with } \varepsilon_t^L iid \sim N(0,\sigma^2), \quad (13)$$

Total labor dedicated to farm production is the sum of own-household labor and hired labor. These are considered perfect substitutes. Labor employed depends on an exogenous shock to the labor market that may increase or decrease the amount of available hirable labor. This level need not equal labor demand for a given time period.

Time Constraint

$$T_t = L_t^f + L_t^{nf} \quad (14)$$

Each farmer is endowed with T time, and it is allocated among labor on- and off-farm

Model formulation and solution

Using with the definitions presented above, the economic model can now be formulated. A farmers' objective function is to maximize expected, discounted stream of profits derived from working on and off the farm. Farm work includes cultivation of coffee and other crops. In every period, the farmer chooses whether to continue its current management practice (shade or sun), to switch management practices (to sun or shade), or to abandon coffee production altogether. In addition to choosing a use for their land, farmers choose the level of inputs that will be used for the chosen purpose.

$$\underset{Q_{t+1}(\cdot), X_{t+1}(\cdot), L_t, A}{max} E_0 \sum_{t=1}^{T+\tau} \delta^t \pi\left(X_t, Q_t, L_t^{nf}, A, \overline{A}\right)$$

Where $\tau = 0$ for sun coffee plantations and $\tau \in [0, T]$ for shade coffee plantations.

Consider a simplified version of the model where farmers only grow coffee in their land. This version also abstracts from off-farm labor and credit markets. Finally, I will impose convenient structural forms for the unknown functions $(Q_t, f_i, \gamma_t, \varphi_t)$.

Let f_i and γ_t take convenient Cobb-Douglas forms:

$$f_{sh} = a + L_t^{\alpha_1} A^{\alpha_2} \text{ , where } a \geq 0 \quad (15)$$

$$f_{su} = b + L_t^{\beta_1} A^{\beta_2} Z_t^{\beta_3}, \text{ where } b \geq 0 \text{ and } b \leq a \quad (16)$$

$$\gamma_t = \gamma(Q_{t-1}(L_{t-1}, Z_{t-1}, A), L_{t-1}, Y_{t-1}) + \varepsilon_{t-1}^N, \text{ with } \gamma_t \in (0,1) \text{ and } \varepsilon_t^N iid \sim N(0,\sigma^2) \quad (17)$$

Using all the structure above, the current time profit and total profit stream equations corresponding to farmers currently growing shade coffee take the following form:

$$\pi_t^{sh} = P_q \gamma_t(\cdot)\left(a + L_t^{\alpha_1} A^{1-\alpha_1}\right) - wL_t - F + \beta_{PES}A + D_t(\sum \omega A_j) \quad (18)$$

and

$$E_0 \sum_{t=6}^{2T+5} \delta^t \pi_{sh} = E_0 \sum_{t=6}^{2T+5} \delta^t \{P_q \gamma_t(\cdot)(a + L_t^{\alpha_1} A^{1-\alpha_1}) - wL_t - F + \beta_{PES}A + D_t(\sum \omega A_j)\} \quad (19)$$

The First Order Conditions (FOC's) are:

$$(L_t): \alpha_1 P \gamma_t L_t^{\alpha_1 - 1} A^{1-\alpha_1} - w + E\left[\delta P \frac{\partial \gamma_{t+1}}{\partial L_t} \cdot Q_{t+1}\right] = 0 \quad (20)$$

which imply an optimal level of labor input, an optimal output level, and an optimal per period profit that look as follows:

$$L_*^{Sh} = \left[\frac{\alpha_1 P \gamma}{w - \delta P\left[E\frac{\partial \gamma_{t+1}}{\partial L_t} \cdot Q_{t+1}\right]}\right]^{\frac{1}{1-\alpha_1}} \cdot A \text{ ,} \quad (21)$$

$$Q_*^{Sh} = Q(a, \alpha_1, P, w, \gamma, A, A_j, E\frac{\partial \gamma_{t+1}}{\partial L_t}, EQ_{t+1}, D_t(\cdot)) \quad (22)$$

and

$$\pi_*^{Sh} = \pi\left(a, \alpha_1, P, w, \gamma, A, A_j, E\frac{\partial \gamma_{t+1}}{\partial L_t}, EQ_{t+1}, \beta_{PES}, D_t(\cdot)\right) \quad (23)$$

Similarly, for farmers currently growing sun coffee, the current time profit and total profit stream equations take the following form:

$$\pi_t^{Su} = P_q \gamma_t(\cdot)(b + L_t^{\beta_1} Z_t^{\beta_2} A^{1-\beta_1-\beta_2}) - wL_t - w_z Z_t + D_t(\sum \omega A_j) \quad (24)$$

and

$$E_0 \sum_{t=6}^{2T+5} \delta^t \pi_{sh} = E_0 \sum_{t=6}^{2T+5} \delta^t \{P_q \gamma_t(\cdot)(b + L_t^{\beta_1} Z_t^{\beta_2} A^{1-\beta_1-\beta_2}) - wL_t - w_z Z_t + D_t(\sum \omega A_j)\} \quad (25)$$

The FOC's are:

$$(L_t): \beta_1 P \gamma_t L_t^{\beta_1 - 1} Z_t^{\beta_2} A^{1-\beta_1-\beta_2} - w + E\left[\delta P \frac{\partial \gamma_{t+1}}{\partial L_t} \cdot Q_{t+1}\right] = 0 \quad (26)$$

$$(Z_t): \beta_2 P \gamma_t L_t^{\beta_1} Z_t^{\beta_2 - 1} A^{1-\beta_1-\beta_2} - w_z + E\left[\delta P \frac{\partial \gamma_{t+1}}{\partial Z_t} \cdot Q_{t+1}\right] = 0 \quad (27)$$

Which imply optimal levels of labor and capital inputs, coffee output, and per period profits:

$$L_*^{Su} = \frac{1}{\beta_2}\left[\frac{\frac{\partial \gamma_{t+1}}{\partial Z_t}}{\frac{\partial \gamma_{t+1}}{\partial L}}(\beta_1 Z_*^{Su} - w) + w_z\right] \text{and} \qquad Z_*^{Su} = \frac{1}{\beta_1}\left[\frac{\frac{\partial \gamma_{t+1}}{\partial L_t}}{\frac{\partial \gamma_{t+1}}{\partial Z_t}}(\beta_2 L_*^{Su} - w_z) + w\right] \quad , \quad (28\text{-}9)$$

$$Q_*^{Su} = Q(b, \beta_1, \beta_2, P, w, w_z, \gamma, A, A_j, E\frac{\partial \gamma_{t+1}}{\partial L_t}, EQ_{t+1}, D_t(\cdot)) \quad (30)$$

and

$$\pi_*^{Su} = \pi\left(b, \beta_1, \beta_2, P, w, w_z, \gamma, A, A_j, E\frac{\partial \gamma_{t+1}}{\partial L_t}, EQ_{t+1}, D_t(\cdot)\right) \quad (31)$$

Comparative Statics

Ultimately, the goal of this theoretical exercise is to compare the stream of profits a Puerto Rican farmer expects to attain by growing shade coffee to those he would receive from growing sun coffee. However, interesting behavioral responses may arise given the public goods aspect of the problem. In particular, it would be interesting to assess the following theoretical relations:

$$\frac{\partial \pi^{Sh}}{\partial \beta_{PES}} = \sum_{t=6}^{2T+5} \delta^t A + \sum \omega \frac{\partial A_j}{\partial \beta_{PES}} \cdot D \quad (A)$$

This relationship measures whether or not shade-coffee farmers are benefiting by a subsidy program, and if so to what extent. Intuitively, this comparative static should be positive. Furthermore, recognizing there is a relationship between the size of the lump-sum subsidy and the area devoted to shade coffee by other farmers, it is possible that the overall effect is larger than the direct effect of the subsidy alone.

$$\frac{\partial \pi^{Sh}}{\partial A_j} = \sum \omega \frac{\partial D}{\partial A_j} \gtreqless 0 \quad (B)$$

Comparative static (B) examines whether or not there are positive externalities to a shade-coffee farmer from other farmers' choice of management regime. Although the ecology argument is that this relation is positive over the long-run, it is possible that market factors, such as increased competition for scarce labor, will make the sign in this relationship ambiguous. The spatial aspect of the problem is relevant for distributional effects given that for farmers to capitalize on the ecosystem services it is more convenient to have large adjacent areas of secondary-forest (shade plantations) than many scattered farms.

$$\frac{\partial Q^{Sh}}{\partial A_j} \gtreqless 0 \quad (C)$$

The way the model is designed, has (C) equal zero. However, allowing for this relationship is interesting because it indicates the existence of sorting behavior or some type of learning process. It would be useful to identify this effect in a spatial analysis of distributional impacts and would serve as guide for policy-makers for a target population.

$$\frac{\partial \pi^{Su}}{\partial A_j} = \sum \omega \frac{\partial D}{\partial A_j} \gtreqless 0 \quad (D)$$

Comparative static (D) identifies whether or not sun-coffee farmers are substantial beneficiaries of the externality. This is important as it reflects the public goods nature of the problem. Perhaps, positive externalities actually serve as incentives for farmers to switch to sun the more profitable, and now better nourished sun coffee.

$$\frac{\partial \pi^{Su}}{\partial \beta_{PES}} = \sum \omega \frac{\partial D}{\partial A_j} \frac{\partial A_j}{\partial \beta_{PES}} \gtreqless 0 \qquad \text{(E)}$$

Finally, comparative static (E) examines contemplates a situation where the subsidy program may incentivize some farmers to free ride on the ecosystem services provided by shade-coffee adopters. If the type of farmer that free-rides happens to "dis-adopt" shade coffee, the program may in fact constitute a loss to the ecological objective (especially if the farmer owns large farm areas).

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Effect of Blending on Selected Sweet Potato Flour with Wheat Flour on Nutritional, Anti-Nutritional and Sensory Qualities of Bread

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Abstract- This study was conducted to determine the possibility of blending selected sweet potato flour to wheat flour to produce breads and to evaluate nutritional, anti-nutritional factors, quality and sensory attributes of breads. Because of its potential source of nutrients compared to yellow and white sweet potato varieties, orange sweet potato cultivar was selected for bread making and six blending ratios of its flour with wheat flour (0:100, 5:95, 10:90, 15:85, 20:80 and 25:75) were designed. Functional properties of composite flour such as wet gluten and water absorption capacity was decreased and, increased respectively as blending ratio of sweet potato flour increases. Quality parameters of breads such as loaf size (volume, specific volume and height) were significantly decreased but loaf weight was increased as blending ratio of sweet potato flour increases.

Keywords: sweet potato, variety, proximate, mineral, anti-nutritional factors, breads, blending ratio, functional properties, quality parameters, sensory attributes.

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Endrias Dako [α], Negussie Retta [σ] & Gulelat Desse [ρ]

Abstract- This study was conducted to determine the possibility of blending selected sweet potato flour to wheat flour to produce breads and to evaluate nutritional, anti-nutritional factors, quality and sensory attributes of breads. Because of its potential source of nutrients compared to yellow and white sweet potato varieties, orange sweet potato cultivar was selected for bread making and six blending ratios of its flour with wheat flour (0:100, 5:95, 10:90, 15:85, 20:80 and 25:75) were designed. Functional properties of composite flour such as wet gluten and water absorption capacity was decreased and, increased respectively as blending ratio of sweet potato flour increases. Quality parameters of breads such as loaf size (volume, specific volume and height) were significantly decreased but loaf weight was increased as blending ratio of sweet potato flour increases. Increase sweet potato flour in blending ratio significantly increased the moisture, ash, fiber, carbohydrate, calcium, iron and zinc content of the breads and resulted in a decrease in the protein, fat, energy, phosphorus, phytate, phytate: calcium, phytate: iron, phytate: zinc and [phytate x calcium]: zinc molar ratios of the breads. Sensory attributes such as appearance, aroma, taste, mouth feel and overall acceptability indicated that control bread was more preferred by consumers than sweet potato flour supplemented breads. However, breads made up to using 15% sweet potato flour supplemented accepted by consumers (scored above like slightly range), this leads to the conclusion that nutritional improved, anti-nutritional reduced and consumer acceptable breads can be prepared by supplementing up to 15% SPF in WF.

Keywords: sweet potato, variety, proximate, mineral, anti-nutritional factors, breads, blending ratio, functional properties, quality parameters, sensory attributes.

I. Introduction

Bread is a food product basically formed from flour, water, salt and yeasts. Bread flour is commonly made from wheat but it can be produced from other cereals like maize, rye, barley, rice and non-grain plants. Flour is the major basic ingredient in bakery products. Due to its important characteristics, wheat flour is the main ingredient in most types of breads (Aboaba and Obakpolor, 2010). Bread contains a good source of nutrients, such as macronutrients (carbohydrates, protein and fat) and micronutrients (minerals and vitamins) that are essential for human health to all population. However, the nutrient contents of bread products are depend on the chemical composition and baking processes used (Mohammed *et al.,* 2008).

Bread mainly produced form wheat flour but it can also be produced from composite flour such as a mixture of wheat and non wheat flours or wholly non wheat flour (David, 1992). The use of composite flour is advantageous in bread making for developing countries as it promotes high-yielding native plant species, increases nutritional values and enhances domestic agriculture production (Jolaosho, 2010). The goal of earlier researcher with composite flours was to save the largest possible percentage of wheat flour in the production of certain baked products. However, recently some research findings had showed that composite flour in new product development was used to improve nutritional value and sensory quality of the final products (Ammar *et al.,* 2009; Mepba *et al.,* 2007; Shoukat *et al.,* 2006).

Development in technology and research area showed that composite flours of sweet potato processed in to different food products for various purposes. A variety of food products such as doughnuts, biscuits, cakes, breads, cookies, fried chips, ice cream, porridge, breakfast foods and weaning foods have been made from sweet potato composite flour (Greene *et al*., 2003 ; Truong and Ramesh, 2010). Sweet potato flour can serve as source of nutrients (carbohydrates, protein, dietary fiber, beta-carotene, minerals (Ca, P, Fe and K) and can also add natural sweetness, color and flavor to processed food products (Woolfe, 1992). Hence, the development of appealing processed products from sweet potatoes play a major role in raising awareness on the potential use of the crop around the world.

An increased consumption of dietary fiber in daily diet has been recommended by nutritionists to improve health. High dietary fiber content of food is one of the most important factors in terms of developing healthy diets to reduce the incidences of cardiovascular diseases, diabetes, obesity and reduction of glucose metabolism and promotion of the growth of beneficial gut micro flora (Brennan, 2005). Depending on varieties,

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sweet potatoes are low in protein but rich in dietary fiber and carbohydrate content so a successful combination of sweet potato variety with high nutritive value with wheat flour for bread production would be nutritionally advantageous. Fiber is an important nutritional contributor of sweet potatoes in human diet. So that integration of wheat flour and sweet potato flour enhance the fiber content of bread and may have a significant effect on human health (Anton, 2008).Thus, the aim of this study was to determine the appropriate substitution level of selected sweet potato flour for wheat flour in bread making.

II. Materials and Methods

a) Description of the sampling area and sampling methods

Three sweet potato varieties with orange, yellow and white flesh colors were collected from Areka Agricultural Research Center (Figure 2.1). Wheat flour was obtained from KOJJ Food Processing Complex P.L.C. currently used for bread production. The other ingredients such as compressed yeast, powdered salt (NaCl) and improver were purchased from the local market in Addis Ababa.

A) Koka-6(Yellow) B) Falaha (White) C) Kulfo (Orange)

Figure 2.1 : Three sweet potato varieties with different storage root flesh colors

b) Experimental study setting

Breads were baked in Entoto Technical and Vocational Education Training (TVET) and A laboratory experiment was conducted at the laboratories of Addis Ababa University and Ethiopian Health and Nutrition Research Institute.

c) Preparation of sweet potato flour

Flour from sweet potato was prepared based on the method described by Adeleke and Odedeji (2010) and shown in figure 2.2

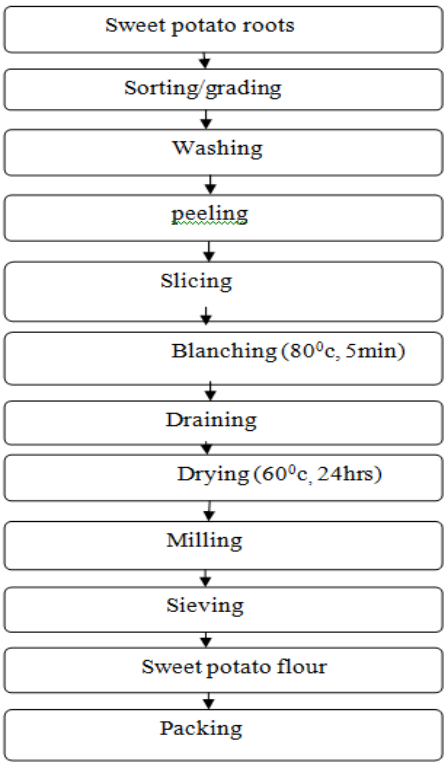

Figure 2.2 : Flow chart for the preparation of sweet potato flour

d) Preparation of composite flour

Six different blend proportions including control were designed (Table 2.1) based on the blend proportions used by Ifie (2011) in his bread formulated form sweet potato flour and wheat flour with slit modifications such that 5% and 10% more sweet potato flours are included in this blend preparation.

Table 2.1 : blending ratios of sweet potato flour and wheat flour in bread formulation

Sweet potato flour (%)	Wheat flour (%)
0	100
5	95
10	90
15	85
20	80
25	75

e) Bread preparation processes

Breads were formulated, prepared and baked based on the straight dough method used by Anton (2008) with slight modifications as the mixtures were mixed and kneaded with water in a flat wooden material manually instead of using electric mixer. Except water (variable) similar amount of all ingredients such as flour (100%), salt (1%), improver (1.5%) and yeast (2%) were used in each blend during the preparation of the dough (Table2.2). These ingredients in bread formulation were determined based on knowledge from traditional experienced bakers and literatures (Mepba *et al.,* 2007; Mardiana, 2008; Jolaosho, 2010; Ukpabi, 2010).

Table 2.2 : Ingredient used in dough formulation per loaf

Ingredient	Composition (%)
Flour	100
Yeast	2
Salt	1
Improver	1.5
Water	Variable

For bread baking, the straight dough method was used (Anton, 2008), all the ingredients were added at the same time (Figure 2.3) and mixed manually for 5 minutes and kneading was done until consistent dough was obtained. The resulted dough was left to rest for 20 minutes at room temperature (first proofing) then 100g piece of dough was divided, rolled and molded. Each piece was placed in metal pan and let to ferment for 45 minutes at room temperature (final proofing) then the baking process was carried out in electrically heated oven at 200^{0}C for 20 minutes. After baking loaves were separated from the metal pan and allowed to cool at room temperature before evaluation. The cooled loaves were dried at 60^{0}C for 9 hours and milled in to a fine powder using electric grinder (High-Speed sampling machine model- FW100) until to pass through 0.425mm sieve mesh size.

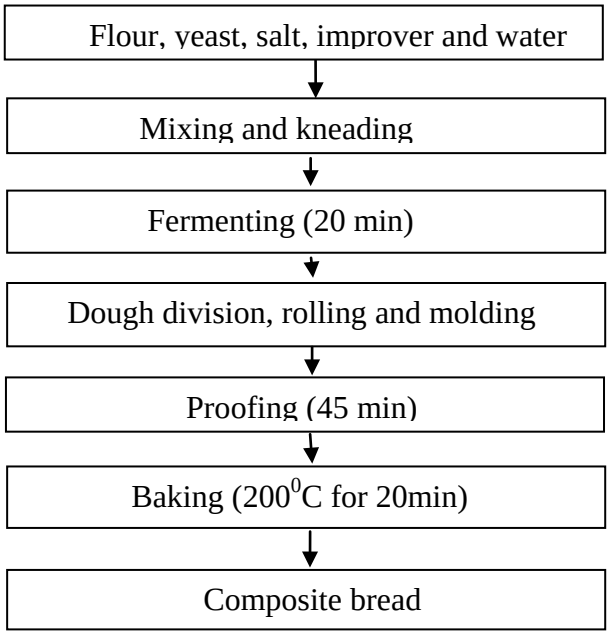

Figure 2.3 : Flow chart for bread making process

f) Methods of Analysis

i. *Determination of functional properties of composite flours*

Water absorption capacity was determined using the centrifuge method of Sosulki (1962) as cited in Edema *et al.* (2005). The gluten amount was evaluated by the standard methods of AACC test procedure (AACC, 2000).

ii. *Evaluation of bread quality parameters*

The loaf volume(VL) was measured by using seed displacement method (Mepba *et al.,* 2007) with slit modification using chickpea instead of barley seed. Loaf weight (W) of breads were measured after cooling for one hour on digital balance (Masood *et al.,* 2011). Specific loaf volume (VS) was calculated in the following expression:

$$\text{Specific Loaf Volume}(\text{cm}^3/\text{g}) = \frac{\text{VL}}{\text{W}}$$

iii. *Sensory evaluation of bread*

The sensory evaluation was carried out for consumer acceptance to evaluate loaf attributes such as appearance, aroma, taste, mouth feel and overall acceptability of the bread sample within two hours after baking. Twenty four panelists comprising of students and staff members from Food Science and Nutrition program of AAU and students and staff members of Hotel Management department in Entoto Technical and Vocational Education Training Institute (TVET) were randomly selected to perform the evaluation. Nine-point category scales was used to rate the attributes ranging

from like extremely to dislike extremely as used by (Mepba *et al.,* 2007).

iv. *Proximate analysis*

The moisture content was determined according to AOAC (2000) using the official method 925.09 by oven drying. Crude fiber content was determined according to AOAC (2000) using official method 962.09. Protein content was determined according to AOAC (2000) using the official method 979.09. Total ash content was determined according to AOAC (2000) using the official method 923.03.The crude fat content was determined according to AOAC (2000) using official method 4.5.01. Total carbohydrate content was calculated by difference using the formula as follows:

Carbohydrate (%) = 100 – (% crude protein + % crude fiber + % total ash + % crude fat)

Total energy content was obtained using Atwater conversion factors 4, 9 and 4 for each gram of crude protein, crude fat and carbohydrate and expressed in calories, respectively (Guyot *et al*., 2007).

$$\text{Total energy}\left(\frac{\text{Kcal}}{100\text{g}}\right) = (9 \times \%\text{Fat}) + (4 \times \%\text{Protein}) + (4 \times \%\text{Carbohydrate})$$

g) Mineral Analysis

Calcium, magnesium, iron and zinc were determined according to the standard method of AOAC (2000) using an Atomic Absorption Spectrophotometer (Varian SAA-20 Plus). Phosphorus was determined using UV-VIS spectrometer

h) Analysis of anti-nutritional factors

Phytate content was determined using method described by Latta and Eskin (1980) and later modified by Vaintraub and Lapteva (1988).Tannin content was determined using the method of Burns (1971) as modified by Maxson and Rooney (1972).Oxalate content of sample was determined using method originally employed by Ukpabi and Ejidoh (1989).

i) Statistical analysis

The effect of blending ratio on nutritional, anti-nutritional and sensory attributes of breads was analyzed with one way ANOVA. Mean differences were statically significant at $p<0.05$ and the means of each parameter were compared using Duncan's multiple range test procedures to separate the means using SPSS, version 15.0 software.

III. Results and Discussions

a) Functional properties of composite flours

The mean wet gluten content of blends was significantly ($p<0.05$) decreased from 30.44 to 16.87g/100g for 100% wheat flour to 25% SPF in blending proportion, respectively (Table 3.1.). The highest (30.44g/100g) and lowest (16.87g/100g) mean wet gluten content was observed in 100% wheat flour and 25% blend of sweet potato flour, respectively. Generally, the mean wet gluten content was significantly ($P<0.05$) decreased as blending ratio of sweet potato flour increased. This means that the sweet potato-wheat flour blends significantly decrease gluten content; this is because of gluten is absent in sweet potato flour and as blending ratio increases the wet gluten content decreases. Similar ideas were reported by (Kun-Lun *et al.,* 2009; Hamed *et al.,* 1973).

Table 3.1 : Effect of blending ratio on functional properties of composite flours

Blending ratio	Wet gluten content (g/100g)	Water absorption capacity (ml/100g)
0%	30.44 ± 0.31^{a}	65.60 ± 0.42^{f}
5%	28.38 ± 0.15^{b}	73.20 ± 0.21^{e}
10%	25.24 ± 0.24^{c}	75.32 ± 0.13^{d}
15%	23.85 ± 0.12^{d}	81.60 ± 0.33^{c}
20%	19.88 ± 0.24^{e}	89.57 ± 0.23^{b}
25%	16.87 ± 0.09^{f}	91.61 ± 0.18^{a}

Reported values are the mean ±SE (n=3). Means with different letters in the same column are significantly different (P<0.05).

The mean water absorption capacity of sweet potato flour and wheat flour was 194.58ml/g and 65.60ml/100g, respectively. The mean water absorption value of control and blend flours ranged from 65.60-91.61ml/100g (Table3.1). Blending proportion significantly ($P<0.05$) affected water absorption capacity of flours. Generally, the mean water absorption capacity was significantly ($P<0.05$) increased as blending proportion of sweet potato flour increased. Similar outcomes were investigated by (El-Zainy *et al.*, 2010; Sukhcharn *et al.,* 2008). This increment in water absorption capacity as SPF increase in blend ratio might be contributed by sweet potato flour; because moisture content was low in sweet potato flour than wheat flour which increases water absorption capacity as more sweet potato flour was supplemented in blending ratio.

b) Evaluation of quality parameters of bread

Table 3.2 : Effect of blending ratio on quality parameters of breads

Blending ratio	Volume (cm^3)	Weight (g)	Specific volume (cm^3/g)	Height (cm)
0%	467.98± 1.80[a]	84.09± 1.02[e]	5.68± 0.08[a]	5.77± 0.11[a]
5%	461.08± 3.30[b]	87.19 ± 0.53[d]	5.29 ± 0.07[b]	5.58 ± 0.04[a]
10%	420.37 ± 2.90[c]	89.32 ± 0.69[c]	4.71± 0.06[c]	4.92 ± 0.04[b]
15%	357.87 ± 1.96[d]	91.14± 0.17[b]	3.93± 0.02[d]	4.68± 0.10[c]
20%	312.50± 1.48[e]	92.79 ± 0.16[b]	3.37 ± 0.12[e]	4.22± 0.06[d]
25%	260.47± 2.79[f]	94.78 ± 0.15[a]	2.75 ± 0.03[f]	3.75 ± 0.03[e]

Reported values are the mean ±SE (n=3). Means with different letters in the same column are significantly different (P<0.05).

The dough (100g) was weighed before baking and the breads were weighed after baking. Blending ratio was showed significant increase (P<0.05) in weight of loaves as sweet potato flour increases in blending (Table 3.2). This increment might be contributed by the higher water absorption capacity of sweet potato flour than that of wheat flour. These results were well agreed findings of (Hamed *et al.*, 1973; Greene and Bovel-Brenjamin, 2004).On the other hand, volume of loaves were significantly decreased (P<0.05) as sweet potato flour increased in blending(Table 3.2). The results in this study were agreed with other findings (El-Zainy *et al*., 2010; Greene and Bovel-Brenjamin, 2004; Kun-Lun *et al.,* 2009; Hamed *et al.*, 1973).This is because sweet potato is soft with low gluten content and rich in fiber and thus the loaf reflect the gluten content of the bread The specific volume of breads was significantly (p<0.05) decreased as blending ratio of SPF to WF increased in breads(Table 3.2). This decrement in specific volume of breads can be resulted from decreased wet gluten content with increased supplementation of SPF on WF that results in increased loaf volume. Moreover the extra water absorption capacity of more SPF supplemented on WF those results in increased weight of final breads. Hence, specific volume is the ratio of loaf volume to loaf weight expected to be decreased. This result was agreed with El- Zainy *et al.* (2010).

Figure 3.1 : Breads made from wheat flour and wheat-sweet potato composite flour

A. Control (100%WF), **B.** 95% WF and 5% SPF,**C.** 90% WF and 10% SPF, **D.** 85% WF and 15% , **E.** 80% WF and 20% SPF, **F.** 75% WF and 25% SPF.

Blending ratio was caused a significant decrease (P<0.05) in an average loaf height of breads as sweet potato flour supplementation level increased in blending(Table 3.2). This observed reduction in loaf height as supplementation of WF with SPF increased might be contributed with less and less gluten level presence during dough formulation as more and more SPF was added in blending.

c) *Sensory analysis of breads*

Table 3.3 : Effect of blending ratio on sensory characteristics of breads

Blending ratio	Appearance	Aroma	Taste	Mouth Feel	Overall Acceptability
0%	7.92± 0.16^{a}	7.58± 0.16^{a}	7.46± 0.17^{a}	7.08± 0.18^{a}	7.17± 0.21^{a}
5%	7.42± 0.17^{ab}	7.25 ± 0.24^{ab}	7.13 ± 0.30^{ab}	6.88 ± 0.21^{a}	6.79± 0.28^{ab}
10%	6.88 ± 0.18^{b}	6.83 ± 0.24^{b}	6.83± 0.21^{ab}	6.00 ± 0.23^{b}	6.54 ± 0.20^{abc}
15%	6.08 ± 0.29^{c}	6.25± 0.30^{c}	6.67± 0.29^{bc}	5.88± 0.23^{bc}	6.17± 0.25^{bc}
20%	5.88± 0.19^{c}	6.33 ± 0.18^{c}	6.71 ± 0.21^{bc}	5.54± 0.27^{bc}	5.83± 0.23^{cd}
25%	5.75± 0.28^{c}	6.46 ± 0.27^{c}	6.33 ± 0.28^{c}	5.21 ± 0.28^{c}	5.38 ± 0.34^{d}

Reported values are the mean ±SE (n=24). Means with different letters in the same column are significantly different (P<0.05).

Table 3.3 shows that breads made at 15%, 20% and 25% sweet potato substitution levels were significantly (P<0.05) different in some of the attributes tested (appearance, aroma, taste and mouth feel) from the control bread hence control bread being more preferred by the panelists. However, at 5% and 10% SPF substitution levels there were no significant (P>0.05) difference in the mean acceptability of control bread and sweet potato supplemented breads. The panelists mean score test revealed that the control bread was scored higher in all the tested attributes. This does not mean that other bread samples were not acceptable, even at 25% substitution level the panelists seem to like the aroma and taste of bread produced from sweet potato and wheat flour blend. Despite the fact that control bread was more preferred to sweet potato supplemented breads, the average mean score of overall acceptability of up to 15% SPF composite breads are above 6 (like slightly) suggesting that they are acceptable range by consumers. This higher sensory attribute scoring for control bread compared with sweet potato and wheat flours composite breads could be due to the familiarization of the consumers to the normal wheat bread (Olaoye *et al*., 2006). This result was agreed with previous works of (Aniedu and Agugo, 2010; Greene and Bovell-Benjamin, 2004; Sukhcharn *et al.*, 2008).

d) *Nutritional composition*

i. *Nutritional composition of flours*

Table 3.4 : Chemical composition of sweet potato flour and wheat flour (on dry weight basis)

Constituents (%)	Wheat flour	Sweet potato flour
Moisture(g)	12.38± 0.04^{a}	8.37± 0.02^{b}
Protein(g)	11.63 ±0.18^{a}	2.74 ± 0.01^{b}
Fat(g)	1.97 ± 0.02^{a}	1.12 ± 0.01^{b}
Crud Fiber(g)	1.83 ± 0.01^{b}	3.83±0.04^{a}
Ash(g/100g)	0.78± 0.15^{b}	4.30 ± 0.03^{a}
Carbohydrate(g)	84.04± 0.18^{b}	88.00±0.02^{a}
Total Energy (Kcal)	400.53± 0.14^{a}	373.00±0.15^{b}
Calcium(mg)	27.41 ± 0.02^{b}	45.54 ± 0.01^{a}
Phosphorus(mg)	24.66 ± 0.01^{a}	20.68 ± 0.01^{b}
Iron (mg)	3.65 ± 0.02^{b}	11.46 ± 0.11^{a}
Zinc(mg)	0.69±0.01^{b}	0.93±0.01^{a}
Phytate(mg)	158.38 ± 0.24^{a}	77.74 ± 0.01^{b}

Reported values are the mean ±SE (n=3).
Means with different letters in the same rows are significantly different (p<0.05)

The mean values for proximate, minerals and phytate composition of wheat flour and sweet potato flour were calculated in 100g of flours and the obtained results are presented in Table 3.4. Sweet potato flour compared to wheat flour contains lower level of crude protein, crude fat, moisture, total energy and higher level of total ash, crude fiber and total carbohydrate content. Considering to minerals and phytate composition, sweet potato flour has higher level of calcium, iron and zinc and lower level of phosphorus and phytate than wheat flour. This result indicates that there is significantly compositional difference between sweet potato flour and wheat flour in their levels of proximate, minerals and phytate content. Therefore, blending of sweet potato flour to wheat flour will contribute to increase nutrients which were lower in one of the component of composite flours of breads.

ii. *Nutritional composition of breads*

a. *Proximate composition of breads*

Table 3.5 : Effect of blending ratio on proximate composition (g/100g) of breads

Blend ratio	Moisture*	Protein	Fat	Ash	Fiber	CHO**	T.E***
0%	30.77± 0.31^{f}	11.17± 0.01^{a}	1.73± 0.02^{a}	1.59± 0.01^{f}	1.76± 0.01^{f}	83.74± 0.01^{cd}	395.25± 0.17^{a}
5%	32.81± 0.04^{e}	10.86 ± 0.04^{b}	1.48 ± 0.03^{b}	1.82 ± 0.03^{e}	1.96± 0.01^{e}	83.87± 0.09^{c}	392.29± 0.29^{b}
10%	33.47 ± 0.02^{d}	10.66 ± 0.06^{b}	1.40± 0.04^{bc}	2.16 ± 0.04^{d}	2.22 ± 0.01^{d}	83.55 ± 0.03^{d}	389.47 ± 0.38^{c}
15%	34.90 ± 0.02^{c}	9.94± 0.02^{c}	1.36± 0.01^{cd}	2.40± 0.01^{c}	2.43± 0.01^{c}	83.88± 0.05^{c}	387.51± 0.06^{d}
20%	35.49± 0.03^{b}	9.31 ± 0.06^{d}	1.32 ± 0.02^{d}	2.58± 0.02^{b}	2.63± 0.02^{b}	84.16± 0.07^{b}	385.73± 0.22^{e}
25%	37.15± 0.03^{a}	8.34 ± 0.13^{e}	1.23 ± 0.02^{e}	2.83 ± 0.02^{a}	2.75± 0.01^{a}	84.85± 0.17^{a}	383.85± 0.08^{f}

*Reported values are the mean ±SE (n=3). Means with different letters in the same column are significantly different (P<0.05), *Wet basis, **Total carbohydrate, ***Total energy (Kcal/100g).*

The mean moisture content of breads ranged from 30.77-37.15g/100g (Table 3.5). Breads at 25% SPF substitution level had the highest mean moisture value (37.15g/100g) while the control one had the least value (30.77g/100g). Statistical analysis showed that the mean moisture content of all experimental breads were significantly increased (p<0.05) as substitution levels of sweet potato flour increased. This increment could be attributed to the water binding capacity of sweet potato flour. The present finding was consistent with reports of Aniedu and Agugo (2010).

Control bread had the highest mean protein content (11.17g/100g) while bread at 25% SPF substitution level had the least value (8.34g/100g) (Table 3.5). The mean protein content of breads were significantly decreased (p<0.05) as substitution levels of sweet potato flour increased. Low protein content was observed with all sweet potato supplemented breads compared to the control bread. This could be as a result of the low protein content in sweet potato flour than wheat flour. The present finding was consistent with reports of (Aniedu and Agugo, 2010; El- Zainy *et al*., 2010; Ifie, 2011).

Table 3.5 shows that the fat content of breads ranging from 1.23-1.73g/100g. Control bread had the highest mean fat content (1.73g/100g) while bread at 25% SPF substitution level had the least value (1.23g/100g). The mean fat content of breads were significantly decreased (p<0.05) as substitution levels of sweet potato flour increased. These reductions in fat content of breads observed in current study due to sweet potato flours contain low fat when compared to wheat flours. These results were well agreed with the findings of (Aniedu and Agugo, 2010; Ifie, 2011).

The mean fiber content of breads ranged from 1.76-2.75g/100g (Table 3.5). Control bread had the least mean fiber content (1.76g/100g) while bread at 25% SPF substitution level had the highest value (2.75g/100g). The mean fiber content of breads were significantly increased (p<0.05) as substitution levels of sweet potato flour increased. This increment in mean fiber content of breads could be due to the high quantity of fiber in sweet potato flour than that of wheat flour. The present findings were consistent with results of (Aniedu and Agugo, 2010; El- Zainy *et al*., 2010; Ifie, 2011).

The mean ash content of breads ranged from 1.59-2.83g/100g (Table 3.5). All blended breads had significantly higher (p<0.05) value of mean ash content when compared with the control bread. The effects of blend ratio was significantly increased (p<0.05) in mean ash content with SPF supplementation level on wheat flour increased. This increment in mean ash content of breads might be attributed by sweet potato flour; as sweet potato flour contains high ash level when compared to wheat flour. These results were in full agreement with results reported by (Aniedu and Agugo, 2010; El- Zainy *et al*., 2010; Ifie, 2011).

The mean carbohydrate content of breads ranged from 83.55-84.85g/100g (Table 3.5). The mean carbohydrate content of breads in this finding was increased even though some irregularity value was also happened. Control bread did not show significant difference (p>0.05) in carbohydrate content up to 15% SPF substitution level but was significantly different (p<0.05) with breads made up of 20% and 25% SPF substitution levels. The highest and lowest mean carbohydrate content were observed with breads supplemented at 25% SPF and 5% SPF levels, respectively. This increment might be attributed by sweet potato flour; as sweet potato flour contains high carbohydrate level when compared to wheat flour. A similar result had been reported by Ifie (2011).

The energy content of breads ranged from 383.85- 395.25Kcal/100g (Table 3.5). The energy content of breads was significantly decreased (p<0.05) with SPF substation level increased. This decrement in total energy of breads as the ratio of SPF increased in the blend, therefore, might be attributed by less energy content of sweet potato flour.

b. *Mineral content of breads*

The calcium content of breads ranged from 21.08-31.42mg/100g (Table 3.6). The calcium content of breads were significantly increased (p<0.05) as

substitution levels of sweet potato flour increased. This could be due to high content of calcium in sweet potato flour than wheat flour. This result was consistent with finding of El- Zainy *et al.* (2010).

Table 3.6 : Effect of blending ratio on mineral composition of breads (mg/100g)

Blending ratio	Calcium	Phosphorus	Iron	Zinc
0%	21.08± 0.01^{f}	19.23± 0.02^{a}	2.92± 0.01^{f}	0.52± 0.01^{e}
5%	22.11± 0.01^{e}	19.12 ± 0.01^{b}	3.30± 0.01^{e}	0.56 ± 0.01^{ed}
10%	24.55 ± 0.02^{d}	18.78 ± 0.02^{c}	3.76± 0.02^{d}	0.59 ± 0.01^{cd}
15%	26.90 ± 0.01^{c}	18.42± 0.02^{d}	4.27± 0.01^{c}	0.62± 0.02^{bc}
20%	29.14± 0.01^{b}	17.98 ± 0.01^{e}	4.65 ± 0.02^{b}	0.64± 0.02^{b}
25%	31.42± 0.01^{a}	17.51 ± 0.02^{f}	5.09± 0.01^{a}	0.68 ± 0.01^{a}

Reported values are the mean ±SE (n=2). Means with different letters in the same column are significantly different (P<0.05)

The mean phosphorus content of breads ranged from 17.51-19.23mg/100g (Table 3.6). The phosphorus content of breads were significantly decreased ($p<0.05$) as substitution levels of sweet potato flour increased. This decrement in phosphorus level of breads as the ratio of SPF increased in the blend, therefore, might be attributed by less phosphorus content of sweet potato flour.

The mean iron content of breads ranged from 2.92-5.09mg/100g (Table 3.6). The iron content of breads were significantly increased ($p<0.05$) as substitution levels of sweet potato flour increased. Higher score of iron content was observed with all sweet potato supplemented breads compared to the control bread. This could be due to high content of iron in sweet potato flour than wheat flour. A similar result was observed by El- Zainy *et al.* (2010). Low level of zinc content was observed in all investigated breads and the mean value ranged from 0.52-0.68mg/100g. The mean zinc content of breads were significantly increased ($p<0.05$) as blending ratio of sweet potato flour increased. This could be due to high content of zinc in sweet potato flour than wheat flour; a similar result was investigated by El- Zainy *et al.* (2010).

The phytate content of breads was significantly decreased ($p<0.05$) with SPF substitution levels increased(Table 3.7). Control bread had the highest value of phytate (98.88mg/100g) and was significantly different ($p<0.05$) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (67.43mg/100g). This decrease could be attributed to low level of phytate in sweet potato flour than wheat flour.

The phytate: calcium molar ratio of breads was significantly decreased ($p<0.05$) with SPF substitution levels increased(Table 3.7). Control bread had the highest value of phytate: calcium molar ratio (0.29) and was significantly different ($p<0.05$) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (0.14). This decrease could be attributed to the low and high level of phytate and calcium in sweet potato flour than wheat flour.

The phytate: calcium molar ratios >0.24, indicative of poor calcium bioavailability (Norhaizan and Faizadatul, 2009). The phytate: calcium molar ratio in the present study for control and 5% SPF substituted breads were higher than the reported critical level; this indicates that absorption of calcium adversely affected by phytate in these breads. But in case of other breads (10%-25% SPF substituted breads) the value was lower than the reported critical level, which shows that absorption of calcium not affected by phytate in these breads.

Table 3.7 : Effect of blending ratio on phytate and phytate mineral molar ratios of breads

Blending ratio	Phytate (mg/100g)	Phy:Ca	Phy:Fe	Phy:Zn	[PhyxCa]:Zn (mg/100g)
0%	98.88±0.34^{a}	0.29±0.01^{a}	2.89±0.01^{a}	18.82±0.41^{a}	0.099±0.001^{a}
5%	89.94±0.65^{b}	0.25±0.01^{b}	2.31±0.02^{b}	16.03±0.10^{b}	0.094±0.004^{a}
10%	87.29±0.65^{c}	0.22±0.01^{c}	1.96±0.00^{c}	14.67±0.05^{c}	0.093±0.003^{a}
15%	75.83±0.64^{d}	0.18±0.01^{d}	1.52±0.02^{d}	12.12±0.49^{d}	0.083±0.004^{b}
20%	72.21±0.65^{e}	0.16±0.01^{e}	1.32±0.02^{e}	11.19±0.19^{de}	0.082±0.002^{b}
25%	67.43±0.33^{f}	0.14±0.01^{f}	1.13±0.01^{f}	10.25±0.05^{e}	0.081±0.001^{b}

Reported values are the mean ± SE (n=3). Means with different letters in the same columns are significantly different (P<0.05)

The phytate: iron molar ratio of breads was significantly decreased ($p<0.05$) with SPF substitution levels increased(Table 3.7). Control bread had the highest value of phytate: iron molar ratio (2.89) and was significantly different ($p<0.05$) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (1.13). This decrease could be attributed to the low and high level of phytate and iron in sweet potato flour than wheat flour. The phytate: iron molar ratio >1, indicative of poor iron

bioavailability (Norhaizan and Faizadatul, 2009). The phytate: iron molar ratio in the present study for all breads were higher than the reported critical value, which implies the absorption of iron from all experimental breads were found inhibited by phytate and as a result the bioavailability of iron is poor in these breads.

The mean phytate: zinc molar ratio of breads ranged from 10.25-18.82 (Table 3.7). The mean phytate: zinc molar ratio of breads was significantly decreased ($p<0.05$) with SPF substitution levels increased. Control bread had the highest value of phytate: zinc molar ratio (18.82) and was significantly different ($p<0.05$) compared to all other SPF supplemented breads while bread supplemented with 25% SPF had the least value (10.25). This decrease could be attributed to the low and high level of phytate and zinc in sweet potato flour than wheat flour. The phytate: zinc molar ratios >15, indicative of poor zinc bioavailability (Norhaizan and Faizadatul, 2009). The phytate: zinc molar ratio in the present study for control and 5% SPF substituted breads were higher than the reported critical level, indicating that absorption of zinc was found adversely affected by phytate in these breads. But in case of other breads (10%-25% SPF substituted breads) the value was found lower than the reported critical value, indicating that absorption of calcium was not affected by phytate in these breads.

The [phytate x calcium]: zinc molar ratio of breads ranged from 0.081-099mg/100g (3.7). Generally, the mean [phytate x calcium]: zinc molar ratio of breads was significantly decreased ($p<0.05$) with SPF substitution levels increased. This decrease could be attributed to the low and high level of phytate and zinc in sweet potato flour than wheat flour. The potential effect of calcium on zinc absorption in the presence of high phytate intakes has led to the suggestion that the [phytate x calcium]: zinc molar ratio may be a better index of zinc bioavailability than the phytate: zinc molar ratio alone (Obah and Amusan, 2009). High calcium levels in foods can promote the phytate-induced decrease in zinc bioavailability when the [phytate x calcium]: zinc molar ratio greater than 200mg/100g (Norhaizan and Faizadatul, 2009). In this study, the values of [phytate x calcium]: zinc molar ratios of all breads were found less than the reported critical level. Therefore, bioavailability of zinc is not affected by calcium in the presence of phytate levels in all experimental breads.

IV. Conclusion and Recommendations

The result of present study showed that supplementation of sweet potato flour to wheat flour greatly decreased dough stability and loaf size (volume, specific volume and height) due to the dilution of gluten matrix in wheat flour. Composite flours have lower level of wet gluten content and higher level of water absorption capacity than control(wheat) flour. Breads prepared from SPF supplemented had significantly increased levels of moisture, ash, fiber, carbohydrate, calcium, iron and zinc content than control(wheat) bread. This was due to the high levels of these nutrients in SPF compared to wheat flour. On the other hand, there was a decrease in protein, fat, energy and phosphorus levels of breads as substitution of SPF increased in blending ratio. Moreover, the phytate content and phytate mineral molar ratios of blended breads were also significantly decreased than control(wheat)bread. Thus, supplementation of SPF can reduce phytate level, enhance mineral bioavailability and improve nutritional status of wheat bread.

Nevertheless, all nutritionally rich food products may not be always desired to consumer acceptance. Results of sensory attributes in terms of appearance, aroma, taste, mouth feel and overall acceptability indicated that control bread was more preferred by consumers than SPF supplemented breads. However, breads made up-to using 15% SPF substituted level accepted by consumers (scored above like slightly range), this leads to the conclusion that nutritional improved, anti-nutritional reduced and consumer acceptable breads can be prepared by supplementing up to 15% level SPF in WF.

Based on the current study, it is recommended that breads production from sweet potato and wheat composite flours should be given emphasis and processors should be encouraged to utilize the potential nutrient source of sweet potato flour. Since such breads are a good source of dietary fiber, which may also be of benefit in the prevention of cardiovascular diseases and cancers. Since protein value is low in sweet potato cultivars, it is encouraged that sweet potato crop should be consumed along with legumes. Thus, farmers who cultivate sweet potato crop should also cultivate legumes in order to compensate protein value of sweet potato for their growing children.

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References Références Referencias

1. AACC (2000). Approved Methods of the American Association of Cereal Chemists. 10th Edition, Arlington.

2. Aboaba, O. and Obakpolor, E. A. (2010). The leavening ability of baker's yeast on dough prepared with composite flour (wheat/cassava). *African Journal of Food Science*, 4(6): 325 – 329.
3. Adeleke, R. O. and Odedeji, J.O. (2010). Functional properties of wheat and sweet potato flour blends. *Pakistan Journal of Nutrition,* 9 (6): 535-538.
4. Ammar, M.S., Hegazy, A.E. and Bedeir, S.H. (2009). Using of taro flour as partial substitute of wheat flour in bread making. *World Journal of Dairy & Food Sciences,* 4 (2): 94-99.
5. Aniedu, C. and Agugo, U.A. (2010). Acceptability of bread produced from hausa-potato and sweet potato composite flours. *Journal of Agriculture and Social Research*, 10(2): 162-166.
6. Anton, M. (2008).Utilization of sweet potato starch, flour and fiber in bread and biscuits: physic-chemical and nutritional characteristics. A thesis submitted in partial fulfillment of the requirements for the degree Master of Technology in Food Technology. Massey University
7. AOAC (2000). Association of Official Analytical Chemists. Official Methods of Analysis, 17th edition. Washington, DC.
8. Brennan, S. C. (2005). Dietary fiber, glycemic response, and diabetes. Molecular Nutrition, Food Resource, 49: 560-570.
9. Burns, R.R. (1971). Methods for estimation of tannin in grain Sorghum. *Agronomic Journal*, 63: 511-512.
10. David, D. (1992). Perspectives in composite and alternative flour products. Invited paper, Natural Resources Institute United Kingdom, Paris
11. Edema, M. O., Sanni, L.O. and Abiodun, S.I. (2005). Evaluation of maize-soybean flour blends for sour maize bread production in Nigeria*. African Journal of Biotechnology,* 4 (9): 911-918.
12. El-Zainy, A. R., Shalaby, A. O., Amany, A. S. and Eman, A. F. (2010). Effect of adding sweet potato flour to wheat flour on the properties of pan bread. *Journal of Food and Dairy Sciences,* Mansoura University*,* 1(7): 387-396.
13. Greene, J.L. and Bovell-Benjamin A.C. (2004). Macroscopic and sensory evaluation of bread supplemented with sweet potato flour. *Journal of Food Science*, 69(4):1-8.
14. Greene, J.L., Bromfield, E., Dean, D., Abdalla, M. and Bovell-Benjamin, A.C. (2003). Bread making properties of sweet potato flour. Technical Paper No. 2003-01-2617. Society for Automotive Engineers (SAE), Warrendale, PA, USA.
15. Guyot, J.P., Rochette, I. and Treche, S. (2007). Effect of fermentation by amylolytic lactic acid bacteria, in process combinations, on characteristics of rice/soybean slurries: A new method for preparing high energy density complementary foods for young children. Food Chemistry, 100: 623–630.
16. Hamed, M.G., Refai, F.Y., Hussin, M. F. and El-Samahy, S.K. (1973). Effect of adding sweet potato flour to wheat flour on physical dough properties and baking. Food Technology, 50: 140-146.
17. Ifie, I. (2011). Sensory and nutritional quality of Madiga produced from composite flour of wheat and sweet potato. *Pakistan Journal of Nutrition,* 10 (11): 1004-1007.
18. Jolaosho, A. (2010). Effect of bromate on the specific volume of bread made from selected composite flour. A project submitted to the department of food science and technology, university of agriculture, Abeokuta. In partial fulfillment of the requirement for the award of Bachelor of Science
19. Kun-Lun, W., Sung, W. and Yang, C. (2009). Characteristics of dough and bread as affected by the incorporation of sweet potato paste in the formulation. *Journal of Marine Science and Technology*, 17 (1): 13-22.
20. Latta, M. and Eskin, M. (1980). A simple and rapid colorimetric method for phytate determination. *Journal of Agricultural and Food Chemistry*, 28:1315–1317.
21. Mardiana, A. Z. (2008). Effects of partial substitution of wheat flour with chempedak (*artocarpus integer*) seed flour on the physicochemical, organoleptic and microbiological attributes of the bread. Thesis submitted in fulfillment of the requirements for the degree of Master of Science
22. Masood, S. B., Javaid, I., Ambreen, N., Faiza, S. and Ahmar, J. (2011). Effect of Flour Blending on Bread Characteristics. *Internet Journal of Food Safety*, 13: 142-149.
23. Maxson, E. D. and Rooney, L. W. (1972). Evaluation of methods for tannin analysis in sorghum grain. Cereal Chemistry, 49: 719-729.
24. Mepba, H. D., Lucy, E. and Nwaojigwa, S. U. (2007). Chemical composition, functional and baking properties of wheat-plantain composite flours. *African Journal of Food Agriculture Nutrition and Development*, 7 (1): 1-23.
25. Mohammed, S., Al-Mussali, M. A. and Gahri, A. (2008). Nutritive value of commonly consumed bread in Yemen. *E-Journal of Chemistry*, 6(2): 437-444.
26. Norhaizan, M. E. and Faizadatul A. W. (2009). Determination of phytate, iron, zinc, calcium contents and their molar ratios in commonly consumed raw and prepared food in Malaysia. *Malaysia Journal of Nutrition,* 15(2): 213 – 222.
27. Obah, G. and Amusan, T.V. (2009). Nutritive value and antioxidant properties of cereal gruels produced from fermented maize and sorghum. Food Biotechnology, 23: 17-31.
28. Olaoye, O. A, Onilude, A. A and Idowe, O. A. (2006). Quality Characteristics of Bread Produced from

Composite Flours of Wheat, Plantain and Soybeans. *African Journal of Biotechnology*, **5(11):** 1102-1106.
29. Shoukat, B., Tariq, M. and Asia, L. (2006). Effect of Flaxseed (*Linum usitatissimum*) on the baking properties of cakes and cookies. *International Journal of Agriculture Research*, **1(5):** 496-502.
30. Sosulki, F.W. (1962). The centrifuge method for determining flour absorptive in hard red spring wheat. Cereal Chemistry, **39:** 344-347.
31. Sukhcharn, S., Riar, C. S. and Saxena, D. C. (2008). Effect of incorporating sweet potato flour to wheat flour on the quality characteristics of cookies. *African Journal of Food Science*, **2:** 65-72.
32. Truong, V. D. and Ramesh Y. (2010). Sweet potato purees and powders for functional food ingredients. *In: sweet potato: post harvest aspects in food,* Editors: Ray, R. C. and Tomlins, K. I. pp, 117-161
33. Ukpabi, U. J. (2010). Farmstead bread making potential of lesser yam (*Dioscorea esculenta*) flour in Nigeria. *Australian journal of crop science,* **4(2):**68-73.
34. Ukpabi, V. J. and Ejidoh, J. I. (1989). Effect of deep out frying on the oxalate content and the degree of itching of cocoyams (*Xanthosoma and colocassia* spp). Technical paper presented at the 5th annual conference of the Agriculture society of Nigeria.
35. Vaintraub, I. A. and Lapteva, N. A. (1988). Colorimetric determination of phytate in unpurified extracts of seeds and the products of their processing. Analytical Biochemistry, **175:** 227.
36. Woolfe, J. A. (1992). Sweet potato, an untapped Food Resource, Cambridge: Cambridge University press. In. proc. Of 8th ISTRC-AB Symposium, pp.141.

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Manifestation of Some Meadow Grasses of Local Origin, under Conditions of the Central Balkan Mountain in Bulgaria

By Dimitar Mitev & Galina Naydenova

Summary- In the period of 2011-2015, a field experiment was conducted in the foothill region of the Central Balkan Mountain. The behaviour of some meadow grasses of local origin was studied, which had not been used before, under artificial sowing conditions. It has been found that there is an opportunity to cultivate French rye grass and white bentgrass under conditions of highly gleyed pseudopodzolic soils. Under the experimental conditions, the most productive species were red and tall fescue. The average green matter yield of red fescue was 21.70 $t.xa^{-1}$, and dry matter – 7.032 $t.xa^{-1}$. In comparison, tall fescue surpassed it insignificantly according to average green matter yield (5.07%), but it was also insignificantly inferior according to dry matter (5,73%). Perennial ryegrass and big quaking grass were the most low-yielding grasses in the current study. Their average green mass, for the period of study, was 16.30 $t.xa^{-1}$ and 16.10 $t.xa^{-1}$, and dry matter was 4.159 $t.xa^{-1}$and 4.878 $t.xa^{-1}$.

Keywords: *meadow grasses, hypothesis.*

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Summary- In the period of 2011-2015, a field experiment was conducted in the foothill region of the Central Balkan Mountain. The behaviour of some meadow grasses of local origin was studied, which had not been used before, under artificial sowing conditions. It has been found that there is an opportunity to cultivate French rye grass and white bentgrass under conditions of highly gleyed pseudopodzolic soils. Under the experimental conditions, the most productive species were red and tall fescue. The average green matter yield of red fescue was 21.70 t.xa^{-1}, and dry matter – 7.032 t.xa^{-1}. In comparison, tall fescue surpassed it insignificantly according to average green matter yield (5.07%), but it was also insignificantly inferior according to dry matter (5,73%). Perennial ryegrass and big quaking grass were the most low-yielding grasses in the current study. Their average green mass, for the period of study, was 16.30 t.xa^{-1} and 16.10 t.xa^{-1}, and dry matter was 4.159 t.xa^{-1}and 4.878 t.xa^{-1}.

Red fescue and white bentgrass had the highest percentage in the grasslands. In the end of the study period (2015), it was respectively 83.3% and 81.8%.

Self-sowing of other meadow grasses of local origin was found, based on availability of their seeds in the soil.

A hypothesis is formed that each "structural unit" (…, species, population, cultivar,…) represents a peculiar "energy-information system", with the corresponding "projection in Time

Keywords: meadow grasses, hypothesis.

I. Introduction

The idea, on the advantages (Mitev and Petrov, 1999) and disadvantages (Hector, 1998) of the simple and mixed grasslands in comparison to the individually created meadow grasslands, has had a long history (Darwin, 1872). It has carried on during the years with unceasing power (Mitev and Naydenova, 2015; Sanderson et al., 2004). The global climate changes impose the selection of species, which should establish such kind of grasslands, that the latter could resist the extreme environmental conditions of the habitat (Ives et al., 2000). Grassed areas take a significant share in production of harsh fodder, which in turn forms a positive norm of profitability in agriculture (Frank et al., 1998; Totev et al., 2000, etc.). It is necessary to mention that in the selection of components in order to establish a meadow grassland, attention should be paid not only to the productivity and respectively to the economy, but also, for example, to its influence over the environment (Kanneganti et ah, 1998; Bloom and Mallik, 2004). The grasslands using permits to go beyond the traditional limits of the commonly accepted views about agriculture, ecology, preservation, and land management, which must also include sustainable development, decreased pesticide use and artificial fertilizers, and soil protection (Watkinson et al., 2001; Krueger et al., 2002; Mitev and Naydenova, 2008; Faroq et al., 2013). The specificity in water consumption regulation for different species increases soil humidity and lowers its temperature. The heat regulation of soil leads to decrease in its air temperature (Shumway, 2000; Wilson, 1996), which increases their significance in ecological terms. The change in nutrient transfer and absorption of the created organic matter (Koukoura, 1998) permits to look for "a preserving approach in the re-establishment of degraded areas", which are determined in some regions in Bulgaria (Mitev and Naydenova, 2008). A number of researches, which have been carried out in Bulgaria, show the impossibility to create qualitative and long-lasting meadow grasslands using foreign seeds (Chourkova, 2007; Goranova-Naydenova, 2002; Mitev, 1997; Stoeva, 2001; Totev, 1984; etc.) This differs from the idea of realization of the Evolution of Increased Competitive Ability (Bossdorf et al., 2005). Sometimes, the introduced species could make enormous economic difficulties (Perrings et al., 2000). The difference in relation to meadow grasses (Goranova-Naydenova, 2002; Mitev, 1997 etc.) required to conduct a large-scale selection programme for creation of meadow grass cultivars of local origin, meeting the conditions of the habitat. Every particular region is distinguished by a peculiar specificity, which could make it unique in ecological terms (Ward1e et al. 1987; Mitev and Naydenova, 2015).

The aim of present study was to determine the manifestation of some meadow grasses of local origin under the conditions of the Central Balkan Mountain.

II. Material and Methods

The experiment was set in the experimental field of RIMSA - Troyan, located at the altitude of 384 m, in

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the spring of 2010, using the block method, with 4 replications, with a size of the experimental parcel of $1m^2$. The soil is pseudopodzolic, with a high degree of gleying, characterized by pH (KCl) 3.9, exchangeable cations in meqv/100 g soil, Al - 1.6; Mn - 1.3; Ca+Mg - 4.5. (Mitev and Belperchinov, 2000). The average annual rainfall amount in the region of the experiment for a long-term period (1965 - 2000) was 734,4 mm, and for the vegetation period - 453 mm. Soil was ploughed in depth of 18 – 20sm in autumn. Before sowing, the soil was brought to a garden state. Sowing was conducted manually in 2010 in a disperse manner, with 800 seeds capable of germinating at $1m^2$, without fertilization. After sowing the earth was rolled. The variants of study are as follows: 1. Red fescue (Festuca rubra L.), 2. Perrenial ryegrass (Lolium perenne L.), 3. Cock's foot (Dactilis glomerata L.), 4. French rye grass (Arrhenatherum elatius P.B.-Avena elatior L.), 5. Tall fescue (Festuca arundinacea Schreb), 6. Big quaking grass (Briza maxima L.), 7. Golden oat grass (Trisetum flavescens L.), 8. White bentgrass (Agrostis alba L.= Agrosris stolonifera L.). Local populations of species were used. Green and dry matter yield were followed in t.xa-1, as well as the botanical composition of grasslands in the period 2011 – 2015. Grasses were cut in the phase of full heading/ear formation. In the year of sowing (2010) the experiment was not harvested, but two sanitary cuttings were performed in order to fight weeds. For the statistical data processing were used analysis of variance (ANOVA) and a multiple comparison of mean values in relation to green and dry matter yield by means of least significant differences (LSD0.05). A part of the results were published in the previous article (Mitev, 2014 [(2)])

III. Results and Discussions

Green and dry matter yields are shown in figures 1 and 2. The most productive species for an average long-term period (2011 - 2015) were red and tall fescue. The average green matter yield of red fescue was 21.70 $t.xa^{-1}$, as dry matter was 7.032 $t.xa^{-1}$. In comparison, tall fescue surpassed it insignificantly in the average green matter yield (5,07%), and it was also insignificantly inferior according to dry matter (5,73%). The least productive were perennial ryegrass and big quaking grass for the conditions of the experiment. Their average green matter yield for the period was respectively 16.30 $t.xa^{-1}$ and 16.10 $t.xa^{-1}$, and dry matter was 4.159 $t.xa^{-1}$and 4.878 $t.xa^{-1}$.

Species, such as French rye grass, golden oat grass and white bentgrass, which have not been cultivated as cultural species till now in the region of foothills of the Central Balkan Mountain, gave way with unproven differences in the average dry matter yield of red fescue. In other studies, the latter species has shown its advantages in productive terms, in comparison with a number of other meadow grasses (Mitev, 1995; Mitev et al., 2013; Totev, 1984). In some years (2012), white bentgrass formed 13.21% more green matter in comparison with red fescue, golden oat grass was by 9,43% more; and French ryegrass was 11.32% more. In 2012 only the French ryegrass gave 24.25% more dry matter in comparison with red fescue. The manifestations of white bentgrass give reasons to compare it in a certain relation with red fescue. It is known that red fescue reaches a balance of substances in its issues at a low level of ionic density (Brrogowski and Trasczyk, 1978), which allows it successfully to assert itself on the account of natural soil resources. Cock's foot had approximately 3.2 times higher requirements in relation to that study. Regardless of unproven mathematical differences between the above-mentioned two cultures, the comparison in their dry matter productivity showed interesting correlation. In odd years of study (2011; 2013; 2015), red fescue surpassed in its yield the white bentgrass. In even years (2012; 2014), their productivity was approximately equal. This „succession" brings about the feeling of a peculiar „pulsation of systems", which is found in other author's studies. It is different as a manifestation in years, for each of the species and is caused by the synchronicity or its lack with the rhythm in Nature, with its energy essence. It is also possible when a definite energy status is reached to determine the shrinking and expanding in the area of species distribution (Mitev and Yasheva, 1998). French ryegrass has spread in the region in the last 3-4 decades. White bentgrass has spread for the last 1-2 decades.

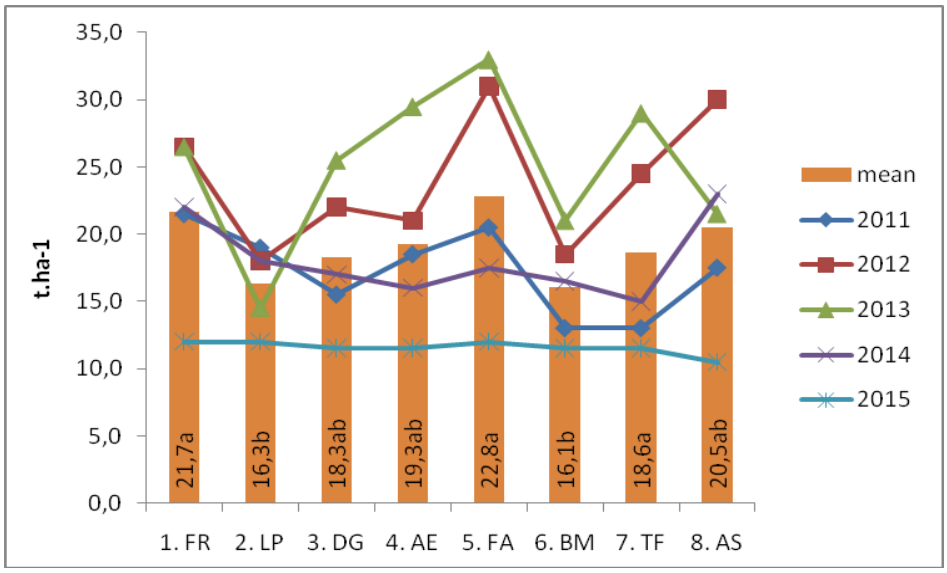


Figure 1 : Green matter yield in years and average for the period, t.ha^{-1}

**Note: 1. Red fescue (F.R.) 2. Perennial ryegrass (LP), 3. Cock's foot (DG), 4. French rye grass (AE), 5. Tall fescue (FA), 6. Big quaking grass (BM), 7. Golden oat grass (TF), 8. White bentgrass (AA=AS)*

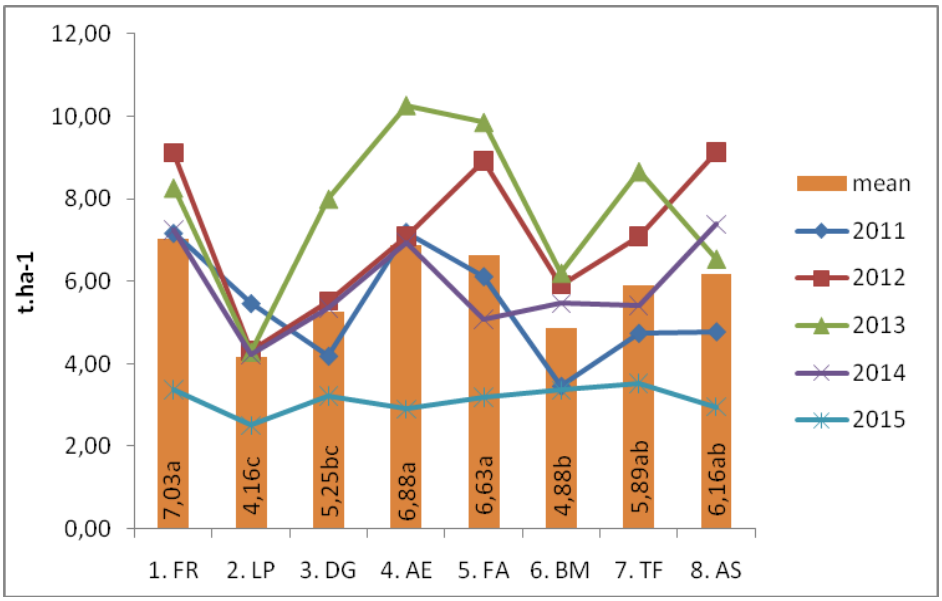


Figure 2 : Dry matter yield in years and average for the period, t.ha^{-1}

**Note: 1. Red fescue (F.R.) 2. Perennial ryegrass (LP), 3. Cock's foot (DG), 4. French rye grass (AE), 5. Tall fescue (FA), 6. Big quaking grass (BM), 7. Golden oat grass (TF), 8. White bentgrass (AA=AS)*

It is considered that forage production quantity is a result of reduced invasion of unwanted weed vegetation (Tracy and Sanderson, 2004), the recovery of the available feeding resources (Gilroy and Trewavas, 2001; Reiche et al., 2001) and so on. The use of these resources depends on the physiological and phenological peculiarities of components in the grasslands (Sanderson et al., 2004). Moreover, that could be the combination of these and other factors with the concrete condition of the plant material included in the study (Mitev, 2004).

From this perspective, the botanical composition of grasslands and the species ability to counteract to the local weed complex are of interest (Figure 3). Big quaking grass established itself extremely difficult in the grassland. In the first harvest year (2011), its participation in the cut grass was only 6.2%. In 2012 its share reached up to 89.3%, and in 2014 it was 85.7%. The percentage share of white bentgrass in the grassland in the first and second experimental year was very high - respectively 90.9% and 89.3%. In the fourth harvest year of the grassland

(2014), its share was decreased at 58,8%, but it was increased on 81.8% in 2015.These results are different from the previously established for the area of subalpine zone of the Central Balkan Mountain susceptibility to drought, unstable productivity and presence of that species in the grassland (Totev, 1970 a, b). Its relatively good productivity, in combination with its high percentage of participation in the total forage mass in the fourth and fifth years of use, raise the necessity for further research on its manifestation in artificial grass sowing.

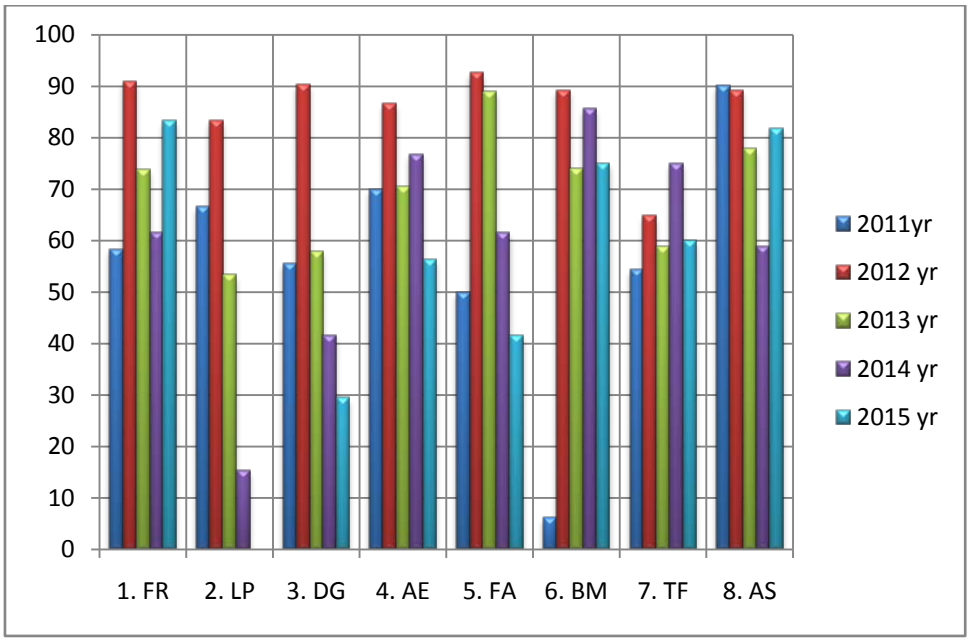


Figure 3 : Relative share of sown grasses in the grassland in years, %

**Note: 1. Red fescue (F.R.) 2. Perennial ryegrass (LP), 3. Cock's foot (DG), 4. French rye grass (AE), 5. Tall fescue (FA), 6. Big quaking grass (BM), 7. Golden oat grass (TF), 8. White bentgrass (AA=AS)*

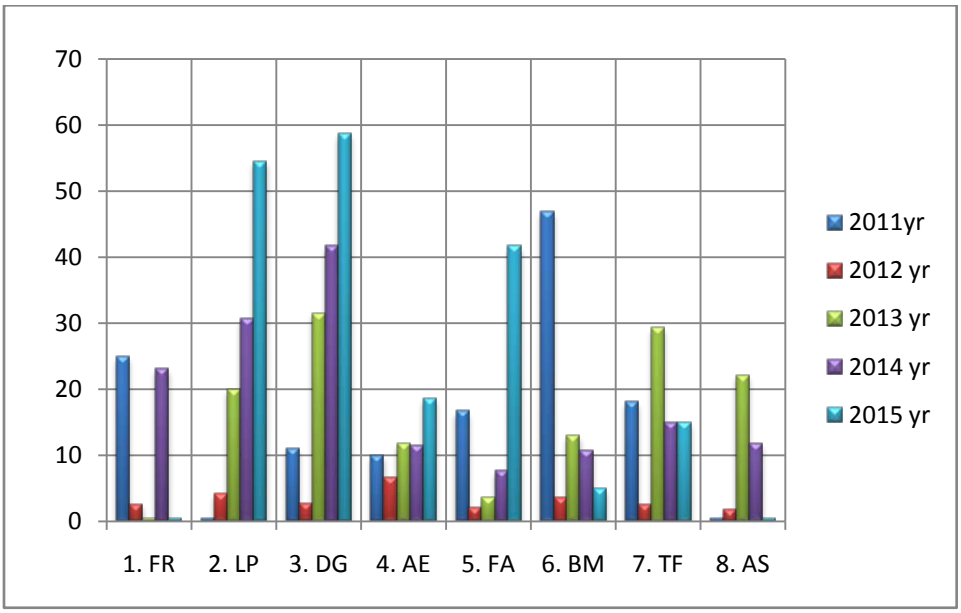


Figure 4 : Relative share of self-sown forage trees in years, %

**Note: 1. Red fescue (F.R.) 2. Perennial ryegrass (LP), 3. Cock's foot (DG), 4. French rye grass (AE), 5. Tall fescue (FA), 6. Big quaking grass (BM), 7. Golden oat grass (TF), 8. White bentgrass (AA=AS)*

In certain years red fescue showed a high percentage of participation in grasslands. In the end of the five-year period, it was 83.3%, and the presence of weeds was small. The participation of other self-sown

meadow species of local origin in the red fescue grassland was more significant - in 2014 their share was 23.1, and in 2011 - 25.0%. (Figure 4). The ability of white bentgrass and red fescue forms used in that case (Mitev, 1996) to form root system, made them especially useful to fight water and wind erosion in many areas in our country.

Tall fescue and French ryegrass showed a high percentage of participation in the created grasslands in the second and third vegetation. Fast decrease in cock's foot share was found in the grassland for the experimental conditions in 2015 - 29.4%. In comparison, the participation of big quaking grass, white bentgrass and red fescue in the grasslands was twice higher in the same year - respectively 75.0%; 81.8% and 83.3%.

Even in the self-sowing, meadow grasses created mixed grasslands with the available seeds in soil of species of local origin. Similar development was also noticed in the current experiment discussed here. Self-sowing of false red fescue, common white bentgrass was found etc. Their relative share was very high in the cut grass for the species of cock's foot and perennial ryegrass, which dropped relatively quickly from the grassland. A relatively sustainable development was observed for French rye grass and golden oat grass under the conditions of that experiment.

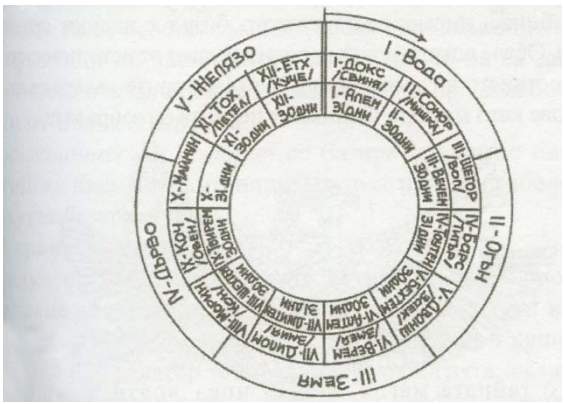
The influence of geographical location over the quantity of the available seeds of local origin in soil is known (Peeters and Janssens, 1998; Stohlgren et al., 1999; Tracy and Sanderson, 1999). Unlike that, a productive expression of the existing seeds in the soil is searched in the experiment described here.

We search for the possible causes for the condition of grasslands in the results shown above. The established results lead us to the notion that the habitat conditions of grasslands should be determinant in the selection of the constituent species, their origin, sowing period etc. The influence of factors, such as nutrients, light, space etc., over the behaviour of species has been discussed in previous author's articles (Mitev and Belperchinov, 1996; Mitev and Yasheva, 1998; Mitev$_{(1)}$ unpublished). It is considered that there is a connection between the energy essence of Nature and condition of the concrete "structural units" (..., species, population, cultivar) (Mitev, 2004; Mitev and Naydenova, 2012). There is a view that their behaviour in the environment is determined by the level of energy saturation that is reached. Its change leads to shrinking and expanding in the area of spreading, i.e. to a formation process. Besides there is a mutual conditionality between the energy level reached and the hereditary information created (Mitev and Yasheva, 1998. If each "structural unit"(..., species, population, ...) represents a peculiar "projection in Time" (Mitev, 2004; Mitev and Naydenova, 2012), then it is not difficult to assume that the combination of components (in this case of grass species, including these in the soil etc.) lead to interaction on "a time level"? The principles for symmetry of Time (equivalent to directions "future"- "past" for each moment) lead directly to the law on preservation of energy (Mitrani, 1989) and to durability of grasslands in the cases discussed here. Hence come the assumption that each grassland, regardless the number of its components, represents a peculiar "energy-information system" (Mitev and Naydenova, 2014; 2015), directly related to the essential characteristics of Nature.

The notion of ancient people that the Earth is exposed to constant energy impact with a definite rhythm is well known. Its change determines an adequate reaction in Nature (Baggott, 2000; Wong, 1997 etc.). Each different species is subjected to different interdependences (Aldrich, 1978; Cleeveland and Duvic, 1992; Kunz et al., 2011; Mannila; 1980 etc.). At the same time there are irrevocable rules that led to creation of the calendars of some ancient nations. Attention should be paid on the comparison of some of the calendars (Baggott, 2000; Madzharov, 2001; Madzharov et al., 2002; Valchev, 1986; Wong, 1997 etc.) They are based on thousand-year old traditions. There are certain cases of coincidence in the main conclusions in the contemporary studies (Thompson, 1989) with those of ancient times (Baggott, 2000). The most ancient notions of people of cosmogony have found their final form in the Book of Changes (I Ching), and the structure of the ancient Bulgarian calendar shows a direct relation to these (Velev, 2000). Each particular year is subjected to corresponding constellation and trigram (Bahshi Iman, 1680; quoted after Madzarov et al., 2002). Trigrams reflect fundamental concepts of the ancient notion of the world (I Ching, 1996)

Ancient people considered that all manifestations in the Universe arise from the law on the modification of the energy. There are "five spinnings/elements" in it ("water"; "fire"; earth"; wood"; "metal"). "Five spinnings" are levels of the qualitative changes of energy, which are dependent on the changes of "the fifth elements". After completion of each

cycle, there is a new genesis. The term "spinning" speaks about cyclical changes.



The calendar consists of 10 "heavenly stems" and 12 "earthly branches". Ten "stems" are characterized by the transition of positive principles into negative, and vice versa: odd "stems" are positive (i. e. with surplus), and even numbers are negative (i. e. a lack of certain energy). "Stems" characterize heavenly energy, and "branches" - the earthly.

Древният български календар (според Борис Рогев)

These ten "heavenly stems" are combined with twelve "earthly branches" in 60-year cycle. Depending on the full rotation of the Earth's axis in space, it could span a period of 20160 years (Valchev, 1986). The odd years (2011; 2013; 2015), covered in the current study, are characterized by "a lack" of energy (Yin), and the even by "surplus"(Yang). It is necessary to make a difference between even "stems" and even years. Based on the theoretical formulation for the origin of species (that they are "a peculiar projection in Time") (Mitev, 2004; Mitev and Naydenova, 2012), as well as that each grassland represents a peculiar "energy-information system" (Mitev and Naydenova, 2014; 2015), which is in a direct connection with the essence of Nature, we come to the opportunity to connect them with the beginning of the research program for modeling the behaviour of cultures. In this way the opportunity appears to reach the knowledge of the ancient Bulgarians. Usually the media introduce us to the formulations of the ancient Chinese calendar, but not with those of the ancient Bulgarian. It is considered as necessary to point out that the concepts "heavenly stems" and "earthly branches" are based on the knowledge of the Chinese calendar. The Bulgarian ones are not known to the authors. The readers are less familiar with specialized literature of some Chinese researchers because of certain reasons (Li You and Yin Ting 2008; He Juan 2009, etc.). About 2500-3000 years ago, a part of the Bulgarian nation lived in the region of the great northern bend of the Yellow River (Huang He), today's China. Bulgarian and Chinese people had a direct cultural, economic and political exchange. After the foundation of the Chinese Empire (4-3 c. BC) and the subsequent military defeat of Bulgarians, our ancestors retreated to the west, and later participated in the so called "Migration Period" in the beginning of the New Era (the new system of chronology). It is natural that during the ages, after breaking the contact between Bulgarians and Chinese, some differences between the calendar systems appeared. It is considered, that for the establishment of the Bulgarian calendar, were needed observations in the course of 70 thousand years (Pophristov, 2015)(!!!)

IV. Conclusions

It has been found that there is an opportunity to cultivate French rye grass and white bentgrass under conditions of highly gleyed pseudopodzolic soils in the region of the Central Balkan Mountain.

During the study period (2011-2015) the most productive were red fescue and tall fescue. The average for the period green matter yield of red fescue was 21.70 t.xa-1, as dry matter was 7.032 t.xa-1 In comparison, tall fescue surpassed it insignificantly in the average green matter yield (5,07%), and it was also insignificantly inferior according to dry matter (5,73%). The lowest yields were found for perennial ryegrass and big quaking grass. Their average green matter yield for the period was respectively 16.30 $t.xa^{-1}$ and 16.10 $t.xa^{-1}$, and dry matter was 4.159 $t.xa^{-1}$ and 4.878 $t.xa^{-1}$.

Red fescue and white bentgrass had the highest percentage in the grasslands. In the end of the study period (2015), it was respectively 83.3% and 81.8%.

It was found self-sowing of meadow grasses of local origin, at the base of availability of their seeds in the soil.

References Références Referencias

1. Aldrich, D. T. A. (1978). The effect of years and location on the performance of grass species and varieties. Journal of the Science of Food and Agriculture. 29. (3) p 303.
2. Baggott, A. 2000. The Celtic wheel of life. Gyle & Macmilan Publishers, Dublin. Ireland. pp. 31-87.
3. Bahshi Iman, 1680 quotation after Madzharov; Yuhma; Koleva G. "Golden Bulgaria" 2002, p. 98. "Alfiola" Varna.
4. Bloom, R., Mallik, A.U. 2004. Indirect effects of black spruce (Picea mariana) cover on community structure and function in sheep laurel (Kalmia angustifolia) dominated heath in eastern Canada. Plant and Soil. 265, p. 279-393.
5. Bossdorf, O., A. Auge, L. Lafuma, W. E. Rodgers, E. Sieman, D. Prati. 2005. Phenotypic and Genetic Differentiation between Native and Introduced Plant Population. – Oecologia., **144**, 1-11.
6. Brrogowski Z., T. Trasczyk. 1978. The effect of mineral fertilization on ionic balance in some meadow grasses. Polish Ecological Studies. V. 4. 1. 135-143.
7. Cleaveland, M. K., D. N. Duvic, 1992 Iowa climate reconstructed from tree rings, 1640-1982. Water Resource Research, Washington, D. C. American Geophisical Union. Oct. 1992 .V. 28 (10) p. 2607-2615.
8. Chourkova B. 2007. Botanical composition and productivity of birdsfoot trefoil in mixtures with Meadow Grasses in Bulgaria. Journal of Balkan ecology, vol. 10, №1, 57-61.
9. Darwin Ch. 1872 The origin of the species. – Reprinted by Macmilian publ. co. New York.
10. Farooq, M., A.A. Bajwa1, S.A. Cheema1 and Z.A. Cheema, 2013. Application of Allelopathy in Crop Production. *International Journal of Agricultural Biology*, 6: p.1367–1378).
11. Frank, D.A., S.J. McNaugdhton, B.F. Tracy 1998 The ecology of the earth's grazing ecosystems. Bioscience. 48:513-521).
12. Gilroy, S. A., A. J. Trewavas, 2001. Signal processing and transduction in plant cells: the end of the beginning . Nature Molecular Cell Biology Reviews 2: p. 307-314.
13. Hector, 1998 The effect of diversity on productivity: Detecting the role of species complementary. Oikos. 82: 597-599).
14. He Juan 2009 The application of the five phases-ancient ten months' calendar in the theory of Inner Canon of Huangdi. China Journal of Traditional Chinese Medicine and Pharmacy Vol. 24 No. 9 pp. 1118-1120.
15. I CHING, (1996) (according to Shtutskiy, Yu. K.). Classical Chinese Book of Changes, p. 12. Sofia. "Shambala".
16. Ives, M.A., J.L. King, K. Giross 2000 Sta/ilitw and species richnes in complex communities. Ecol. Lett. 3: 399-411).
17. Kanneganti, V. R., R. P.Walgenbach, L. J. Massingill. 1998. Daily and seasonal forage availability under rotational grazing of a mixed-species temperate pasture. J. Sust. Agric. 12:49-66.
18. Koukoura, A. 1998. Decompozition and nutrient release from C_3 and C_4 plant litters in a natural grassland. Acta Oecologia (Lerlin) 126:429-433.
19. Krueger, W. C.,M. A. Sanderson, J. B. Cropper, M. Miler-Goodman, C. E. Kelley, R. D. Pieper, P. L. Slaver, M. J. Trlica. 2002. Environmental impacts of livestock on U.S. grazing lands. Council for Agricultural Science Technology issue paper 22. Cast. Ames. IA.
20. Kunz, A.; M. M. Blanke; T. L Robinson, 2011 Effects of global climate change on apple 'Golden Delicious' phenology - based on 50 years of meteorological and phenological data in Klein-Altendorf.
21. Li You; Yin Ting 2008 Remove from marked Records Research on "Five evolutive phase and six climatic factors" and Chinese medical constitution. China, Journal of Traditional Chinese Medicine and Pharmacy Vol. 23 No. 11 pp. 952-954.
22. Madzharov, Hr. 2001. The great conspiracy against Bulgarians. Alfiola. Varna. p. 197.
23. Madzharov, Hr., V. Yuhma and G. Koleva. 2002. Golden Bulgaria. Alfiola. Varna. p. 98.
24. Mannila, T.; 1980 Journal of the Scientific Agricultural Society of Finland, 1980, 52, 4, pp 393-402, 13 ref.
25. Mitev, D. 1995 Meadow grasses, suitable for pastures in the foothill regions of the Balkan Mountains. Jubilee scientific session. Plovdov, vol. 4. book 2, p. 269-272
26. Mitev, D., 1996 Diversity of the biological characteristics of the red fescue (Festuca rubra L.) clones of local origin. Plant Science, vol. XXXIII, No4, pp. 39-42.
27. Mittev, D. 1997. Study on Some Biologic Features of Red Fescue Regarding Its Selection Needs. – Ph. D. Thesis, RIMSA - Troyan, 118-122.
28. Mitev D. 2004 Study on the Behaviour of Some Ref Fescue Generations.-Proceedings of the Scientific Session on "Technics, Agrarian Scientists and Technologies", 24 October 2003, House of Scientists, Plovdiv 2003, 114-119.
29. Mitev D. 2014(1) Adaptability of some cultivars and populations legume grasses towards the ecological variability in the region of the Central Balkan mountain, Journal of Mountain Agriculture on the Balkans V. 17, 5, 2014, 1178—1186.
30. Mitev, D. 2014(2). Comparative study on the forage potential of some meadow grasses of local origin

under conditions of the Central Balkan Mountain. Journal of Mountain Agriculture on the Balkans. vol.17, 5, 1154-1165.

31. Mitev D. (1) unpublished. Influence of the year of experiment setting over the manifestations of red fescue and bird's foot trefoil, cultivated independently and in competitive conditions.
32. Mitev D., Kr. Belperchinov 2000 Ecological plasticity of some grass associations with the participation of red fescue located along the slopes of the foothills of the Balkan Mountain. 1. Productivity and botanical composition of independent sward of red fescue. International Scientific Conference "Achievements in the sphere of agrarian and social sciences", Stara Zagora.
33. Mitev, D., B. Churkova, M. Iliev, 2013. Comparison of some grasses and legumes of local origin under conditions of the Central Balkan Mountain. . Journal of Mountain Agriculture on the Balkans. Vol.16, 5, 1233-1246
34. Mitev D., Kr. Belperchinov. 1996. The nature of competition between red fescue (*Festuca rubra* L.) and bird's-foot trefoil (*Lotus corniculatus* L.). Forest science. 3, p. 34-40.
35. Mitev, D., G. Naydenova 2008. Durability of artificial grasslands with red fescue (Festuca rubra L.) along Middle Balkan mountain slopes. Part 1. General grasslands state. Journal of Balkan Ecology, vol. 11, 2, p. 171-182.
36. Mitev, D., G. Naydenova 2012 To the question about the behaviour of some red fescue generations. Banat's Journal of Biotechnology. III(6), p.59-67.
37. Mitev D., G. Naydenova, 2014 Permanence of sown sward situated along the slopes of the Central Balkan mountain. Biotechnology in Animal Husbandry 30(3), pp. 509-515.
38. Mitev D., G. Naydenova, 2015 To the issue of durability of some artificial meadow swards under the conditions of the Central Balkan mountain-Bulgaria. 1. Productivity. Journal of Mountain Agriculture on the Balkans. Vol.18, 6, 983-995.
39. Mitev D., D. Petrov 1999 On the analysis of the relations of competition among plants. Grasland Ecology. V., B. Bistrica. 155-161).
40. Mitev D., D. Yasheva. 1998. F. rubra and L. corniculatus. The effect of their orientation with respect to the foir cardinal point - Forest Science. 35, 1-2, 56-65.
41. Mitrani, L. 1989 "Science and none science", p.115, Science and Art Publishing House, Sofia.
42. Peeters A., F. Janssens. 1998. Species-rich Grasslands: Diagnostics, Restoration, and Use in Intensive Livestock Production Systems. – Grassl. Sci. Eur. 3, 375-393.
43. Perrings, C., M. Williamson, S. Dalmazzone 2000 The economics of biological invasions. Edward Elgar, Cheltenham.
44. Pophristov, D., 2015. About Bogomils from "a mouth to an ear". VBB Publishing House, Sofia.
45. Reich, P.B.,J. Knops, D. Tilman, J. Kraine, D. Ellswrth, M. Tjoelker, T. Lee, S. Naeem, D. Wedin, D. Bahauddin, G. Hendrey, S. Jose, K. Wrage, J. Goth and W. Bengston. 2001. Plant diversity enhances ecosystem responses to elevated CO2 and nitrogen deposition. Nature (London) 410: p. 809-812.
46. Stohlgren T.J., L.D. Schell, and B. Vanden Heuvel. 1999. Haw grazing and soil quality affect native and exotic plant diversity in Rocky Mountain grasslands. Ecol. Appl. 9:45-64.
47. Sanderson, M.A., R.H. Skinner, D.J. Barker, G.R. Edwards, B.F. Tracy, D.A. Wedin 2004. Plant species diversity and management of temperate forage and grazing land ecosystems. Crop Science, 44:1130-1144.
48. Shumway, S. W. 2000. Facilitative Effects of a Sand Dune Shrub on Species Growing Beneath the Shrub Canopy. – Oecologia (Berlin), **124**,138-148.
49. Stoeva, K. 2001. Determination of Perennial Grasses and Their Mixtures for Creation of Some Artificial Swards in the Conditios of Strandja Mountains. – Plovdiv, 108 – 124.
50. Goranova-Naydenova, G. 2002. Study on Populations and Sorts of Red Clover in Accordance with the Selection and Seed Production. – Ph. D. Thesis, RIMSA - Trpyan, 98 – 104
51. Thompson, M. L. 1989 The 18,6-year lunar cycle: its possible relation to agriculture. Cycles, March/April, p.65-69.
52. Totev, T. 1970 a. Comparative study on perennial grasses under conditions of Troyan. Plant Science. 3, 147-155.
53. Totev, T. 1970 b. Results of attempt to improve basically the highland pasture of the type of Nardus stricta. Jubilee collection. Sofia. Zemizdat. 315-324
54. Totev, T. 1984. Studies on Improvement and Usage of Natural Meadows and Pastures in the Foothill, Mountain and High Mountain Regions in the Central Balkan Mountains, D. Sc. Thesis, Plovdiv, 284-293.
55. Totev, T., K. Belperchinov, B. Churkova, V. Lingorski, Ts. Mihovski, D. Mitev, 2000. Effects of the NPK fertilizer application modes on the yields and economic results from meadow grass species in the region of Troyan. Journal of Mountain Agriculture on the Balkans. Vol.3, 1, 43-50.
56. Tracy B.F., M.A. Sanderson. 1999. Seed bank diversity in grazing lands of the Northeast United States. J. Range Manage. 53:114-118.
57. Trasy, B.F., and M.A. Sanderson, 2004. Relationships between forage plant diversity and

weed invasion in pasture communities. Agric. Ecosyt. Environ. 102:175-183.
58. Velev, G., 2000. Bulgarian national calendar – Foundation and essence. Tangra. Tan Nak Ra Publishing Sofia. p. 49.
59. Valchev, Y. (1986) Calendar and word. Sofia. p.123-125.
60. Wardle D.A. 1987. Allelopathy in the New Zealand. – Journal of Experimental Agriculture, **15**, 243-255.
61. Wong,E. 1997. "The Shambhala guide to Taoism". PP: 144-154 P.O.Boxx. 308. Bosston, MA. 02117. p.57-87.

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Women in Smallholder *Fadama* Farming: Significance, Roles and Constraints

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Keywords: *agriculture, smallholders, fadama, gender, food security, nigeria.*

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I. Introduction

Fadama is a Hausa[1] word for wetlands or the seasonally flooded or floodable floodplains along major savannah rivers and/or depressions on the adjacent low terraces. In this paper, *fadama* is used in a narrow way to refer to "actual water surfaces of the ponds and swamps left behind as the floodwaters retreat from the floodplains of the largest river (FAO, 2008) and not simply the seasonally flooded lands that tend to dry up after the rainy season. In the savannah and arid/semi-arid areas of Northern-Nigerian (where rainfall is often low or erratic) *fadama* are an important source of agricultural production and have been utilized using traditional methods and indigenous knowledge of the ecosystem accumulated over centuries (Lustig, 2008). Smallholder farming families engage in subsistence farming in which family needs determine the scale of production and wherein small plots of land are cultivated by individual owners or sub-owners using age-old methods of soil and water management. Smallholders uses mainly family labor which could be augmented with minor hiring of labor and labor exchanges with other farmers at peak seasons. The essential factors of production – land, labor, and capital are provided within the family.

Smallholders can hardly be characterized as a homogenous group. They are diverse and varied and include a wide array of rural people who practice intensive, permanent, diversified agriculture on relatively small farm areas of dense population. A characterizing feature of smallholders is the organizing unit of the family household where agricultural labor is mobilized, resources are managed and consumption is organized. Most smallholders utilize the scarce land available to them and optimize per unit area production. About two-thirds of all the agricultural holdings in the world are between one and five hectares. About two-thirds of all the agricultural holdings in the world are between one and five hectares. The bulk of the food need of the world's population is, therefore, provided for by these smallholders who cultivate units in the 1-5 hectare range. (Von Grebmer et al., 2008).

The relationship between gender roles and agriculture is an intricate, complex but essential one. This is even truer for developing countries where women are closely associated with smallholder agricultural production. Half of world's staple food (wheat, rice, maize) is produced by rural women, most of whom live in developing countries and account for between 60 and 80 percent of the food in these countries (World Bank, 2001, Oputa et al., 1985, Erenstein et al., 2003). In sub-Saharan Africa, for instance, 80% of basic foodstuffs both for consumption within the household and for sale are produced by women (90 per cent of women in SSA are farmers) (World Bank, 2007c, Carrol et al., 1990, Marx et al., 1971). Similarly, women provide labor on most farms through activities like sowing, weeding, fertilizer and pesticide application, harvesting and threshing of crops and food processing and storage (FAO, 2005).In Nigeria, more than 80% of rural women are engaged in agricultural production and forestry and provide more than 70% of the labor force (Holt-Giménez, 2008, Henschen, 2009, Fairtrade Foundation, 2009).

The role that women play in agricultural production has increased in the last decades in many

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[1] The language (Hausa) is a Chadic language belonging to the Afro-Asiatic language family and it is one of the three major languages spoken mostly in Northern Nigeria and across West Africa.

developing countries. This change of trend in gender role and division of labor, particularly in developing countries like Nigeria, has partly been explained in terms of the neo-liberal policies experimented with in most developing countries (e.g. structural adjustment programmes) since the early 1980s. The effects of liberalizationon smallholders include higher input costs, lower farm-gate prices and cuts in access to credit and extension services. This problem was compounded by increasing land scarcity especially in sub-Saharan Africa (Atkinson, 1991), high rates of mortality of working men due to HIV/AIDS, rural-urban migration of men searching for better opportunitiesThe effect of this is more on smallholders as women become principal farmers in the absence of men (Blaikie and Brookfield, 1987). This phenomenon has been described as the 'feminization of agriculture,' i.e. increased participation of women in the agricultural labor force as independent producers, unremunerated family workers or as agricultural wage workers (Bryant and Bailey, 1997, Robbins, 2004). It is not just the task of food provisioning that has fallen more and more to women but other social responsibilities such as educating the children (Gray and Moseley, 2005).

However, that the 'feminization of agriculture' does not always mean empowerment. Whereas in some cases and cultural contexts women's role as economic producers has translated into more power in the household and community, in others women continue to be subordinate to men. Despite the greater responsibility that changes in agricultural production has thrust on women, they face immense problems such as limited or no access to land, credit, extension services and technology(Peet and Watts, 1996, Bryant and Bailey, 1997, Peet and Watts, 2004, World Bank, 2007a, World Bank, 2007b). Generally, it is very difficult for women to overcome these obstacles because even their political and organizational rights are severely curtailed and their involvement in policy and decision making minimal(Derbyshire, 2002, Zuckerman, 2002, Chattopadhyay and Duflo, 2004, World Bank, 2005, Inter-Parliamentary Union, 2006, UNIFEM, 2007)

II. Study Area and Participants

The participants in this research were rural farmers in two villages in North-Central Nigeria: Karshi and Baddeggi, two small agrarian communities in North Central Nigeria. Karshi, the core study area and the place that provided the bulk of the data for the research, is one of the satellite towns of Abuja, Nigeria's capital city. It covers a land area of 8,000 square kilometers and is located in the middle of the country. Abuja falls within latitude 7° 25' N and 9° 20° North of the equator and longitude 5° 45' and 7° 39'. Karshi is one of the typical settlements in Abuja and consists mainly of rural indigenous communities engaged mostly in farming and related activities. Gwari, Gwandera and Gwandu are Karshi's predominant ethnic groups.

Baddeggi is a small district of Bida town, the second largest city in Niger State. Bida sits on the Bako River, one of the several minor tributaries of the Niger River. It is approximately 100 km/60 mi southwest of Minna and 200 km/120 mi northeast of Ilorin and falls on Latitude 9° 4' 60 N, Longitude: 6° 1' 0 E. Baddeggi is a major trade center for rice, which is mainly cultivated in the *fadamas* of the Niger and Kaduna rivers. It is predominantly inhabited by the Nupe people. Most of the inhabitants of Karshi and Baddeggi are farmers involved in both upland and lowland (*fadama*) farming. Baddeggi served as a comparative study of the similarities and differences with Karshi and the underlining general structure that generates them.

III. Data and Methods

Methodological Triangulation was used in this research. It is pluralistic, mixing the mainly qualitative data (generated from in-depth interviews) with quantitative data (generated from survey methods) (Hurst, 1990). This is in line with the realist epistemology/ontology that sees reality as stratified; on the one hand social objects have a real ongoing existence irrespective of what we know of them, while on the other hand they are affected by the way they are construed (Moody, 1996). Triangulation considers as false the claim that quantitative and qualitative methodologies are incompatible (Altieri, 1998) and seeks to avoid simple generalizations by enabling a more comprehensive understanding of social phenomenon carter (Moseley, 2005).

Over a period of four months, 47 people were interviewed in-depth in Karshi and 21 in Baddeggi. The research strategy consisted of mixed techniques led principally by a core interview schedule which was complemented by a follow-up strategy, involving survey techniques used to accurately measure the demographic features of the research participants and the extent of agrochemical use. The research methodology was Grounded Theory (GT) as the research was concerned with expanding an explanation of *fadama* agriculture through the identification of its key elements and then categorizing the relationships of those elements to the context and process of the experiment (Collings, 1995, FAI, 2004). The data collected was mainly analyzed using the qualitative GT technique which helped to achieve a more critical and reflexive interpretation of the statistics generated and hence helped to avoid the often simple, general and impersonal nature of statistics.

IV. Results and Findings

In Karshi village, 47 farmers were interviewed. Of these, 27 (57.4%) were females and 20 (42.6%) were male. Like in many parts of Nigeria, smallholder rice farming in Karshi is predominantly done by women (table 1). Others are involved in cultivating such crops as cowpea and a broad range of vegetables. In Baddeggi,

however, 81% of the respondents were men while only 19% were women. The involvement of women in both communities is related to religious and cultural norms.

An examination of the *fadama* farming in Karshi immediately reveals the place and importance of women in the production chain. Inextricably linked to agriculture and to the role that women play in food production in Karshi are other complex issues such as religion, social process and power relations. Findings in Karshi reveal and corroborate what is now a widely accepted fact, namely the role of women in development and food provision in Africa and many parts of the developing world. In Karshi, a substantial quantity of the food consumed and sold is produced by women. For instance, rice is the exclusive reserve of women while the men are involved in the cultivation of crops such as yam, cassava, maize and sorghum. In addition to rice, however, other important crops grown by women in Karshi include cowpea, vegetables and fruits and beans. Much of Karshi's agricultural productivity relies on women labor and the multiple roles they play in the general life of the community. Women, in Karshi, are the string that holds together the social milieu and ensure stability through efficient juggling of their roles as farmers, mothers, marketers, cooks and health care providers.

74.5% of the respondents in Karshi were Muslims, while 25.5% were Christians or practitioners of traditional religion. All of the respondents in Baddeggi were Muslims. Religion is an important factor and shapes such issues as land ownership, marriage, and indeed the whole social milieu. Nevertheless, the understanding and practice of religion slightly differs in the case of Karshi and Baddeggi. In the former, the majority of women were involved in farming, whereas in the latter, very few women were involved in farming due restrictions placed on them by their husbands on religious grounds. In both cases, though, access to female farmers was initially difficult due to religious restriction (*purdah*).

Table 1 : Statistical distribution of farmers based on sex and farm size in Karshi

		Karshi		Baddeggi	
		Frequency	Percentage	Frequency	Percent
Sex	Male	20	42.6	17	81.0
	Female	27	57.4	4	19.0
	Total	47	100.0	21	100.0
Farm Size	1Ha & Below	28	59.6	6	28.6
	Between 2-4Ha	19	40.4	15	71.4
	Total	47	100.0	21	100.0

Majority (59.6%) of the respondents in Karshi cultivate between 0.2 to 1Ha of land, whereas 40.4 % cultivate between 2-4Ha (table 1). In Baddeggi, however, a higher percentage of the respondents (40.4%) have between 2-4Ha while 59.6 have 1ha or less. The bulk of the farmers, therefore, fit into the general characteristics of smallholder farmers typical in many developing countries of Africa. Similarly, land use is intensive among the majority of the respondents as they attempt to alleviate land constraints. As in many parts of Africa, arable land is a priced commodity in Karshi and Baddeggi in light of scarcity and population growth. The problem is compounded in Karshi because of the influx of people into Federal Capital Territory (Abuja) and land loss to road construction through the community. The pressure on land is also not helped by the lack of viable alternative employment opportunities in the non-farm sector.

The size of a man's land in the two communities is closely linked to his ability to produce more and invariably, this places him well above other members of the community. As indicated above, the bulk of the farmers with more than 1ha of land are men as women almost exclusively cultivated between 0.2-1ha of land.

Respondents in Karshi were between the ages of 29-56. The mean age of the farming sample is 37 (with the minimum being 29 and maximum 56). The mode age is 38. In Baddeggi, the age range is higher with the mean age being 43, while the median and mode ages are 42 and 38 respectively. It appears, consequently, that most of the farmers are in their prime age and therefore energetic for farming purpose. In contrast however, the age distribution shows fewer young people engaged in *fadama* farming in the areas of study. This can be explained by factors that include migration, the search for more profitable sources of income, and the fact that most male children of these farmers are enrolled in schools (primary and secondary).

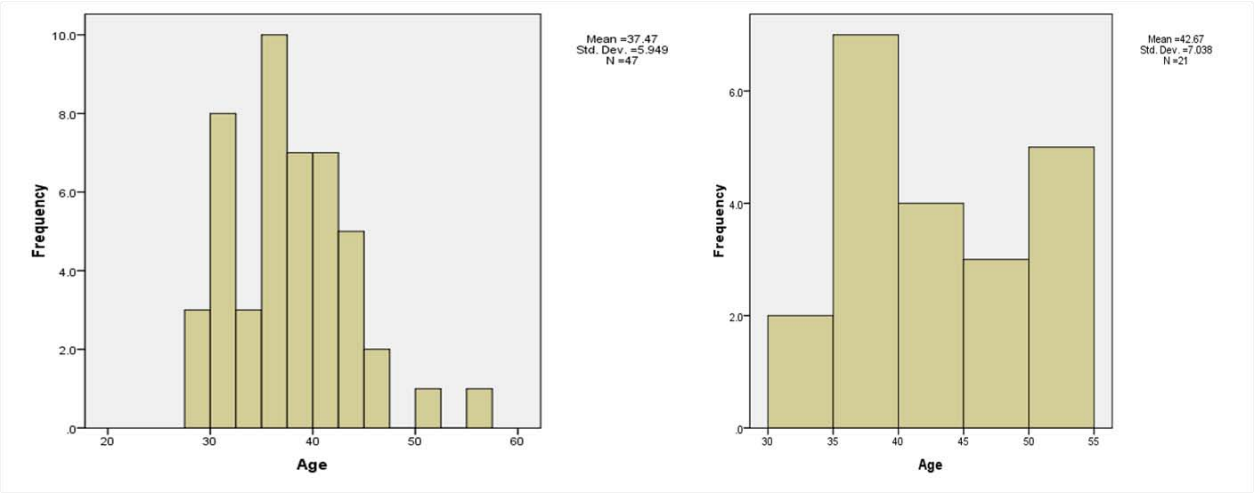

Figure 1 : Histograms showing age distribution of farmers in Karshi and Baddeggi

The boxplot (fig. 2) below compares the distribution of age across sex in Karshi. The median age of males is higher and, overall, the age ranges are higher. The spread of ages, indicated by the size of the shaded boxes and the length of the T-bars, is also higher for males than for females. In Baddeggi, however, the median age of women was lower given that few women farmers were interviewed.

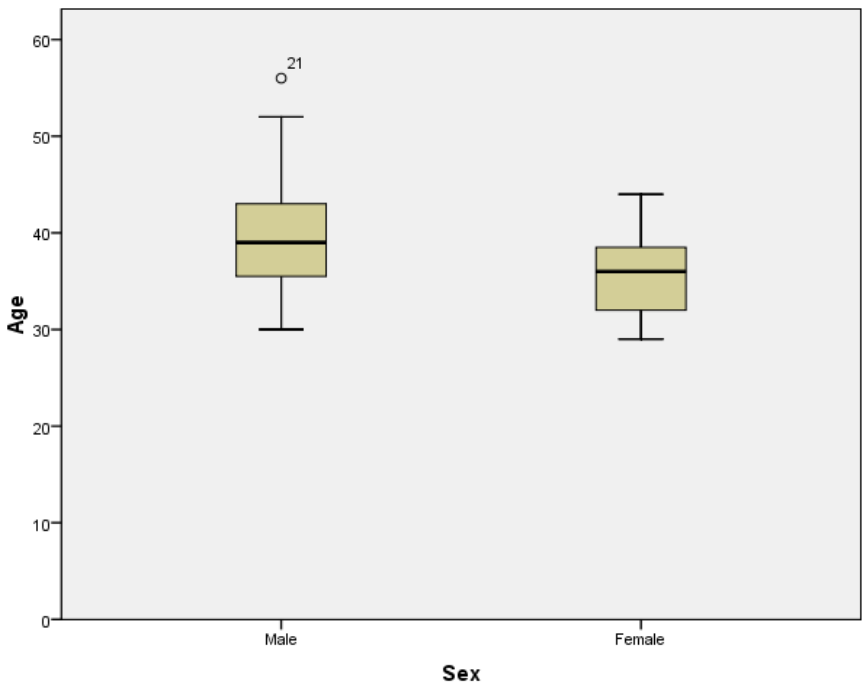

Figure 2 : Boxplots illustrating age distribution of male and female farmers in Karshi

A cross tabulation of sex and age shows significant differences in the age distribution between men and women. The data for age was recoded into 3 equal groups as indicated in below (table 2.). In Karshi, none of the men respondents is between the age ranges of 20-29 and 11.1% of female respondents fit into that age bracket. 50% of men respondents fall between the age categories 30-39 in contrast to 66.7% of the female respondents (table 23). While 22.2% of the female respondents are between the ages 40-49, most of the men respondents (40%) fall within that age bracket. 2 of the men respondents (10%) fall between 50-59, with none of the female respondents within that age range. Majority of the female respondents therefore, are younger than their male counterparts in Karshi.

Table 2 : Cross-tabulation of sex with age categories for Karshi and Baddeggi

		Karshi				Baddeggi			
		Age categories				Age categories			
		20-29	30-39	40-49	50-59	20-29	30-39	40-49	50-59
Sex	Male Count	0	10	8	2	0	5	7	5
	% within sex	.0%	50.0%	40.0%	10.0%	.0%	29.4%	41.2%	29.4%
	Female Count	3	18	6	0	0	4	0	0
	% within sex	11.1%	66.7%	22.2%	.0%	.0%	100.%	0%	.0%
	Total Count	3	28	14	2	0	9	7	5
	% within sex	6.4%	59.6%	59.6%	4.3%	.0%	42.9%	33.3%	23.8%

Among the male respondents in Baddeggi, 5 (29.4%) were between 30-39; 7 (41.2%) fall within the 40-49 range and 5 (29.4%) are between 50-59. All the 4 female respondents are in the 30-39 age brackets. The median age of the respondents in Baddeggi is therefore higher than that in Karshi among both sexes.

All of the respondents in Karshi and Baddeggi are married, with most of the men being polygamous (only 2 of the male respondents in Karshi were monogamous). All the respondents have children, with the highest percentage (67%) in Karshi having between 5-9 dependents, which also represent the average size of most households. 33%, have between 5-21 dependents. In both Baddeggi, the mean number of children is about 8. The majority of the farmers, therefore, depend on family labor.

Most of the women as seen above are in their most productive age and they invest most of their energy in the agricultural enterprise. Women's labor is the lifeline of Karshi's agriculture as they are involved in all stages of agricultural production: land preparation, planting, weeding, chemical application, harvesting, transporting, processing and marketing. In addition to working on their own farms, they also help their husbands at various stages of the process of agricultural production. Thus, women spend more hours on average on farms than men do, most of whom claim to attend to other more 'masculine' functions. Generally, men make decisions while women do the real work.

V. Educational Qualifications

The level of literacy among the farmers in Karshi is very low with only a handful of them able to read and write. As shown in table 3 (below), 61.7% of the farmers did not have any formal education while only 23.4 have had primary school education. None of the respondents had post-secondary school education. In Baddeggi, on the other hand, 33% had no formal education while 47.6% had primary school education with the remaining 19% having some form of formal education beyond primary school. The level of formal education is, therefore, higher in Baddeggi than in Karshi. The reason for this is the well-established status of Baddeggi as a major farming and trading center with a significant government presence.

However, 86% of the respondents in both communities have Qur'anic education which is mandatory for children between the ages of 5-18 in most Muslim households. Some of the respondents are able to read and write Arabic but cannot read nor write in English.

Table 3 : Level of education, risk awareness and use of protective clothing among Karshi farmers

		Karshi		Baddeggi	
		Frequency	*Percentage*	*Frequency*	*Percent*
Education	No formal education	29	61.7	7	33.3
	Up to Primary School	11	23.4	10	47.6
	Up to secondary sch.	7	14.9	4	19.0
	Total	47	100.0	21	100.0

VI. Sources of Income of Respondents

The majority of the respondents in Karshi (74.5%) have agriculture (crop and animal husbandry) as their only source of income (table 4). The other 25.5%, in addition to farming (usually in a reduced scale than the previous group), are involved in other off-farm activities. In Baddeggi, 71.4% of the respondents depend exclusively on crop and livestock production for their income, while 28.6% depend on other off farm activities, in addition to agriculture. Off farm income sources include trading and crafts such as mat weaving, carpentry and building. Most of the respondents in both Karshi and Baddeggi (75.6%) are involved in both rain-fed agriculture and recession farming (irrigation).

Savings (*adashe* in Hausa) is a common practice among the farmers in Karshi and involves financial cooperation among friends, cooperatives, colleagues and trading partners. According to Woolcock(1998)*adashe* is "a spontaneous 'bottom-up' group formation, initiated and sustained by members themselves in response to their isolation from orthodox commercial banks" (p. 183).

Table 4 : Sources of income of respondents

		Karshi		Baddeggi	
		Frequency	*Percentage*	*Frequency*	*Percent*
Income	Farming/livestock	35	74.5	15	71.4
	Farming with other	12	25.5	6	28.6
	Total	47	100.0	21	100.0

The general gross income of the farmers at the end of each farming season was reasonably high (table 5). In Karshi, the highest category of farmers (62.5%) earn between NGN50, 000-NGN100, 000 while 22.9% (mostly those who own between 2-4Ha) earn above NGN100, 000. Only 12.5% of the respondents earn NGN50, 000 or less. In Baddeggi, the majority of the respondents (57.1%) earn more than NGN100, 000, 28.6% earn between NGN50, 000-100,000 and 14.3% earn less than NGN50, 000. The higher income among Baddeggi farmers is related to their farm size, proximity to a river (hence water availability) and the research institute (The National Cereal Institute) with the fringe benefits it offers by way of agricultural extension.

Table 5 : Income by categories

		Karshi		Baddeggi	
		Frequency	Percentage	Frequency	Percent
Income (By category)	NGN50,000 & Below	6	12.5	3	14.3
	NGN50,000-100,000	30	63.8	6	28.6
	Above NGN100,000	11	23.4	12	57.1
	Total	47	97.9	21	100.0
	Missing system	1	2.1		

Much of the income is invested on meeting social pressures especially on health and the education of their children. Due to poor storage and loss during harvest, the income of the farmers is negatively affected.

In Karshi, the right of women to what they produce is well protected as the woman is fully entitled to what she produces and to the proceeds from sale of the same. She is under no compulsion to give or share with the husband her income. Most women, however, share in the responsibility of feeding their children and often take from their reserves in the event that the husband is unable to provide sufficiently for the family. This is important because many of the women are in polygamous relationships and, whereas it is the husband's traditional duty to provide food for the family and shoulder other social pressures, it is often the women who are left to carry the burden. For instance, the health care needs of the children are met by women from their income. Findings in Karshi thus conforms to extant literature that shows that play a key role not only in agricultural processes, feeding of the family but also providing general care for children (Quisumbing et al., 1995).

The men in Karshi are, for the most part, supportive of their wives and, in addition to showing goodwill, some of the men give their wives financial assistance and assist them with some aspects of production such as applying chemicals on their farms. Similarly, the men ensure that their wives have access to as much land as they need and as is available. In general, the men are aware of the important role their wives play as mothers, wives and farmers. This recognition is higher among men who do other jobs alongside farming (artisans) and who often look up to their wives to supplement their income.

VII. Land Acquisition

The method of land acquisition among the respondents in Karshi indicated the following: majority of the (female) respondents (57.4%) acquire land either from husband or from family. 33.4% acquire land by inheritance while the remaining 8.5% get their land either by borrowing or pledge. In Baddeggi, majority of the respondents (85.7%) acquire their land through inheritance with the remaining 14.3% (the female respondents) acquiring theirs from their husbands.

Table 6 : Means of land ownership in Karshi and Baddeggi

		Karshi		Baddeggi	
		Frequency	*Percentage*	*Frequency*	*Percent*
Means of land ownership	From husband/family	27	56.2	3	14.3
	Land from inheritance	16	33.3	18	85.7
	Borrowing/pledge	4	8.3	0	.0
	Total	47	97.9	21	100.0

This can be explained by the fact that the majority of the farmers were women and, culturally speaking, they are not allowed to own their own land; neither can they inherit land. In general, a combination of cultural reasons and the nature of the tenure system in Nigeria makes land acquisition difficult outside one's place of ethnic origin (Abdullahi, 1981).They are allowed to work on land owned by their husband or their father. Generally, therefore, the majority of the respondents who are women cannot have long term plans because they do not own land, which is an important resource not only for subsistence but also as security for credit and means for access to other credits (Acati, 1983). Studies from other African countries like Ghana show that women only held land in a small percent of households (Deere and Doss, 2006).

Notwithstanding their input to agricultural production, women are greatly disadvantaged and they cannot own land in Karshi. Findings from the fieldwork amply demonstrate that the disadvantageous position of women in traditional African communities is firstly a result of religious and cultural anachronism which understands 'the woman in a certain' way and thus constructs her identity and role accordingly. For instance, in Karshi, women are considered as subordinate to their male counterparts and in many ways their rights, such as access to land is tied to marriage and hence to men. This not only gives the man precedence and power over the woman but also restricts efficient planning on the woman's part as the land can be taken away in the event of divorce or the death of the husband.

In general, however, three factors determine land tenure and women rights in Northern Nigeria: religion (*Shari'a*), local customs, and politics (GRAIN, 2008). Thus, if smallholders are generally maligned in government's development policy, women suffer twice the pain. First, they are rarely targeted by agricultural programmes which are very male-centric based on a limited understanding of the roles women play in agricultural production. Secondly, women are further restricted by religious and socio-cultural conditions which view them as subservient to men and second class citizens.

The perpetuation of this conception of the feminine is deliberately upheld as a means of control and ascendancy by the man. The realm of the sacred (religion), which is considered as sacrosanct and infallible, provides a subterfuge for this continued dominance. In an open admission, the chief of Karshi admitted that men use land ownership as leverage against women. This allows them to exercise power and control over the woman. Men, often use threats of land withdrawal to reduce the risk of dissent and rebellion from their wives. According to the chief, "the women are as powerful as it were, because they earn good money from farms and in a way, the man cannot really tell her much, because she contributes in family sustenance. The land, therefore, is the only means of control the husband has over the wife." Thus, men defend and perpetuate the laws of land inheritance because it favors them (Taylor, 2009). The response of women through 'silence' has only affirmed and consolidated traditional gender roles. Many women are reluctant to discuss the issue of land rights but when they do, they express dissatisfaction at the present status quo. Whereas some accept the situation on the basis of religion and culture, a few others express a desire to see a change, even though they realize it is going be difficult given those prevailing circumstances. The women respondents are aware of their contribution to the rural economy and family subsistence and are proud of having an independent source of income from their husbands'. Similarly, they show consciousness of the power dynamics which men perpetuate in the name of culture and religion. However, none of the respondents feel they can change the existing order even if they all wish they had more access to land and credit.

VIII. Labor

Land preparation, weeding and harvesting are mostly done manually with the help of traditional farm implements. None of the farmers in Karshi has regular access to a tractor. Thus, land preparation and weeding is often labor intensive, especially on rice farms and this in part explains the appeal of herbicides.

Table 7 : Source of labor in Karshi and Baddeggi

		Karshi		Baddeggi	
		Frequency	*Percentage*	*Frequency*	*Percent*
Labor	Self/family labor	36	76.6	11	52.4
	Hired Labor	11	23.4	10	47.6
	Total	47	100.0	21	100.0

About 77% of the farmers in Karshi use family-based labor, often with help from other extended family members and farmer organizations (*gandu* or *gaiya*). The remaining 23%, who represent the more 'successful' of the farmers (owning between 2-4Ha of farm) employ outside labor ranging between 3-5 people to help with farm work. Among the respondents in Baddeggi, the majority (52.4%) rely on family labor and 47.6% rely at some point during the farming season on hired labor. The higher percentage of farmers relying on external labor in Baddeggi is related to the fact that more farmers own between 2-4ha of land. In general, however, hire is not very common among the respondents in both Karshi and Baddeggi. In Karshi, most of the work is done by women

and their female children as preference is given to male education over female education and this means that the girl child is often at home with the mother.

Polygamous families are able to mobilize and take advantage of the bigger labor pool available to them and hence are able to produce more. Also, the few more successful farmers can hire outside labor which often consisted of individuals (mainly single men) and families with insufficient land.

Those who do not work as paid laborers are often engaged in off-farm activities and artisanship both around the two communities and in the nearby cities of Abuja and Bida. Thus, through a combination of farm and off-farm activities, the people of Karshi and Baddeggi are able to manage their poverty. Yet, there was no visible evidence of competition and younger single men did not seem keen on taking up full-time farming for what they consider to be the absence of 'incentives'. Similarly, class formation and differentiation was not visible mainly due to the influence of Islam which is critical of economic competition, class struggle and materialism.

The use of family based manual labor can be attributed to a number of reasons. Firstly, land preparation and weeding are feasible because the respondents farmed small farm sizes (between 0.5-1Ha see table 22). Similarly, the size of most families is a contributing factor to its feasibility [or lack of it]. Many of the families are polygamous with over 92% of the men farmers in both communities having between 2-3 wives in line with Islamic principles. The mean number of children for each family is 8. Most men farmers work averagely between 5-8 hours daily (except on market days and on Friday, which is the Muslim holy day). The number of working hours is higher among women farmers who often spend between 8-12 hours daily on the farm or doing farm-related activity.

Generally, it is considered that Islam defines clear roles for men and women and exempts secluded women from farming. This is obviously the case in Baddeggi where all the men interviewed were men who do not allow their wives to farm. The basis for this, as claimed by all the men, is religion which defines their role as bread winners of the family. However, the opposite situation obtained in Karshi, a similar Muslim dominated community where women are allowed to farm. This confirms recent study which shows an increase in the number of women involved in agriculture, even in Northern Nigeria (The Economist, 2009, Taylor, 2009). It further shows a difference in understanding and interpreting religious precepts and laws.

In addition to their major role as food producers, Karshi women - like all rural women - have to meet the demands placed on them by religion and socio-cultural circumstances. Thus, they often have to return home at given hours and take care of domestic needs: cook for the family, take care of the children and wait on their husband. Many mothers take their infant children along to the farms and look after their needs between working hours. So, women often take break to breastfeed their children and clean them up. Thus, competing tasks, especially during the farming season, takes a lot of energy from women and exposes them to so many health risks. For example, after the exhaustion of working on the farm, the women come home to cook with babies strapped on their backs while enduring the smoke from the firewood. Some of the women complain about having backache, general fatigue (from bending down, and working on the land to pounding yam – all of which are labor intensive) and respiratory problems. Notwithstanding, they have to carry on because a break means more difficulties in the family. Additionally, women also feed and milk animals and raise poultry and other small animals. Women labor is often only complemented by help from female children, co-wives and co-operatives (*gaiya*)

Most of the male children (about 88%) and 55% of female children are enrolled in either primary or secondary school, which makes them available for work on farm only on certain days. Labor shortage is a common occurrence especially during peak periods of land preparation, planting, weeding and harvesting. Female labor constitutes the bulk of the family labor as they are involved in planting, weeding, threshing, winnowing, and transportation.

Of the respondents, 75% have had between 7 years of *fadama* farming experience, while the other 25% have between 8-15 years of farming experience. Thus, it can be safely assumed that all the farmers interviewed are experienced in the farming and management practices of *fadama* areas.

IX. Conclusion

Women play a crucial role in smallholder agricultural production in many developing countries including Nigeria. Through the plurality of the activities they perform, they are key to the survival of poor rural households. Such activities range from crop production, livestock care and food and fuel provisioning. The role that women play in rural households has grown in light of increased male migration to urban areas leading to the feminization of agriculture.

In spite of the fact that the proportion of woman-headed households have grown to almost one third in many developing countries, women continue to be marginalized in agricultural policies: they have less access to land, capital, credit and other social assets than men and most importantly in many developing countries by cultural practices as evidenced by findings in Karshi and Baddeggi.

To challenge the multiple constraints women engaged in fadama farming face, it is critical for women to build on the limited rights and privileges already in place as a means to overcoming and transforming the ideologies, attitudes, values, structures and behavior that

create hierarchical and dominating power relations in their communities. By so doing, women can articulate their demands and exert more influence (Jain, 2005). Also, at the policy level, the use of affirmative action has been advocated for as a means of "reducing poverty, generating income and increasing women's self-esteem, empowerment and economic autonomy" (Vargas-Lundius, 2007).

References Références Referencias

1. ABDULLAHI, A. 1981. *The Problems and Prospects of the Green Revolution for Agricultural and Rural Development of Nigeria: Technical and Environmental Perspective,* Zaria, Ahmadu Bello University.
2. ACATI, E. G. 1983. *Expert Consultation on Women in Food Production,* Rome, Italy, FAO.
3. ALTIERI, M. 1998. Ecological Impacts of Industrial Agriculture and the Possibilities For Truly Sustainable Farming. *Monthly Review,* 50, 60-71.
4. ATKINSON, A. 1991. *Principles of Political Ecology,* London, Belhaven Press.
5. BLAIKIE, P. & BROOKFIELD, H. 1987. *Land Degradation and Society,* London, Methuen.
6. BRYANT, R. L. & BAILEY, S. 1997. *Third World political ecology,* London, Routledge.
7. CARROL, C. R., VANDERMEER, J. H. & ROSSET, P. M. 1990. *Agroecology,* New York, McGraw Hill.
8. CHATTOPADHYAY, R. & DUFLO, E. 2004. Women as Policymakers: Evidence from Randomized Policy Experiment in India. *Econometrica,* 72, 1409–1443.
9. COLLINGS, H. G. 1995. *Commercial Fertilizers: Their Sources and Use,* New York, McGraw Hill Book Co.
10. DEERE, C. D. & DOSS, C. 2006. Gender and the Distribution of Wealth in Developing Countries. *Research Paper No. 2006/115.* UNU-WIDER, Helsinki: UNUWIDER
11. (World Institute for Development Economics Research of the United Nations University.
12. DERBYSHIRE, H. 2002. Evaluation of Gender Mainstreaming in Oxfam's Advocacy Work on Poverty Reduction Strategy Papers. *Stage 1: Briefing Paper for Country Case Studies.* Oxfam, Oxford.
13. ERENSTEIN, O., LANÇON, F., AKANDE, S. O., TITILOLA, S. O., AKPOKODJE, G. & OGUNDELE, O. O. 2003. Rice production systems in Nigeria: A survey. Abidjan, Côte d'Ivoire: West Africa Rice Development Association (WARDA).
14. FAI 2004. Fertilizer Statistics 2003–04. New Delhi: The Fertilizer Association of India.
15. FAIRTRADE FOUNDATION 2009. The global food crisis and Fairtrade: Small farmers, big solutions? - A Fairtrade Foundation report. London: Fairtrade Foundation.
16. FAO. 2005. *Gender and food security* [Online]. Rome, Italy: FAO. Available: http://www.fao.org /Gender/en/agri-e.htm [Accessed 19 May 2008 2008].
17. FAO 2008. The State of Food Insecurity in the World 2008: High food prices and food security – threats and opportunities. Rome, Italy: Food and Agriculture Organization of the United Nations.
18. GRAIN 2008. The 2008 land grab for food and financial security. *GRAIN Briefing October 2008.* Barcelona: GRAIN.
19. GRAY, L. C. & MOSELEY, W. G. 2005. A Geographical Perspective on Poverty-Environment Interactions. *The Geographical Journal,* 171, 9-23.
20. HENSCHEN, H. 2009. Experts See Food Crisis Unless Agriculture Aid Focus Shifts. *Dow Jones Newswires*, 24 February 2009.
21. HOLT-GIMÉNEZ, E. 2008. The World Food Crisis: what's behind it and what we can do about it. Oakland: Institute for Food and Development Policy.
22. HURST, P. 1990. *Rainforest politics: ecological destruction in South-East Asia,* London, Zed Books.
23. INTER-PARLIAMENTARY UNION 2006. Women in Politics: 60 Years in Retrospect
24. Geneva, February. *Data Sheet No. 4. Note.* IPU.
25. JAIN, D. 2005. Rethinking the Need for and Structure of the National Machineries for Women's Advancement. *Background paper for the Expert Group Meeting "The Role of National Mechanisms in Promoting Gender Equality and the Empowerment of Women.* Rome.
26. LUSTIG, N. 2008. Thought for Food: the Causes and Consequences of Soaring Food Prices - Shapiro Lecture.
27. MARX, K., DOBB, M. & RYAZANSKAYA, S. W. 1971. *A contribution to the critique of political economy,* London, Lawrence and Wishart.
28. MOODY, R. 1996. Mining the world: the global reach of Rio Tinto Zinc. *The Ecologist,* 26, 46-52.
29. MOSELEY, W. G. 2005. Global Cotton and Local Environmental Management: The Political Ecology of Rich and Poor Small-Hold Farmers in Southern Mali. *The Geographical Journal,* 171, 36-55.
30. OPUTA, C. O., NANDA, J. S. & CHADHARRY, R. C. 1985. *Rice Production in Nigeria,* Ibadan, Federal Agricultural Co-ordinating Unit.
31. PEET, R. & WATTS, M. 1996. *Liberation ecologies: environment, development and social movements,* London, Routledge.
32. PEET, R. & WATTS, M. 2004. *Liberation ecologies: environment, development, social movements,* London; New York, Routledge.
33. QUISUMBING, A. R., BROWN, L. R., FELDSTEIN, H. S., HADDAD, L. & PEÑA., C. 1995. Women: The Key to Food Security. *Food Policy Statement 21.* Washington DC: International Food Policy Research Institute.

34. ROBBINS, P. 2004. *Political Ecology: A Critical Introduction,* New York, Blackwell.
35. TAYLOR, M. The global 'land grab': Mitigating the risks and enhancing the opportunities for local stakeholders. The global land grab: a human rights approach 3D/ADH Seminar, 16th May 2009 2009 Geneva.
36. THE ECONOMIST. 2009. Buying farmland abroad: Outsourcing's third wave. *The Economist*, May 21st 2009.
37. UNIFEM 2007. The State of the World's Children 2007. New York: United Nations.
38. VARGAS-LUNDIUS 2007. Rosemary, in collaboration with Annelou Ypeij. Polishing the Stone. A Journey through the Promotion of Gender Equality in Development Projects. Rome: International Fund for Agricultural Development.
39. VON GREBMER, K., FRITSCHEL, H., NESTOROVA, B., OLOFINBIYI, T., PANDYA-LORCH, R. & YOHANNES, Y. 2008. Global Hunger Index: The Challenge of Hunger 2008. Washington, D.C: IFPRI.
40. WOOLCOCK, M. 1998. Social capital and economic development: Toward a theoretical synthesis and policy framework. *Theory and Society,* 27, 151-208.
41. WORLD BANK 2001. Smallholder Irrigation Market Initiative: Study on the Dissemination Potential of Affordable Drip and Other Irrigation Systems and the Concrete Strategies for Their Promotion. Washington, DC: The World Bank.
42. WORLD BANK 2005. Evaluating a Decade of World Bank Gender Policy. Washington, DC: Operations Evaluation Department, World Bank, .
43. WORLD BANK 2007a. Enhancing Agricultural Innovation: How to Go beyond the Strengthening of Research Systems. Washington, DC: World Bank.
44. WORLD BANK 2007b. The World Development Report 2008 Agriculture for Development. Washington, DC: World Bank.
45. WORLD BANK 2007c. World Development Report 2008: Agriculture for Development. Washington, DC: The International Bank for Reconstruction and Development / The World Bank.
46. ZUCKERMAN, E. 2002. Poverty Reduction Strategy Papers and Gender. *Background paper for the Conference "Sustainable Poverty Reduction and PRSPs—Challenges for Developing Countries and Development Cooperation.* Berlin.

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Comparison of Three Sweet Potato (*Ipomoea Batatas* (L.) Lam) Varieties on Nutritional and Anti-Nutritional Factors

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Abstract- In this study the nutritional and anti-nutritional status of yellow, white and orange fleshed sweet potato varieties (Ipomoea batatas L. Lam) in their raw roots unpeeled and peeled were determined. The nutritional and anti-nutritional values of three sweet potato varieties were significantly ($p<0.05$) varied due to cultivar variation, processing conditions and their interaction. Orange sweet potato variety contains the highest level of moisture, fat, ash, carbohydrate, energy, calcium and iron in unpeeled condition and fiber, moisture, fat, ash, calcium, iron and zinc in peeled condition. On the other hand, yellow sweet potato variety contains the highest level of protein, phytate, phytate: calcium, phytate: iron and phytate: zinc molar ratios in both unpeeled and peeled conditions while the highest value of fiber, oxalate and tannin in unpeeled condition.

Keywords: *sweet potato, variety, proximate, mineral, anti-nutritional factors.*

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Abstract- In this study the nutritional and anti-nutritional status of yellow, white and orange fleshed sweet potato varieties (Ipomoea batatas L. Lam) in their raw roots unpeeled and peeled were determined. The nutritional and anti-nutritional values of three sweet potato varieties were significantly ($p<0.05$) varied due to cultivar variation, processing conditions and their interaction. Orange sweet potato variety contains the highest level of moisture, fat, ash, carbohydrate, energy, calcium and iron in unpeeled condition and fiber, moisture, fat, ash, calcium, iron and zinc in peeled condition. On the other hand, yellow sweet potato variety contains the highest level of protein, phytate, phytate: calcium, phytate: iron and phytate: zinc molar ratios in both unpeeled and peeled conditions while the highest value of fiber, oxalate and tannin in unpeeled condition. White sweet potato variety contains the highest and lowest values of phosphorus and phytate in both unpeeled and peeled conditions and it was found in intermediate position for other nutrients compared to other two cultivars. Due to peeling, the fat, carbohydrate and energy values were significantly increased but all other parameters were significantly decreased.

Keywords: sweet potato, variety, proximate, mineral, anti-nutritional factors.

I. Introduction

Root and tuber crops refer to any growing plant that stores edible material in underground root, corm or tuber (Ugwu, 2009). Many of the developing world's poorest farmers and food insecure people are highly dependent on root and tuber crops as a source of food, nutrition, and cash income (Scott *et al*., 2000). The nutritional value of root and tuber crops lies in their potential ability to provide one of the cheapest sources of dietary energy in the form of carbohydrates. The amount of energy supplied by these crops is about one third of that of an equivalent weight of grains such as rice or wheat because these crops have high water content than cereals. However, the high yields of these root and tuber crops ensure an energy output per hectare per day which is considerably higher than that of grains (Woolfe, 1987).

In Ethiopia, sweet potato (*Ipomoea batatas L.* Lam) production ranks third after Enset (*Enset ventricosum* (W.) Cheesman) and potato (*Solanum tuberosum L.*) compared to other root and tuber crops. It is one of the major traditional food crops in the country. The crop cultivation is common in densely populated areas of the South, South-West and Eastern parts of the country and Southern Nation and Nationalities People Regions (SNNPR) is the highest producing area. It is an important food crop during hunger periods in areas such as Wolaita, Sidama, Kanbata Tanbaro, Gamo Gofa and Hadiya zones in SNNPR from February to May (Endale *et al.,* 1994).

When compared to other crops sweet potato is an attractive crop among farmers due to its high productivity, universal uses, high caloric content and good taste. Other important characteristics of sweet potato are; it tolerant adverse environmental conditions such as drought, it requires low soil fertility, high rainfall and very little labor and care (CIP, 1995). In addition to these attributes, it has also short production cycle, high nutritional value and sensory attributes in terms of flesh colors, taste and texture (Woolfe, 1992; Bovell-Benjamin, 2007; ILSI, 2008). Moreover, it contributes to food security and farmers' income in countries like Ethiopia (Terefe and Geleta, 1994).

Currently different varieties of sweet potato cultivars are cultivated and consumed in Ethiopia. These cultivars contain different skin colors (e.g. pink, cream, orange and white) and flesh colors (e.g. white, cream, orange and yellow). As with all crops the nutritional status of sweet potato cultivars vary from place to place depending on the climate, soil type, the crop variety and other factors (Ingabire and Hilda, 2011). Depending on the variety, sweet potatoes are rich in carbohydrates, dietary fiber, ash, ß-carotene, minerals and other nutrients (Woolfe, 1992; Bovell-Benjamin, 2007; ILSI, 2008). However, with all its desirable traits, sweet potatoes also contain potential plant toxins and anti-nutritional factors such as phytate, oxalate and tannin (Olayiwola *et al.,* 2009; Eluagu and Onimawo, 2010) that affect the nutrient utilization in the body. Thus, this study was conducted with the aim of selecting sweet potato variety with high nutritive value and low anti-nutritive factors among three sweet potato varieties (yellow-fleshed, white-fleshed and orange-fleshed) currently cultivated and consumed in Ethiopia.

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II. Materials and Methods

a) Description of the sampling area and sampling methods

The plant stems and leaves, storage root skin and flesh color of three sweet potato cultivars collected from Areka Agricultural Research Center which are used for current study were shown in Figure 2.1a, b and c.

Koka-6 variety Falaha variety Kulfo variety

Figure 2.1a : Three sweet potato varieties stems and leaves

Koka-6 variety Falaha variety Kulfo variety

Figure 2.1b : Sweet potato varieties storage root skin colors

Koka-6 variety Falaha variety Kulfo variety

Figure 2.1c : Sweet potato varieties storage root flesh colors

(Photographs by author)

b) Experimental study setting

A laboratory experiment was conducted at the laboratories of Addis Ababa University of Food Science and nutrition program and Ethiopian Health and Nutrition Research Institute.

c) Preparation of sweet potato flour

Flour from sweet potato was prepared based on the method described by Adeleke and Odedeji (2010) and shown in figure 2.2. In the laboratory, within 24 hours of harvesting for all varieties root samples with all root sizes were carefully selected and mixed separately for purpose of including all size in the study. The selected samples were manually cleaned by hand followed with clean water to remove adhering materials and soils. Then the cleaned samples were divided in to two parts for further operation. One portion was hand peeled and submerged in water to avoid enzymatic browning and then sliced to uniform thickness using a stainless steel knife. The slices were blanched in hot water (80^0_C) for 5 minutes in order to inactivate enzymes that may cause browning reaction and followed by immediate cooling in cold water to avoid further cooking (Eluagu and Onimawo, 2010). The cooled slices were

then drained on perforated plastic tray. The slices were dried in a hot air oven (drying oven model, DHG-9055A) at 60^0c until the chips were brittle and easy to be milled (overnight). The dried samples were milled into fine powder using electric grinder (High-Speed sampling machine model- FW100) until to pass through 0.425mm sieve. Sample preparation for second portion was the same as above except that the cleaned samples were unpeeled.

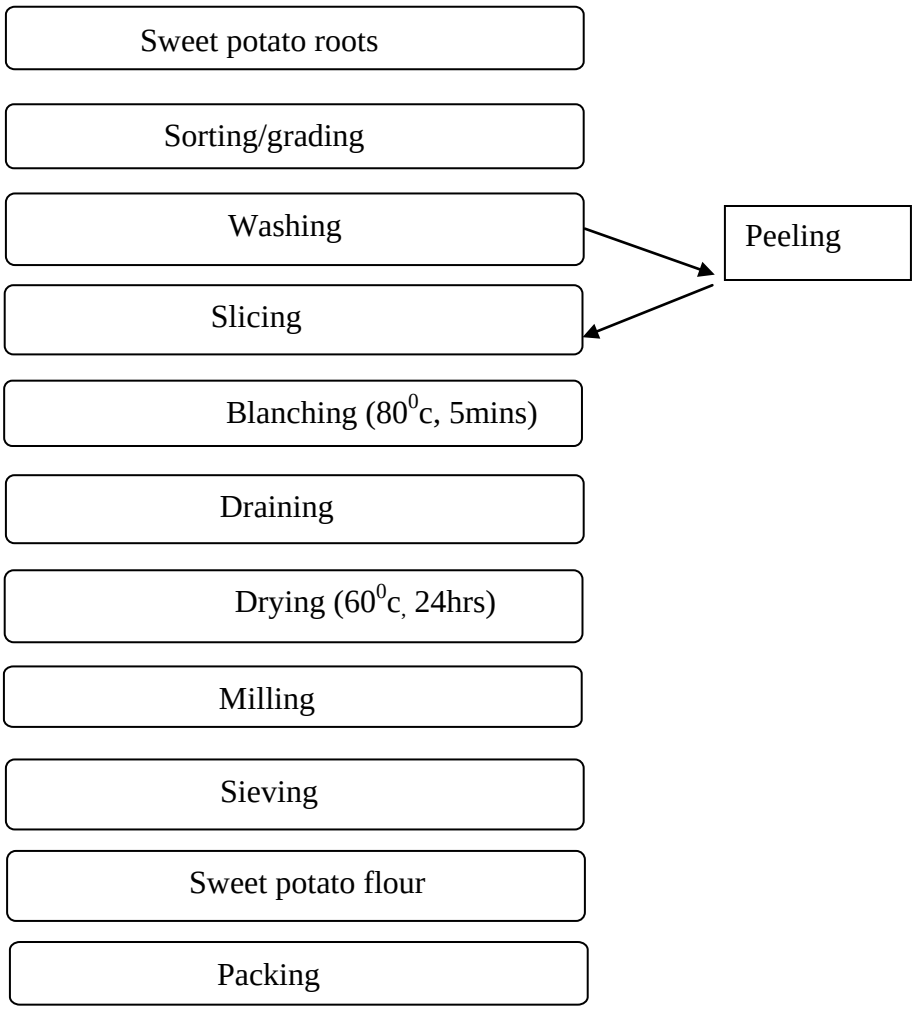

Figure 2.2 : Flow chart for the preparation of sweet potato flour

d) Methods of Analysis

i. *Proximate analysis*

The moisture content was determined according to AOAC (2000) using the official method 925.09 by oven drying. Crude fiber content was determined according to AOAC (2000) using official method 962.09. Protein content was determined according to AOAC (2000) using the official method 979.09. Total ash content was determined according to AOAC (2000) using the official method 923.03.The crude fat content was determined according to AOAC (2000) using official method 4.5.01. Total carbohydrate content was calculated by difference using the formula as follows: Carbohydrate (%) = 100 – (% crude protein + % crude fiber + % total ash + % crude fat)

Total energy content was obtained using Atwater conversion factors 4, 9 and 4 for each gram of crude protein, crude fat and carbohydrate and expressed in calories, respectively (Guyot *et al*., 2007).

$$\text{Total energy}\left(\frac{\text{Kcal}}{100\text{g}}\right) = (9 \times \%\text{Fat}) + (4 \times \%\text{Protein}) + (4 \times \%\text{Carbohydrate})$$

ii. *Mineral Analysis*

Calcium, magnesium, iron and zinc were determined according to the standard method of AOAC (2000) using an Atomic Absorption Spectrophotometer (Varian SAA-20 Plus). Phosphorus was determined using UV-VIS spectrometer.

iii. *Analysis of anti-nutritional factors*

Phytate content was determined using method described by Latta and Eskin (1980) and later modified by Vaintraub and Lapteva (1988).Tannin content was determined using the method of Burns (1971) as modified by Maxson and Rooney (1972).Oxalate content of sample was determined using method originally employed by Ukpabi and Ejidoh (1989).

e) *Statistical analysis*

Data for nutritional and anti-nutritional factors of yellow, white and orange sweet potato cultivars in their roots unpeeled and peeled conditions were analyzed with two-way ANOVA to evaluate the effects of variety and processing. Mean differences were statically significant at $p<0.05$ and the means of each parameter were compared using Duncan's multiple range test procedures to separate the means using SPSS, version 15.0 software.

III. Results and Discussions

a) *Proximate composition of yellow, white and orange fleshed sweet potatoes*

Table 3.1 : Proximate composition (g/100g)

Variety	Moisture*	Protein	Fat	Fiber	Ash	CHO**	Energy***
UYSP	71.73 ± 0.05^{d}	6.50 ± 0.05^{a}	0.49 ± 0.02^{d}	6.65 ± 0.00^{a}	3.49 ± 0.09^{d}	82.88±0.16^{e}	361.86±0.30^{d}
UWSP	72.45 ± 0.03^{c}	4.60 ± 0.10^{b}	0.53 ± 0.03^{d}	5.24±0.01^{b}	4.84 ±0.05 ^{a}	84.79±0.22^{d}	368.12±0.20^{c}
UOSP	76.97 ± 0.23^{a}	2.84 ± 0.41^{cd}	1.00 ± 0.07^{b}	4.52±0.01^{c}	4.94 ± 0.04^{a}	86.72±0.30^{c}	373.97±1.87^{b}
PYSP	68.58 ± 0.45^{f}	4.41± 0.07^{b}	0.66 ± 0.00^{c}	3.59 ± 0.08^{e}	3.04 ± 0.04^{e}	88.32±0.04^{ab}	376.90±0.20^{a}
PWSP	70.51 ± 0.60^{e}	3.46 ± 0.01^{c}	0.72 ± 0.01^{c}	2.94±0.09^{f}	4.04 ±0.05 ^{c}	88.86±0.14^{a}	375.65±0.45^{ab}
POSP	74.84 ± 0.13^{b}	2.48 ± 0.24^{d}	1.12 ± 0.01^{a}	3.83±0.06^{d}	4.33 ± 0.03^{b}	88.01±0.04^{b}	373.05±0.25^{b}

*Reported values are the mean ±SE (n=2). Means with different letters in the same column are significantly different (P<0.05). NB: UYSP & PYSP (Unpeeled and peeled Yellow Sweet Potato), UWSP & PWSP (Unpeeled and peeled White Sweet Potato) and UOSP & POSP (Unpeeled and peeled Orange Sweet Potato), respectively. *Wet basis, **Total Carbohydrate, *** in Kcal/100g.*

i. *Moisture content*

The moisture content of three sweet potato varieties was significantly affected ($P<0.05$) by processing and variety but their interaction did have a non significant effect. The mean values for moisture content among three sweet potato cultivars with two processing methods (Table 3.1) showed statistically significant variations; ranged from 71.73-76.97 and 68.58-74.84g/100g for unpeeled and peeled conditions, respectively. According to the result of statistical analysis, the mean moisture content of orange sweet potato variety was significantly ($P<0.05$) higher than that of both yellow and white sweet potato varieties in both unpeeled and peeled conditions. Similarly, mean moisture content of white sweet potato variety was significantly ($P<0.05$) higher compared to the mean moisture content of yellow sweet potato variety in both unpeeled and peeled conditions.

On the other hand, peeling was significantly decreased ($P<0.05$) the mean moisture content of all three sweet potato varieties. This may be higher amount of water is contained in outer skin layer than that of inner flesh layer of sweet potato roots. Results considering moisture in the present study are in the same line and comparable with works of (ENV/JM/MONO, 2010 and Purcell *et al.* 1989). The reason for the observed differences in moisture content of samples in the present study from earlier works could be attributed to the variety difference, the climate, the type of soils and others factors while the observed differences in moisture content in the current study might be contributed by variety difference.

ii. *Crude protein content*

The crude protein content of three sweet potato varieties was significantly affected ($P<0.05$) by processing, variety and their interaction. As it can be seen from statistical analysis (Table 3.1), significant differences ($p<0.05$) exist between the protein content of the three sweet potato cultivars and the value ranged from 2.84-6.50g/100g in unpeeled and 2.48-4.41g/100g in peeled conditions. The crude protein content of yellow sweet potato variety was significantly ($P<0.05$) higher than that of white and orange sweet potato varieties in both unpeeled and peeled conditions. Similarly, the mean crude protein content of white sweet potato variety was significantly ($P<0.05$) higher compared to the mean crude protein content of orange sweet potato variety in both unpeeled and peeled cases. Such observed differences in crude protein content in the current study might be contributed by cultivars or genetic difference, since all the studied varieties were collected from the same environment and soil type. These results are well agreed within the range of values (1.73 to 11.8%) that had been reported by (Purcell *et al.,* 1989). It was observed that peeling decreases the mean crude protein contents of the three sweet potato varieties; this may be higher amount of protein is accumulated in outer skin layer than that of inner flesh layer of sweet potato roots. Similar results had been reported by (William *et al.*, 1984; ENV/JM/MONO, 2010).

iii. *Crude fat content*

It was observed that the crude fat content is generally low in all investigated sweet potato cultivars; a similar idea had been reported by Boggess *et al.* (1971). The crude fat content of the three sweet potato varieties

was indicated to be significantly affected ($P<0.05$) by processing and variety but not in their interaction. Result in Table 3.1 shows that the mean fat content of three sweet potato cultivars was significantly varied and the mean value ranged from 0.49-1.00g/100g in unpeeled and 0.66-1.12g/100g peeled conditions. The observed value of crude fat in yellow, white and orange sweet potato varieties were 0.49, 0.53 and 1.00g/100g and 0.66, 0.72 and 1.12g/100g in unpeeled and peeled roots, respectively. The mean crude fat content of orange sweet potato variety was significantly ($P<0.05$) higher than that of both yellow and white sweet potato varieties in their unpeeled and peeled cases. Yellow sweet potato cultivar contain lower level of mean crude fat content than that of white sweet potato cultivar in both unpeeled and peeled states but the value was not significantly different ($P>0.05$). This observed difference among the three sweet potato cultivars may be contributed by genetic variation, since other factors are kept constant.

On the other hand, the mean crude fat content was observed to be significantly higher ($P<0.05$) in peeled than that of unpeeled sweet potato root in all their corresponding varieties. This might be dietary fat more accumulated in inner flesh layer than that of outer skin layer of sweet potato roots though biological processes. This result was similar with reported value of ENV/JM/MONO (2010).

iv. *Crude fiber content*

The crude fiber content of three sweet potato varieties was significantly affected ($P<0.05$) by processing, variety and their interaction. It was observed that the mean crude fiber content of three sweet potato cultivars was significantly varied (Table 3.1) and the mean value ranged from 4.52-6.650g/100g for unpeeled and 2.94-3.83 g/100g for peeled roots. The mean fiber content of yellow, white and orange sweet potato varieties was 6.65, 5.24 and 4.52g/100g and 3.59, 2.94 and 3.83g/100g for unpeeled and peeled roots, respectively. The mean crude fiber content of yellow sweet potato variety was significantly ($P<0.05$) higher than that of both white and orange sweet potato varieties in unpeeled condition but the value was significantly ($P<0.05$) higher in orange sweet potato variety than that of both white and yellow sweet potato varieties in peeled condition. The result also indicated that the mean crude fiber content of white sweet potato variety was significantly ($P <0.05$) higher compared to the mean value of orange sweet potato variety for unpeeled and was significantly ($P <0.05$) lower for peeled case. On the other hand, processing conditions were indicated that the mean crude fiber value was significantly higher ($P<0.05$) in unpeeled sweet potato root than that of peeled sweet potato root in all their corresponding varieties. This might be more dietary fiber accumulated in outer skin layer than that of inner flesh layer of sweet potato root. A similar finding had been reported by ENV/JM/MONO (2010).

v. *Total ash content*

The mean ash value of yellow, white and orange sweet potato varieties was 3.49, 4.84 and 4.94g/100g and 3.04, 4.04 and 4.33g/100g for unpeeled and peeled roots, respectively(Table 3.1). The mean total ash content of yellow sweet potato variety was significantly ($P<0.05$) lower than that of both white and orange sweet potato varieties in both unpeeled and peeled roots. Orange sweet potato cultivar has the highest mean ash content than that of white and yellow sweet potato cultivars in both unpeeled and peeled conditions but significant difference was not observed in unpeeled root of orange and white sweet potato cultivars. In considering effect of processing, similar trend was observed like in fiber; the mean ash content was significantly higher ($P<0.05$) in unpeeled sweet potato root than that of peeled sweet potato root in all their corresponding varieties. This might be either more inorganic matter is accumulated in outer skin layer than that of inner flesh layer in storage sweet potato root or some inorganic matter that adhered the skin layer of root might be contributed during processing.

vi. *Total carbohydrate content*

The total carbohydrate content was determined by difference. The total carbohydrate content of three sweet potato varieties was significantly affected ($P<0.05$) by processing, variety and their interaction. All the investigated sweet potato cultivars were significantly varied (Table 3.1.) in their carbohydrate content and the mean value ranged from 82.88-86.72g/100g in unpeeled and 88.01- 88.86g/100g in peeled conditions. The mean carbohydrate content of yellow, white and orange sweet potato varieties was 82.88, 84.79 and 86.72g/100g and 88.32, 88.86 and 88.01g/100g for unpeeled and peeled roots, respectively. The mean carbohydrate content of orange sweet potato variety was significantly ($P<0.05$) higher than that of both yellow and white sweet potato varieties in case of unpeeled root samples while white sweet potato variety has the highest carbohydrate content in peeled condition. A similar idea had been reported by Collins and Walter (1982) that most of the dry matter (85 to 90%) of the sweet potato was carbohydrate. Effect of processing also showed that peeling was significantly increased ($P<0.05$) the mean carbohydrate content of three sweet potato varieties. These observed variations might be result from the difference in the protein, fat, ash and fiber content of varieties and processing.

vii. *Total energy content*

The energy content of three sweet potato varieties was found significantly influenced ($P<0.05$) by processing, variety and their interaction. All the investigated sweet potato cultivars were significantly varied (Table 3.1) in their energy content and the mean

value ranged from 361.86-373.97Kcal/100g in unpeeled and 373.05-376.90Kcal/100g in peeled root samples. The mean energy content of orange sweet potato variety was significantly ($P<0.05$) higher than that of both yellow and white sweet potato varieties in unpeeled root samples while the lowest value was obtained in yellow sweet potato in the same condition. In peeled condition, the highest and lowest mean energy content was observed in yellow and orange sweet potato varieties, respectively even though significant difference was not observed between yellow and white and orange and white sweet potato cultivars.

Similarly carbohydrate, the energy contents in all investigated sweet potato cultivars were high. Thus, the principle use of sweet potato like other starchy root and tuber crops as human food and animal feed is therefore as a source of dietary energy yielding ingredients (Philip, 1991). Effect of processing also revealed that peeling was significantly increased ($P<0.05$) the mean energy content of all the studied sweet potato cultivars. The observed variations in energy content in variety and processing may be contributed from the difference in the protein, fat and fiber content of varieties and processes.

b) Mineral composition of yellow, white and orange fleshed sweet potatoes

i. *Calcium content*

The calcium content of three sweet potato varieties was significantly affected ($P<0.05$) by processing, variety and their interaction. All the investigated sweet potato cultivars were significantly varied (Table 3.2) in their calcium content and the mean value ranged from 7.42-47.04mg/100g and 5.28-45.54mg/100g in unpeeled and peeled root samples, respectively. The mean calcium content of orange sweet potato variety was significantly ($P<0.05$) higher than that of both yellow and white sweet potato varieties in both unpeeled and peeled conditions while yellow sweet potato variety contains the lowest in both unpeeled and peeled cases. This variation might be contributed by cultivar difference. A similar idea had been reported by Elkins (1979) and Lopez *et al.* (1980). In some sweet potato cultivars, high level of average calcium (78.6mg/100g) content had been reported by (Purcell *et al.,* 1989). The observed variation between average range value of calcium content in this result and earlier finding might be attributed by cultivars, climate, soil types, location and other factors (Serge, 1996).

On the other hand, effect of processing revealed that peeling was significantly decreased ($P<0.05$) the mean calcium content of all studied sweet potato varieties. This result is expected because higher value of average ash content was observed in the outer skin layer of sweet potato root than that of inner flesh layer during proximate study currently; hence ash is indicative of the amount of minerals contained in any food sample (Olaoye *et al.,* 2007). Moreover, there might be either more inorganic matter is accumulated in outer skin layer than that of inner flesh layer in storage sweet potato root or some minerals that are adhered with the outer layer of the root from the soil may be attributed calcium during processing.

ii. *Iron content*

The iron content of three sweet potato varieties was significantly affected ($P<0.05$) by processing, variety and their interaction. The mean values for iron content among three sweet potato cultivars with different processing methods (Table 3.2) showed statistically significant variations; ranged from 11.51-15.26mg/100g in unpeeled and 8.70-11.45mg/100g in peeled root samples. The mean iron content of orange sweet potato variety was significantly ($P<0.05$) higher than that of both yellow and white sweet potato varieties in unpeeled and peeled root samples. Similarly as calcium, yellow sweet potato variety contains the lowest iron content in both unpeeled and peeled cases. A similar finding had been reported by Elkins (1979) and Lopez *et al.* (1980). In some sweet potato varieties, low level of iron (1.72mg/100g) content had been reported by (Purcell *et al.,* 1989). This variation might be for the same reasons of calcium content that was mentioned above. The unpeeled root samples contain high level of iron content than that of peeled root samples in all investigated sweet potato cultivars; this might be for similar reasons that are mentioned in calcium content.

Table 3.2 : Mineral composition (mg/100g) of yellow, white and orange sweet potatoes

Variety	Calcium	Phosphorus	Iron	Zinc	Magnesium
UYSP	7.42 ± 0.01^{d}	19.22 ± 0.01^{e}	11.51 ± 0.02^{c}	1.14 ± 0.01^{c}	5.86 ± 0.11^{a}
UWSP	7.95 ± 0.02^{c}	24.50 ± 0.01^{a}	13.35 ± 0.01^{b}	1.97 ± 0.01^{a}	5.98 ± 0.025^{a}
UOSP	47.04 ± 0.05^{a}	22.11 ± 0.01^{b}	15.26 ± 0.02^{a}	1.30 ± 0.01^{b}	3.00 ± 0.075^{b}
PYSP	5.28 ± 0.01^{f}	15.70 ± 0.10^{f}	8.70 ± 0.01^{f}	0.68 ± 0.01^{f}	UD
PWSP	6.04 ± 0.01^{e}	21.80 ± 0.01^{c}	9.69 ± 0.01^{e}	0.79 ± 0.01^{e}	UD
POSP	45.54 ± 0.01^{b}	20.67 ± 0.01^{d}	11.45 ± 0.01^{d}	0.93 ± 0.02^{d}	UD

Reported values are the mean ±SE (n=2). Means with different letters in the same column are significantly different (P<0.05). NB: UYSP & PYSP (Unpeeled and peeled Yellow Sweet Potato), UWSP &PWSP (Unpeeled and peeled White Sweet Potato) and UOSP & POSP (Unpeeled and peeled Orange Sweet Potato), UD (undetected).

iii. *Zinc content*

The zinc content of three sweet potato varieties was significantly affected ($P<0.05$) by processing, variety and their interaction. All the investigated sweet potato cultivars were significantly varied (Table 3.2) in their zinc content and the mean value ranged from 1.14-1.97mg/100g in unpeeled and 0.68-0.93mg/100g in peeled condition. White and orange sweet potato cultivars contain the highest zinc content in unpeeled and peeled conditions, respectively while yellow sweet potato variety contains the lowest zinc content in both unpeeled and peeled conditions. Zinc content is generally low in all investigated sweet potato cultivars. Similar to other minerals, peeling was significantly decreased ($P<0.05$) the mean zinc content of all studied sweet potato varieties even though the zinc content in both unpeeled and peeled cases can be considered low. A similar result had been reported by ENV/JM/MONO (2010) that sweet potato contains higher level of zinc in unpeeled (1.30mg/100g) condition than that of peeled (0.6–1.2mg/100g) condition.

iv. *Phosphorus content*

The phosphorus content of three sweet potato cultivars was significantly influenced ($P<0.05$) by processing, variety and their interaction. The mean values for phosphorus content among three sweet potato cultivars with different processing methods (Table 3.2) was indicated statistically significant variations; ranged from 19.22-24.50mg/100g in unpeeled condition and 15.70-21.80mg/100g in peeled condition. White sweet potato cultivar had the highest value of phosphorus content in both unpeeled and peeled conditions while the lowest value was observed in yellow sweet potato variety in both unpeeled and peeled root samples. A similar finding had been reported by Elkins (1979) and Lopez *et al.* (1980) that the level of phosphorus content is varied from cultivar to cultivar and the observed average value was 39.2-48.9(mg/100g). In some sweet potato cultivars, high level of average phosphorus(115.4 mg/100g) content had been reported by (Purcell *et al.,* 1989). On the other hand, peeling was significantly decreased ($P<0.05$) the mean phosphorus content of all studied sweet potato varieties; a similar idea was observed by ENV/JM/MONO (2010). This variation may be contributed by similar reasons that are discussed above for other minerals.

v. *Magnesium content*

The magnesium content of three sweet potato varieties was determined only in their root samples unpeeled cases (due to shortage of materials) and the mean value ranged from 3.00-5.98mg/100g. The mean magnesium content of orange sweet potato variety was significantly ($P<0.05$) lower than that of both yellow and white sweet potato varieties. On the other hand, white sweet potato variety contains higher level of mean magnesium value than that of yellow sweet potato variety but the value was not significantly different ($P>0.05$) from each other. Generally, the magnesium content of all varieties in this investigation can be considered low next to zinc among the above discussed minerals. A similar idea had been reported by Elkins (1979) and Lopez *et al.* (1980) that the level of magnesium content is varied from cultivar to cultivar and the observed average value was18.3-22.2 (mg/100g). In some sweet potato cultivars, the level of average magnisium (12.20-30.40mg/100g) content had been reported by Ukom *et al.,* (2009). The variations in magnesium content might be contributed cultivars, climate, soil types, location and other factors.

c) *Anti-nutritional factors of yellow, white and orange fleshed sweet potato cultivars*

i. *Phytate and phytate mineral molar ratio*

Results of statistical analysis show that the phytate content of three sweet potato cultivars was significantly affected ($P<0.05$) by processing, variety and their interaction. The mean values for phytate content among three sweet potato cultivars with different processing methods (Table 3.3) indicated statistically significant variations; ranged from 93.37-111.43mg/100g in unpeeled and 49.35-78.38mg/100g in peeled root samples. The mean phytate content of yellow sweet potato variety was significantly ($P<0.05$) higher than that of both orange and white sweet potato varieties in both unpeeled and peeled conditions while significantly the lowest value was observed in white sweet potato cultivar in both unpeeled and peeled conditions. This variation might be attributed by cultivar difference, since all studied sweet potato cultivars were collected from the same environment.

On the other hand, peeling was significantly decreased ($P<0.05$) the mean phytate content of all studied three sweet potato cultivars. This is expected because more phosphorus is accumulated in the outer skin layer of sweet potato root than that of inner flesh layer; hence phytate is natural occurring phosphorus compound.

The mean value of phytate: calcium molar ratio in the present study was 0.91, 0.90, 0.74 and 0.51 for unpeeled yellow sweet potato, peeled yellow sweet potato, unpeeled white sweet potato and peeled white sweet potato cultivars, respectively which were higher than the reported critical molar ratio (0.24) of phytate: calcium, indicating that absorption of calcium was adversely affected by phytate in these roots. But in case of both unpeeled (0.12) and peeled (0.11) orange sweet potato variety, the value was found lower than the reported critical molar ratio of phytate: calcium, indicating that absorption of calcium was not adversely affected by phytate in orange sweet potato roots. However, sweet potato root is consumed in its boiled

state; this might reduce phytate level and enhance the bioabilability of calcium in yellow and white sweet potato varieties. All other calculated molar ratios in this study such as; Phytate: iron, phytate: zinc and [phytate x calcium]: zinc molar ratios for all sweet potato varieties in their unpeeled and peeled conditions were found less (Table 3.3) than their reported critical values, this indicates that absorption of iron and zinc from all studied sweet potato varieties were not inhibited by phytate and as a result these minerals in all roots are bioavailabile.

ii. *Oxalate content*

The oxalate content of three sweet potato cultivars was investigated only in unpeeled case (due to shortage of materials) and the mean value ranged from 3.50-8.80mg/100g (Table 3.3). The mean oxalate content of yellow sweet potato variety was significantly ($P<0.05$) higher than that of both orange and white sweet potato varieties. Similarly, the mean oxalate content of orange sweet potato variety was significantly ($P<0.05$) higher than that of white sweet potato varieties. This observed variation among three sweet potatoes might be attributed by cultivar difference. Oxalates can have a harmful effect on human nutrition and health, especially by reducing calcium absorption and aiding the formation of kidney stones (Noonan and Savage, 1999). However, the oxalate level observed in this study is low and also in recommended range for patients with calcium oxalate kidney stones if they consume up to 600g of any studied sweet potato cultivars per day; as patients are advised to limit their intake of foods with a total intake of oxalate not exceeding 50–60 mg per day (Massey *et al*., 2001).

Oxalate like phytate binds minerals such as calcium and magnesium and interfere with their metabolism. The importance of oxalate content of an individual plant product in limiting total dietary calcium availability is of significance only when the ratio of oxalate: calcium is greater than one (Frontela *et al*., 2009). Under this circumstance, the oxalate has potential to complex, not only the calcium contained in the plant, but also that derived from other food sources (Davis and Olpin, 1979). The oxalate: calcium values of YSP, WSP and OSP was 0.53, 0.20 and 0.06, respectively. These values were lower than the reported critical molar ratio (1.0) of oxalate: calcium, indicating that absorption of calcium not adversely affected by oxalate in all studied sweet potato varieties.

Table 3.3 : Anti-nutritional factors (mg/100g) and phytate mineral molar ratios of yellow, white and orange fleshed sweet potato varieties

Variety	Phytate	Oxalate	Tannin	Phy:Ca	Phy:Fe	Phy:Zn	[PhyxCa]:Zn
UYSP	111.43 ± 0.04^{a}	8.80 ± 0.02^{a}	34.38	0.91 ± 0.001^{a}	0.83 ± 0.005^{a}	9.67 ± 0.8^{b}	0.018 ± 0.005^{b}
UWSP	93.37 ± 0.01^{c}	3.50 ± 0.04^{c}	B.D.L	0.71 ± 0.001^{b}	0.59 ± 0.00^{c}	4.70 ± 0.0^{f}	0.01 ± 0.00^{b}
UOSP	95.15 ± 0.09^{b}	5.71 ± 0.08^{b}	B.D.L	0.12 ± 0.00^{d}	0.53 ± 0.00^{d}	7.39 ± 0.19^{d}	0.09 ± 0.005^{a}
PYSP	78.38 ± 0.01^{d}	UD	B.D.L	0.90 ± 0.00^{a}	0.77 ± 0.005^{b}	11.90 ± 0.00^{a}	0.015 ± 0.005^{b}
PWSP	49.35 ± 0.03^{f}	UD	B.D.L	0.51 ± 0.005^{c}	0.46 ± 0.03^{e}	6.53 ± 0.29^{e}	0.01 ± 00^{b}
POSP	77.75 ± 0.01^{e}	UD	B.D.L	0.11 ± 0.005^{e}	0.58 ± 0.005^{c}	8.15 ± 0.28^{c}	0.10 ± 0.005^{a}

Reported values are the mean ±SE (n=2). Means with different letters in the same column are significantly different (P<0.05). NB: UYSP& PYSP (Unpeeled and peeled Yellow Sweet Potato), UWSP&PWSP (Unpeeled and peeled White Sweet Potato) and UOSP&POSP (Unpeeled and peeled Orange Sweet Potato), UD (undetected), B.D.L (below detection levels).

iii. *Tannin content*

The mean value of tannin content was 34.38 mg/100g in unpeeled yellow sweet potato cultivar and the value was below detection level in unpeeled and peeled white sweet potato variety, unpeeled and peeled orange sweet potato variety and peeled yellow sweet potato variety (Table 3.3). This result indicates that the level of tannin content is absent or insignificant in three investigated sweet potato cultivars except unpeeled condition of yellow sweet potato variety. It was also observed that tannin is accumulated in the outer skin layer of yellow sweet potato variety and it was removed by peeling with the outer skin layer of the root (Table 3.3). The presence of tannin only in yellow sweet potato variety might be contributed by the presence of polyphenolic compound such as flavonoids (quercetin, $C_{15}H_{10}O_{7)}$ which found in yellow sweet potato varieties (Guan *et al.,* 2006) and the absence of tannin in white and orange sweet potato varieties might be lack of these compounds in their roots.

The beneficial or anti-nutritional property of tannin depends on its amount in the diet. The toxicity effects of the tannin may not be significant since the total acceptable tannic acid daily intake for a man is 560 mg (Anonymous, 1973). The current result shows that if a man daily consumes up to 1900 grams of unpeeled yellow sweet potato roots and any amount of unpeeled and peeled white sweet potato, unpeeled and peeled orange sweet potato and peeled yellow sweet potato roots, the level of tannin in these roots will not cause the toxicity effect to man.

iv. Conclusion and Recommendations

a) Conclusion

This study has covered information on the nutritional and anti-nutritional status of yellow, white and orange fleshed sweet potato cultivars in their raw roots unpeeled and peeled conditions. The result showed that the nutritional and anti-nutritional contents of three sweet potato varieties were significantly varied due to cultivar variation, processing conditions and their interactions. Orange sweet potato variety contains the highest level of moisture, fat, ash, carbohydrate, energy, calcium and iron in unpeeled condition and fiber, moisture, fat, ash, calcium, iron and zinc in peeled condition. The protein content was least in orange sweet potato cultivar in both conditions. Yellow sweet potato variety contains the highest level of protein, phytate, phytate: calcium, Phytate: iron and Phytate: zinc molar ratios in both unpeeled and peeled conditions while fiber, oxalate and tannin value was highest in unpeeled condition. White sweet potato variety contains the highest and lowest levels of phosphorus and phytate in both unpeeled and peeled conditions and it was found in intermediate position for other nutrients. On the other hand, peeling was decreased the levels of moisture, protein, fiber, ash, carbohydrate, calcium, phosphorus, iron, zinc and phytate and increased the other parameters such as fat, carbohydrate and energy contents in their corresponding varieties. Among three sweet potato cultivars, this result has indicated that orange sweet potato variety is potentially good source of nutrients compared to other sweet potato varieties.

b) Recommendations

- Since orange sweet potato variety is potentially good source of nutrients among three sweet potato varieties, more emphasis should be given for its cultivation in agricultural sectors as well as farmers land.
- It is highly recommended that sweet potato roots should be consumed in its unpeeled state provided that peeling of sweet potato roots removes most of nutrients that are important to human health.

References Références Referencias

1. Adeleke, R. O. and Odedeji, J.O. (2010). Functional properties of wheat and sweet potato flour blends. *Pakistan Journal of Nutrition,* **9 (6):** 535-538.
2. Anderson, P. (1981). Nutritional consideration into Agricultural and Rural Development. International Food Policy Research Institute, Washington, D.C. U.S.A, Food and Nutrition Bulletin, 4:2.
3. Anonymous, (1973). Tannic acid gain. Food Cosmetol Toxicol. In: Toxicants naturally occurring in foods. National Academy of Sciences, Third Edition: Pp. 112.
4. AOAC (2000). Association of Official Analytical Chemists. Official Methods of Analysis, 17th edition. Washington, DC.
5. Assefa, T., Teshome, A., Engida, T. and Tesfaye, T. (2007). Summary of Progress on Orange fleshed sweet potato research and development in Ethiopia. Proceedings of the 13th ISTRC Symposium, pp. 728 – 731.
6. Boggess, J.S., Mario, J.E., Woodroof, J.G. and Dempsey, A.A. (1971). Changes in lipid composition as affected by controlled storage. *Journal of Food Science*, **32:** 554-560.
7. Bovell-Benjamin, A.C. (2007). Sweet potato: A review of its past, present, and future role in human nutrition. *Advances in Food and Nutrition Research*, **52:** 1-48.
8. Burns, R.R. (1971). Methods for estimation of tannin in grain Sorghum. *Agronomic Journal*, **63**:511-512.
9. Chaudhary, H.R. (1984). Determinants of nutrient adequacy in a rural area of Bangladesh. United Nations Department of Technology Co-operation for development, Katmandu, Nepal. Food and Nutrition Bulletin 1986, **8(4)**.
10. CIP (1995). Sweet potato, treasure for the poor. La Molina, Peru: Intl. Potato Center. Available from: http://www.cipotato.org/sweetpotato/ on December 4, 2007.
11. Collina, W.W. and Walter, W. M. (1982). Potential for increasing nutritional value of sweet potatoes.
12. CSA (1995). Ethiopian Agricultural Sample Enumeration (2001/2002). Report on the Preliminary Results of Area, Production and Yield of Temporary Crops (Meher Season, Private Holdings). Volume I., Part II, Addis Ababa, Ethiopia.
13. Davis, N. T. and Olpin, S. (1979). Studies on the phytate: Zn molar content in diet as determinant of Zn availability to young rats. *British Journal of Nutrition,* **41:** 591-603.
14. Elkins, E.R. (1979). Nutrient content of raw and canned green beans, peaches and sweet potatoes. *Food Technology,* 2:66.
15. Eluagu, E. N. and Onimawo, I.A. (2010). Effect of processing on the mineral composition and anti-nutritional factors of orange fleshed sweet potato (*Ipomoea batatas* L. Lam) flours. *Electronic Journal of Environmental, Agricultural and Food Chemistry,* **9 (6):** 1000-1005.
16. Endale, T., Terefe, B., Mukgeta, D. and Geleta, L. (1994). Improvement studies on Enset and Sweet potato. In: Proceedings of the second national Horticultural workshop in Ethiopia, 1-3Dec.1992.
17. ENV/JM/MONO. (2010). Environment Directorate Joint Meeting of the Chemicals Committee and the Working party on Chemicals, Pesticides and Biotechnology. Sweet Potato (Ipomoea batatas L. Lam.]: key food and feed nutrients, anti-nutrients,

toxicants and allergens. Series on the Safety of Novel Foods and Feeds No. 20
18. Frontela, C., Scarino, M.L., Ferruzza, S.G. and Martínez, C. (2009). Effect of dephytinization on bioavailability of iron, calcium and zinc from infant cereals assessed in the Caco-2 cell model. *World Journal of Gastroenterology,* **28:** 1977-1984.
19. Guyot, J.P., Rochette, I. and Treche, S. (2007). Effect of fermentation by amylolytic lactic acid bacteria, in process combinations, on characteristics of rice/soybean slurries: A new method for preparing high energy density complementary foods for young children. Food Chemistry, **100**: 623–630.
20. ILSI (2008). Nutritionally improved sweet potato. Washington, D.C.: Intl. Life Sciences Inst. Available from: (http://www3.interscience.wiley.com/cgi-bin/fulltext/119423793/PDFSTART). Accessed September 01, 2008
21. Ingabire, M. R. and Hilda V. (2011). Comparison of the nutrient composition of four sweet potato varieties cultivated in Rwanda. *American Journal of Food and Nutrition,* **1(1):** 34-38.
22. Latta, M. and Eskin, M. (1980). A simple and rapid colorimetric method for phytate determination. *Journal of Agricultural and Food Chemistry*, **28** :1315–1317.
23. Lopez, A., William, H.I. and Cooler, F.W. (1980). Essential elements in fresh and canned sweet potatoes. *Journal of Food Science*, **45:** 675.
24. Massey, L. K., Palmer, R. G. and Horner, H. T. (2001). Oxalate content of soybean seeds (Glycine max: Leguminosae), Soya foods and other edible legumes. *Journal of Agriculture and Food Chemistry*, **49:** 4262–4266.
25. Maxson, E. D. and Rooney, L. W. (1972). Evaluation of methods for tannin analysis in sorghum grain. Cereal Chemistry, **49**: 719-729.
26. Noonan, S. C. and Savage, G. P. (1999). Oxalic acid and its effects on humans. *Asia pacific Journal of Clinical Nutrition,* **8:** 64–74.
27. Olaoye, O. A., Onilude, A. A. and Oladoye, C. O. (2007). Breadfruit Flour in Biscuit Making: Effects on Product Quality. *African Journal of Food Science*, 020-023.
28. Olayiwola, I. O., Abubakar, H. N., Adebayo, G. B. and Oladipo, F. O. (2009). Study of sweet potato (*Ipomoea batatas* Lam) foods for indigenous consumption through chemical and antinutritive analysis in Kwara State, Nigeria. *Pakistan Journal of Nutrition,* **8 (12):** 1894-1897.
29. Philip, A. B. (1991). Root crops in the diets of growing pigs. Submitted to the University of Nottingham in fulfillment of the degree of Doctor of Philosophy. Livestock research for rural development, **9(5):** 387-390.
30. Purcell, A. E., Walter, W. M. and Wilson, L. G. (1989). Quality and Preservation of vegetables: Sweet potatoes. Michael, E. (Ed). Department of foods and Nutrition University of Manitoba Winnipeg, Manitoba, Canada. *Journal of Agricultural and Food Chemistry,* **29**: 253-300.
31. Scott, G. J., Rosegrant, M. W. and C. R. (2000). Global projections of root and tuber crops to the year 2020. *Food Policy*, **25:** 561-597.
32. Serge, T. (1996). Tropical Root and Tuber Crops as Human Staple Food. Conference présentèe au I Congresso Latino Americano de Raizes Tropicals 7-10 October 1996, Sao Pedro - SP – Brésil: Montpellier – France
33. Terefe, B. and Geleta, L. (1994). Agronomic Studies on Sweet potato. In: proceedings of the second national horticultural workshop in Ethiopia, 1-3 Dec.1992. Addis Ababa, Ethiopia.
34. Ugwu, F.M. (2009). The Potentials of roots and tubers as weaning foods. *Pakistan Journal of Nutrition,* **8 (10):** 1701-1705.
35. Ukom, A. N., Ojimelukwe, P. C. and Okpara, D. A. (2009). Nutritional composition of selected sweet potato (*Ipomoea batatas* (L) Lam) varieties as influenced by different levels of nitrogen fertilizer application. *Pakistan Journal of Nutrition,* **8(11):** 1791-179.
36. Ukpabi, V. J. and Ejidoh, J. I. (1989). Effect of deep out frying on the oxalate content and the degree of itching of cocoyams (*Xanthosoma and colocassia* spp). Technical paper presented at the 5th annual conference of the Agriculture society of Nigeria.
37. Vaintraub, I. A. and Lapteva, N. A. (1988). Colorimetric determination of phytate in unpurified extracts of seeds and the products of their processing. Analytical Biochemistry, **175:** 227.
38. Wanda, W. C and Walter, Jr. (1989). Fresh roots for human consumption: Natural resource for the Tropics. John, C. B. (Ed). *Maryland Journal of Agricultural & Food Chemistry*, **29:**154-169.
39. William, M. W., Wanda, W. C. and Albert, E.P. (1984). Sweet potato protein: A review. *Journal of Agriculture and Food chemistry,* **32(4):**1-5.
40. Woolfe, J. A. (1992). Sweet potato, an untapped Food Resource, Cambridge: Cambridge University press. In. proc. Of 8th ISTRC-AB Symposium, pp.141.
41. Woolfe, J. A. (1987). The potato in the human diet. CIP, Lima. Cambridge University Press, Cambridge, Britain, Pp. 19-54.

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Participatory on - Farm Evaluation and Demonstration of Improved Forage Species under Rain Fed Condition in Hamer Woreda of South Omo Zone

By Denbela Hidosa, Worku Bedeke & Mesifin Mengistu

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Keywords: *dry matter yield, lablab intoritum, lablab purpureus vigna unguiculata.*

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Keywords: dry matter yield, lablab intoritum, lablab purpureus vigna unguiculata.

I. Introduction

Ethiopia is home, excluding some non sedentary area of country such as pastoral areas of Afar and Somali regions, to approximately 56.71 million of cattle, 29.33 million of sheep, 29.11 million goats, 1.16 million camels, 56.87 million chickens, and 2.03 million horses 7.43 million donkey and 0.40 million mules (CSA, 2015). However, productivity achieved from livestock is very much lower than other African countries or world (Belete et al., 2010; Gebremedhin et al., 2004; FAO, 2009). Many studies confirmed that feed shortage both in quality and quantity is a critical and major cause for a low productivity of livestock in Ethiopia particularly in dry seasons (Mengistu, 2002; Mengistu and Amare, 2003; Zegeye, 2003; Amede et al., 2005; Duguma et al., 2012; Seyoum and Zinash, 1995; Ørskov, 1998; Tolera, 2007; Solomon, 2010 and Alemayehu, 2004). In the study area, which is pastoral and agro pastoral production system, livestock population is entirely depend on the feed from natural pastures is estimated to covers 80-90% of the livestock feed resource (Mengistu, 2006). Especially, in the dry season the availability and quality of natural pasture reduced to such an extent that livestock may not fulfill the energy requirement to maintain their bodyweight. This results in body weight loss and reduction of production and productivity (Galmessa et al., 2013) and made pastoral communities less benefit from prevailed production system in the study area. Improving the feed resource base by identifying alternative and more nutritious feeds is necessary to alleviate the prevailing nutritional constraints of livestock in the study area. One way of improving the production from livestock is by improving the nutritional constraints through the development of improved forage species and proper supplementation with leguminous forages (Poppi and McLennan, 1995) which are rich in crude protein(CP) content usually the most limiting nutrients in tropical livestock diets. Among them *Lablab purpureus* Lablab is drought hardy, and has been grown in arid, semi-arid and humid regions with rainfalls between 200 and 2500 mm (Hendricksen and Minson, 1985b; Cameron, 1988). Dry matter production potential per hectare varies with rainfall, soil condition and time of seeding and it could be yield 3-10 t / DM per ha (Denbela et al., 2015; Alemayehu, 2003; Cameron, 1988; Mayer et al., 1986). Conversely, Vigna unguiculata is one of the most important legume food and feed crops (Bennett-Lartey and Ofori, 1999) and it is widely grown and planted under rain fed conditions in in sub- Saharan Africa (Allen, 1983). However, in the study district, study on evaluation the adaptability of tested forage species is not has been carried out due to remoteness and mobile nature of pastoralists. The on farm evaluation and introduction of these species imperative in order to overcome the feed constraints

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both in quality and quaintly to the study area therefore, this study was aimed to evaluate the high yielding improved legume species and demonstrates to pastoralists' communities.

II. Material and Methods

a) Description of study area

The study area is located in Hamer Woreda of South Omo Zone, the Southern Nations, Nationalities and Peoples Regional state of Ethiopia which is bordered on the South by Kenya, on the South West by Dasenchi woreda, on the West by Nyangatom woreda, on the North by Bena-tsemay woreda and on the East by the Oromia Regional State. The average temperature is above 37°C in most parts of Woreda and altitude varies from 450 meters to 1765 meters above sea level. The average annual rainfall is 400 mm. It is estimated that 66% of the population lead a pastoral production system and 34% of the population practice a crop livestock mixed production system.

b) Selection of trial site and trial pastoralists

Demeka zuria peasant association was selected for on farm participatory evaluation of improved legume forage species in collaboration with Woreda pastoral affairs' office experts and Developmental agents after undertaken in-depth discussion on the objectives of the research activity. Three trial pastoralists' households were selected after community meeting. The criteria for selection of trial pastoralists were availability of land and interest of pastoralist in research process. Finally, training was delivered to Agricultural extension workers, pastoralists (trial and non trial) who involved in research, peasant administrative leaders on Participatory research approach, role of gender in research and forage production strategies and utilizations.

c) Experimental Design and Treatment

After delivery of the training, each trial pastoralist contributed a 0.125 hectare of land. The area was divided in to three plots which have 3m x 4m area and each tested species was planted in each plots using randomized complete block design (RCBD) with three replications. Each trial pastoralists planted *Lablab intoritum, Lablab purpureus and Vigna unguiculata* by using participatory approach at on farm level for their adaptability test. The experimental materials were planted at a spacing of 30 cm and 50 cm between plants and rows respectively by using a seed rate 15 kg per hectare.

d) Crop management and Data collection

The planted species management activity such as hoeing, weeding, Diseases and Pest inspection carried out and trial farms were continuously monitored. The growth performance data like germination (emergence) date, stem height growth, number of leaf, days to 50 % of heading were collected. In order to measure the length of steam and number of leaf per each species at 50% heading age, five plant from middle of two row per plots were randomly taken for height of plant and number of leaf per plant were measured. The average height of plant and number of leaf per plant had been considered for their growth potential of the tested species. Conversely, each tested species were harvested eight week after planting to determine fresh biomass (FBY) and dry matter yield (DMY) production potential. Three samples were randomly taken per plot at quadrates of 50cm x50 cm area by cutting using sickle and weighed samples and transported to Jinka Agriculture research Center and allotted to cut in to small pieces and made pooled it. The representative samples were subjected to oven dried at 105°c for 24hrs at Jinka Agricultural Research Center Animal Feed evaluation Laboratory. The dry matter yield of each species was calculated by the final weight collected from oven dried divided by initial weight before the subjecting to the oven dried.

e) Statistical Analysis

Analysis of data like date of emergence, stem height, number of leaf, days to 50 % of heading and yield data like fresh and dry matter yield were performed by using general liner model (GLM) procedure of SAS statistical soft ware version 9.1. Effect of tested species were considered as significant in all statistical calculation if ($P \leq 0.05$). Means were separated using Duncan's least significant difference (LSD) test with following model.

$$Y_{ij} = A + \beta_i + t_j + e_{ij}$$

Where: Y_{ij} = dry matter yield,

A = General mean of the treatments,

βi = block effects,

tj = treatment(species) effects and

eij = experimental (random) error

VI. Results and Discussion

Table 1 : The fresh biomass yield, dry matter yield, Coefficients of variance and least significance difference tested species

Tested Species	FBY/plot/g ±SE	DMY/plot/g ±SE
Lablab purepureus	504±32[c]	180±27[c]
Lablab intoritum	371±32[b]	113±27[a]
Vigna unguiculata	292±32[a]	170±27[b]
LSD 0.05	8.50	7.90
CV (%)	6.75	5.70

(Means with the same letter in column for fresh biomass yield and dry matter based to 50% flowering stage are not significantly different P<0.05) FBY = Fresh biomass yield (t/ha), DMY = dry matter yield (t/ha), SE = standard error, g= gram, LSD = least significance difference and CV = Coefficients of variance.

The mean value of tasted species biomass yield and other agronomic traits measured were presented in Table 1 and 2 . There were significant difference (P < 0.05) in fresh biomass yield (FBY) and dry matter yield (DMY) production potential between among the *Lablab purpureus, Lablab intoritum and Vigna unguiculata* in the trial peasant association (Table 1). The average fresh biomass yield potential of tested species in to the study area were 20 t/ha, 14.84 t/ha and 12 t/ha respectively for *Lablab purpureus, Lablab intoritum and Vigna unguiculata* which attested that *Lablab purpureus* produced higher fresh biomass than *Lablab intoritum and Vigna unguiculata*. On the other hand conversely, the *Lablab intoritum* is better yielder than *Vigna unguiculata* in the current study. Meanwhile, on the other hand, the dry matter yield (DMY) obtained in this study was revealed that there were also significance difference (P < 0.05) among the *Labalab purpureus, Lablab intoritium and Vigna unguiculata in the study area (*Table 1).

The dry matter production potential of the tasted species to the study area is 7. 2 t /ha, 4.5 t/ha and 6.8 t /ha for *Labalab purpureus, Lablab intoritum and Vigna unguiculata.* The result obtained from this study in the case of *Lablab purpureus* was not corroborated to what Denbela et al. (2015) reported that *Lablab purpureus* produced on average 4.5t/ha at kako trial location and also Amodu *et al*. (2005) reported that Lablab *purpureus* produced dry matter range 4.5 to 4.9 t/ha in November at a location in the Northern part of Nigeria. On the other hand, result obtained in the current study for lablab purpureus corroborated to what Cameron (1988), Mayer et al. (1986) and Alemayehu (2003) reported that it can produced dry matter yield on average 3-5 t/ha in lowland area of Ethiopia. The variability in dry matter yield production might be attributed variability in rainfall, Soil fertility, Agro ecological location and pastoralist adopted management practice (Cameron, 1988; Mayer *et al*., 1986). On the other hand, the dry matter yield obtained from the *Vigna unguiculata* in current study is not corroborated with previous finding reported by Geleti et al. (2014) which indicated that the dry matter yield on average for *Vigna unguiculata* accession grown under rain fed condition ranges from the 10. 74 – 12.57 t/ha. However, it also controversial to what Bilatu et al. (2012) reported which indicated that value obtained in our current study higher dry matter yield (2 t/ha) than what they reported. Likewise, the variation source for dry matter yield b/n our current study *when it was compared with Bilatu and others finding* for *Vigna unguiculata,*which *might* be variation in accession potential which was reported by Anele UY. et al.(2011a) and Rivas -Vega et al.(2006) or it might be seasonal, agro ecological and soil variations (Anele UY. et al. , 2011a ; Anele UY. et al., 2011b) or other factors like trial pastoralists management.

Table 2 : The growth potential of tested species in study area in 2014 cropping season

Species	PH(cm) ± SE	Number of leaf at 4 week ±SE	Number of leaf at 8 week ±SE	Date of germination ± SE	Days t o 50% flowering ±SE
Lablab purepureus	67±0.75[a]	12±0.43[a]	17±0.67[c]	5.23±0.23[a]	48.5±0.89[a]
Lablab Intoritum	80±0.7[b]	8.5±0.43[b]	12±0.67a	5.65±0.23[a]	85.4±0.89[b]
Vigna unguiculata	69.5±0.75[a]	10±0.43[a]	15±0.6[b]	6.7±023[a]	45.8±0.89[a]
LSD 0.05	5.80	7.45	12.32	1.55	25.45
CV (%)	3.70	6.80	6.34	5.25	8.87

(Means with the same letter in a column for each steam and leaf height base are not significantly different at α = P<0.05LSD = least significance difference, CV = Coefficients of variance cm = centimeter, PH = plant height and SE =Standard error

Pertaining to the result obtained in this study on plant height depicted that there were significant difference (P < 0.05) between the *Lablab intoritum* and *Lablab purpureus* and also *Lablab intoritum* and *Vigna unguiculata presented* (Table 2). However, there was none significance difference (P > 0.05) between *Lablab*

Purpureus and *Vigna unguiculata* at 8 week. The plant height recorded for the *Lablab species* was 67±0.75 - 80±0.75 cm at 50 % (8th weeks) which was lower than the value reported by different authors such as M. R. Hassan et al. (2014) (161cm), Yusufali (2005) (150cm) and Omokanye et al. (2000) and Adesoji et al. (2013) (229cm). Meanwhile, the height growth in length obtained for *Vigna unguiculata* in this study revealed that *Vigna unguiculata grown similar to the lablab purpureus not lablab intoritium and* however, it was in line with earlier study that reported by I.A. Ekpo.et al.(2012) . The leaf part of forage very important due to leaf contained better crude protein content and low in structural carbohydrate than any other part (fraction) of forages and played significant role to rumen microbe (Van Soest, 1994). Legumes forges with high biomass of leaf would seem to be those of highest nutritional value (Norton and Poppi, 1995). Therefore, the result on the number of leaf (leaf biomass) per tested species demonstrated that the number of leaf differs significantly ($p< 0.05$) at fourth week of growth period between *Lablab Purpureus* and *Lablab intoritum*, *Lablab intoritum* and *Vigna unguiculata* presented in Table 2. However, on the other hand, the number of leaf count b/n *Lablab Purpureus and Vigna unguiculata* was not significantly differ ($P > 0.05$). The values for number of leaves of experiential in this study on average at 4th week were 12±0.43, 8.5±0.43 and 10±0.43 respectively for Lablab *purpureus, Lablab intoritium* and *Vigna unguiculata.* The value obtained in our current study for *Lablab purpureus* was in line with previous finding reported by Adesoji et al. (2013) at 6 week and however lower than what M. R. Hassan et al. (2014) reported under irrigated condition after sowing in Samaru and the slightly increase in when the week at 8 week (18±0.67, 12±0.67 and 15±0.60) which were higher than the values that reported by M. R. Hassan et al. (2014) at 9 week after sowing under rain-fed conditions. On the other hand, understanding at what stage of forage development is important for harvesting forage with good quality in order to boost the livestock production. One of the important stage is to be advised to farmers/pastoralist to harvest forage is when forage has been started blooming up to 50%, this is due to forage at 50% blooming characterized by high nutrient composition. Therefore, it is highly important to evaluate the exact days of the 50% blooming stage of tested species in order to quantify the dry matter production potential of tested species in to the testing environment, which is noticed that when the forage species are not harvest at appropriate stage it is associated with a decrease in the nutrient content, digestibility, and subsequent nutritional value of the forage. As a plant matures the contents of water, protein, nonstructural carbohydrates, minerals, and vitamins decrease. The current study declared that the there were significant difference ($P < 0.05$) was observed in the days to 50% flowering (blooming) between *Lablab intortum* and *Lablab purpureus*, *Lablab intortum* and *Vigna unguiculata*. However, there is none significance difference ($P > 0.05$) was observed between *Lablab purpureus* and *Vigna unguiculata* presented in Table 2. The first species flowered was *Vigna unguiculata* and *Lablab purpureus* with mean of 45.8 and 48.50 days respectively and which is not corroborated to what Fassil Berhe (2014) reported that *Vigna unguiculata bloomed at 50% within 53 days and whereas, Lablab purpureus was bloomed within 64 days. This is may be attributed due to variation in species* is a fast growing potential (Mark and Paul, 2007) or environmental variation (Anele UY. et al. , 2011a ; Anele UY. et al. , 2011b). While *Lablab intoritum* flowered last with a mean of 85.40.

VII. Conclusion and Recommendation

The current study revealed that the tested improved legume species well performed and adapted to tested Agro ecology with yielded both high fresh and dry matter. The Lablab purpureus (7.2 t/ha) and *Vigna unguiculata* (6.80t/ha) were produced highest dry matter yield and highly important to study area than Lablab intoritum which was produced 4.50 t/ha which was less important to the study area in term of dry matter production potential. The result reported in the current study is from data of one year cropping season. However, for the forage species yields may be variable in other seasons. Likewise, the further research should be conducted to identify their feeding value under different intervention, chemical composition and their response to the disease and pest resistance. Moreover, pastoralists' perceptions need to be studied to incorporate local technical knowledge in future forage varieties evaluation trials and to confirm suitability of the varieties under farmer circumstances. The information obtained would benefit in promotion of the forage varieties in wider scale (through pre-scale-up programs).

VIII. Acknowledgment

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References Références Referencias

1. Adesoji, A. G., Abubakar, I. U., Tanimu, B., & Labe, D. A. (2013). Influence of Incorporated Short Duration Legume Fallow and Nitrogen on Maize, American-Eurasian Journal of Agricultural & Environmental Science, 13(1), 58-67.
2. Amodu, J. T., Adamu, A. M., Adeyinka, I. A., Alawa, J. P., & Jagede, J. O. (2005). The nutritive value of Laboratory ensiled Lablab (Lablab purpureus) and millet (Pennisetum americanum). Tropical Grasslands, 39(2), 117-123.
3. Alemayehu Mengistu (2003). Pasture and forage resource profiles of Ethiopia. EDM printing Press, Addis Ababa, Ethiopia.
4. Anele UY, Sudekum KH, Hummel J, Arigbede OM, Oni AO, Olanite JA, Bottger C, Ojo VO and Jolaosho AO (2011a). Chemical characterization, in vitro dry matter and ruminal crude protein degradability and microbial protein synthesis of some cowpea (Vigna unguiculata L. Walp) haulm varieties. Anim. Feed Sci. Tech., 163: 161-169. 18.
5. Anele UY, Sudekum KH, Arigbede OM, Welp G, Adebayo OO, Jimoh AO and Olubunmi VO (2011b). Agronomic performance and nutritive quality of some commercial and improved dual-purpose cowpea (Vigna unguiculata L. Walp) varieties on marginal land in Southwest Nigeria. Grassland Sci., 57: 211-
6. Bilatu Agza, Binyam Kasa, Solomon Zewdu, Eskinder Aklilu and Ferede Alemu(2007). Animal feed potential and adaptability of some cowpea(Vigna unguiculata) varieties in North West lowlands of Ethiopia.
7. Bennet-Lartey S. O. and Ofori I. 1999. Variability studies in some qualitative characters of cowpea (*Vigna unguiculata* (L.) Walp) accessions from four cowpea- growing regions of Ghana. Ghana J. Agric. Sci. 32: 3-9.
8. Cameron, D G (1988). Tropical and subtropical pasture legumes. Queensland Agricultural Journal. March-April: 110-113
9. CSA (Central Statistical Agency)(2015). Agricultural sample survey, Report on livestock and livestock characteristics, Statistical Bulletin 532, Addis Ababa, Ethiopia.
10. Denbela Hidosa, Bizuayehu Ayele and Mesifin Mengistu(2015). Participatory On - Farm Evaluation and demonstration of improved Legume Forage Species in Benatsemay Woreda of South Omo Zone, Southern Agricultural Research Institute, Jinka Agricultural Research Center, and P. O. Box 96 Jinka, Ethiopia.
11. Duguma B., Tegegne A and Hegde B. P. (2012). Smallholder livestock production system in Dandi district, Oromia Regional State, Central Ethiopia. Global Veterinaria 8(5):472–479.
12. FAO (2009). Production yearbook. Rome: Food and Agricultural Organization of the United Nations.
13. Mengistu, A. (2002). Forage production in Ethiopia: A case study with implication for livestock production. Ethiopian Society of Animal Production (pp. 1–125). Addis Ababa, Ethiopia:
14. Mengistu, A. (2006). Country pastures / forage resource profiles, Ethiopia. FAO, 1–36.
15. Galmessa U., Dessalegn, J., and Tola, A. (2013). Dairy production potential and challenges in Western Oromia milk value chain, Oromia, Ethiopia. Journal of Agriculture and Sustainability 2(1): 1–21.
16. Gebremedhin B., Pender J. and Tesfay G. (2004).Collective action for grazing land management in crop–livestock mixed systems in the highlands of northern Ethiopia. Agricultural Systems 82(3): 273–290.
17. Geleti D., Hailemariam M., Mengistu A. and Tolera A.(2012). Characterization of Elite Cowpea (Vigna Unguiculata L. Walp) Accessions Grown Under Subhumid Climatic Conditions of Western Oromia, Ethiopia: Herbage and Crude Protein Yields and Forage Quality.
18. Hendricksen, R. E. and D. J. Minson, 1985. Growth, canopy structure and chemical composition of Lablab purpureus cv. Rongai at Samford, S. E. Queensland. Tropical Grasslands, 19: 81-87.
19. Mayer L, Chandler D R and Taylor MS 1986 Lab-lab purpureus - A fodder crop for Botswana. Bulletin of Agricultural Research in Botswana No. 5:37-48.
20. M. R. Hassan , J. T. Amodu, I. R. Muhammad, G. E. Jokthan, S. B. Abdu1, B. Abdullahi1, H. Y. Adamu1, A. Musa5, I. Sani1 & T. T. Akpensuen (2014). Forage Yield and Quality of Lablab (Lablab purpureus L. Sweet) Intercropped with Maize (Zea mays L.) With Flooded Irrigation System in the Semi-Arid Zone of Nigeria.
21. Ørskov, E.R., 1998. Feed evaluation with emphasis on fibrous roughages and fluctuating supply of nutrients: A Review. Small Rumin. Res. 28, 1–8.
22. Seyoum, Bediye, Zinash, Sileshi. 1995. Chemical composition, in vitro digestibility and energy values of Ethiopian feedstuffs. Third National Conference of Ethiopian Society of Animal Production (ESAP). Addis Ababa, Ethiopia. 27–28 April 1997, 307–311 pp.
23. Tolera, A., 2007. The role of forage supplements in smallholder mixed farming systems. In: Hare, M.D., Wongpichet, K. (Eds.), Forages: A Pathway to Prosperity for Smallholder Farmers. Proceedings of an International Forage Symposium, Faculty of Agriculture. Ubon Ratchathani University,Thailand, pp. 165–186.

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Sero-Prevalence of Bovine Foot and Mouth Disease in Selected Districts of Eastern Showa Zone, Oromia Regional State, Ethiopia

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Abstract- A cross-sectional study was conducted from September 2014 to July 2015 with the objective of determining sero-prevalence of Foot and Mouth Disease (FMD) in cattle in selected districts of Eastern Showa Zone, Oromia Regional. Blood samples were collected from a total of 634 cattle at Export abattoir, Veterinary Clinics in and around Bishoftu town of Adaa district and Bull screening quarantine station in Adama. The study animals were selected by systematic random sampling and blood samples were collected from jugular vein using sterile vacutainer tube. The blood samples were submitted to the National Veterinary Institute (NVI), and the serum were harvested and processed by using 3ABC-ELISA technique. The current study indicated the overall sero-prevalence of bovine FMD was 10.88% and statistically there were differences (P=0.002) in sero positivity of FMD among animals from Abattoir, Veterinary clinic and Feedlot. The sero-prevalence was higher in animals tested from export abattoirs than those from Feedlot and Clinics.

Keywords: *bovine, FMDV, sero-prevalence, ethiopia, 3ABC-ELISA.*

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Sero-Prevalence of Bovine Foot and Mouth Disease in Selected Districts of Eastern Showa Zone, Oromia Regional State, Ethiopia

Dinaol Belina [α], Yimer muktar [σ], Birhanu Girma [ρ] & Shimelis Mengistu [ω]

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Keywords: bovine, FMDV, sero-prevalence, ethiopia, 3ABC-ELISA.

I. Introduction

FMD is one of the major endemic trans-boundary livestock diseases of socioeconomic importance in Ethiopia. It is highly contagious viral disease of both domestic and wild cloven-hoofed animals (FAO 2007). FMD is caused by virus of the genus Aphtho virus which belongs to the family picornaviridae (Shao et al 2010). There are seven serotypes of the virus namely: A, O, C, SAT-1, SAT-2 SAT-3 and Asia 1. Within serotypes, many subtypes identified by biochemical and immunological tests (OIE 2004) and infection with one serotype does not confer immune protection against another. The serotype O, A and C have had the widest distribution in the world (Rweyemamu et al 2008) and serotype A, O, C and SAT_2 are identified and reported from Ethiopia (Gelaye et al 2005).

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The disease has a high morbidity although mortality is rare in adult animals. However, myocarditis may occur in young animals resulting in death. The recovered animals remain in poor physical condition over long periods leading to economic losses for livestock industries (Sangare 2002). The economic importance of the disease is not only due to production loss, but also because of restrictions on the local and international animal trade (James and Rushton 2002).

The transmission of FMD is primarily occurs via respiratory aerosols and direct or indirect contact with infected animals. Aerosol transmission requires proper temperature and humidity. However, in FMD endemic countries, both the respiratory and oral routes are considerably important. Cattle and sheep may be source of the virus up to 5 days before they develop the clinical signs. Small ruminants mostly develop silent or clinically in-apparent infection and play important role in epidemiology or spread of FMD to cattle, (Radostits et al 2000). In addition to live animals, shipment of untreated meat and meat products, milk and semen from infected animals are also factor for FMD virus transmission. The FMDV can survive for 1-2 days in the human respiratory tract, thus potentially spreading to animals (Asseged 2005). Contact with contaminated fomites such as boots, glove, and clothes can also be a source of infection (Sahle 2004).

After initial replication in cornfield epithelia the virus enters the bloodstream through regional lymph nodes (Alexandersen et al 2003). When susceptible animals are in contact with clinically infected animals, clinical signs usually develop in 3 to 5 day (Kitching, 2002). Most of the time virus vesicles develop at skin and mouth than other organs during the acute phase of the disease and rupture, usually within 48 hr. The viremia persists for 4–5 days (Alexandersen et al 2001). The severity of clinical signs of the disease varies with the strain of the virus, the exposure dose, the age, and the breed of the animal, the host species, and its degree of immunity.

In cattle clinical sign of FMD include fever, dullness, anorexia and fall in milk production followed by oral lesion such as vesicle on the tongue, dental pad, gums, soft palate, nostrils or muzzle that lead to excess salivation, drooling and serous nasal discharge. Teat lesion can occur and cause a decrease in milk

production, and hoof lesion in the inter-digital space and on the coronary band are leading to lameness (Sahle 2004).

In Ethiopia, Understanding of the geographic distribution of the disease and serotypes of FMD the virus involved are among important in puts required to initiate control program, furthermore, lack of awareness of the intermediary cattle dealers regarding the risk and the relatively short distance between production and feedlot locations makes the feedlots particularly vulnerable to the introduction of the disease without diagnosis. In general in Ethiopian the current traditional livestock management with uncontrolled movement of animals, attributes to FMDV spread (Megersa et al 2009). Extensive movement of livestock, the high rate of contact among animals in communal grazing areas, watering points and at commercial markets in Ethiopia is major transmission and dissemination factor (Bayissa and Bereda 2009). Different papers were published on FMD in different area of the country but there is no recent published data from the export abattoir and Veterinary Clinics or feedlot of Eastern Showa, particularly in the Bishoftu and Adama cities. Therefore, this study was designed to investigate the Sero-prevalence of bovine FMD from abattoir, veterinary clinic and feedlot in Adaa district and Adama special zone of Eastern Showa zone in Oromia.

II. Materials and Methods

a) Study Area

The study was conducted in selected Abattoirs and Veterinary Clinics in and around Bishoftu and Bull screening quarantine station (for feedlot) in Adama of East Showa zone. Bishoftu and Adama the two main towns of east Showa zone located to the South East of Addis Ababa. Because of closeness to Addis Ababa in both cities there are huge investments on feedlot and dairy activities and also export abattoirs. Bishoftu of the Adana district has an altitude of 1, 860 m.a.s.l. with an average annual rainfall of 866 mm. It has a bimodal rainy seasons; a main rain season extends from the month of June to September and a short rain season from March to May. The annual average minimum and maximum temperature is 11°C and 26°C respectively. Humidity is about 61.3%. Though those animals from Adama feedlot were originally from different parts of the country they were tested after they stayed a minimum of two months at the screening station. Adama the special zone is located at 8°32`N 39 ° 16`E at elevation of 1712m a.s.l. The City sits between the base of an escarpment to the west, and the Great Rift Valley to the east. Adama has a tropical climate of wet and dry season (NMSA, 2011).

b) Study Animals

The study animals were cattle selected from abattoir and veterinary clinics in and around Bishoftu of Adaa, and Bulls screened for export at screening quarantine station in Adama feedlot. Both sexes and different age groups were included the age groups were considered as (≤4years) Young, (4years<x< 10years) Adult and (≥10 years) Old.

c) Study Design

A cross-sectional study was undertaken from November 2014 to July 2015. During the laboratory work, a total of 634 sera samples collected from abattoir, veterinary clinics and feedlot station were examined by using 3ABC ELISA for the detection of FMD antibodies in Selected districts of eastern Showa Zone of Oromia Region.

d) Sample Size Estimation

The sample size was determined according to the formula given by Thrusfield (2005), by considering 14.5% (Alemayehu et al 2014) previous prevalence and absolute desired precision of 5% at confidence level of 95%.

$$n = \frac{1.96^2 pexp\ (1\text{-}pexp)}{d^2}$$

Where: n= sample size, Pexp= expected prevalence=14.5%, d= absolute precision of 5%.

Accordingly the sample size was 191; however, in order to increase precision of the study it was raised by 3.3 folds and a total of 634 animals were included in the study.

III. Study Methodology

a) Sample collection

A total of 634 blood samples were collected from Abattoir, Veterinary clinic and Adama feedlot by using systematic random sampling method. Blood sample was collected from jugular vein of individual animals by using 10 ml of sterile vacutainer tube and labeled with specific field code. Then the blood was allowed to clot by placing it overnight at room temperature. Then the samples were transported to the National Veterinary Institute (NVI) Laboratory by using an icebox for serological examination. The sera sample then stored at - 20°c until laboratory investigation.

b) Serological test

The serological test was conducted for the Sero-prevalence of FMD by using the 3ABC-ELISA. The 3-ABC-ELISA was used according to the manufacturer's instructions. Briefly, the serum was diluted 1/100, added in duplicate to the wells of a 96-well micro-titer plate pre-coated with the vector-expressed viral 3ABC antigen, and incubated for 60 min at 37°C in a humid chamber. Unbound antibody was washed away, and a horseradish peroxidase-labeled guinea pig anti-bovine immunoglobulin G conjugate was added. Unbound conjugate was removed by washing, and the substrate was added and incubated until the difference in the

optical density (OD) reading between the negative and positive controls become greater than or equal to 0.4 (after about 20 min). The OD was determined for each well at 405 nm with an automatic ELISA reader.

c) Data Analysis

Data was entered in to Microsoft Excel and analyzed by using SPSS version 20.0 statistical software. Prevalence differences of the study variables (infection rate, age, sex, geographic origin of the animals and group of animal from which sample collected were analyzed by chi- square and descriptive statistics. A statistically the difference was considered significant when the calculated p-value is less than 0.05 at 95% confidence level.

IV. Results

Out of 634 sera tested using 3ABC ELISA 69 (10.88%) animals were sero-positive for bovine FMDV. The highest prevalence was recorded in animals from export abattoirs (15.5%) whereas the lowest sero-prevalence was recorded in animals from Clinics. Animals from abattoir were found to be more affected than feedlot and Vet. Clinic groups of animals the difference was statistically significant (P=0.002) (Table 1).

Table 1 : Sero-prevalence of FMD in cattle of different groups of the study animals

Animal group	№ of examined	№ Positive (%)	χ^2 (P-Value)
Feedlot	250	17 (6.8)	
Abattoir	303	47 (15.5)	12.843 (0.002)*
Vet. Clinic	81	5 (6.17)	
Total	**634**	**69 (10.88)**	

* Statistical significant

The prevalence of bovine FMD was statistically insignificant among different age groups (P=0.41), Sex (P=0.85) geographical origin (P=0.45) of the study animals (table 2 and 3).

Table 2 : Sroprevalence of FMD in cattle of different age and sex groups

Variables	levels	№ of examined	№ Positive (%)	χ 2 (P-value)
Age	Young	320	30 (9.37)	1.79 (0.41)
	Adult	248	32 (12.90)	
	Old	66	7 (10.60)	
	Total	**634**	**69 (10.88)**	
Sex	Male	623	68 (10.90)	0.04 (0.85)
	Female	11	1 (9.10)	
	Total	**634**	**69 (10.88)**	

Table 3 : Seroprevalence of FMD in cattle of different origin

Variables	Levels	№ of examined	№ Positive (%)	χ 2 (P-value)
Origin	Borena	369	45(12.20)	3.66 (0.45)
	Harar	33	3(9.10)	
	Wallo	44	3(6.80)	
	Bishoftu	82	5(6.10)	
	Adama	106	13(12.26)	
	Total	**634**	**69(10.88)**	

V. Discussion

The present study showed that, the overall sero-prevalence of bovine FMD was 10.88% which was comparable with the findings of Gelaye et al (2009), who reported 12.05% in the Bench Maji zone, Southern Ethiopia, Molla et al (2010), who reported 8.8% in South Omo Zone and Megersa et al (2009), who reported 9.5% in indigenous cattle in Southern Ethiopia. On other hand, the sero-prevalence of bovine FMD in this study was lower than the findings of Rufael et al (2008), who reported 26.5% from Borena pastoral system, Southern Ethiopia, Mekonnen et al (2011), who reported 24.6 % in Borena and Guji Zones, Tesfaye (2006), who reported

21% in Borena pastoral area. This variation of sero-perevance of bovine FMD reported from the different area of the country by different researcher might be due to variation in management system, intervention and agro-climatic condition. However, the sero-prevalence of bovine FMD reported in this study was higher when compared to the previous findings of Bedru (2006), 5.53%, on quarantined bulls for export at Nazareth and Dire Dawa stations; Jenberie (2008), 5.6%, from Afar Regional State and Abunna et al (2013), reported 8.01% from Dire Dawa and its surroundings, Eastern Ethiopia.

In the current study, age group was also considered as risk factor for Sero-prevalence of bovine FMD and the result showed age was statistically insignificant (P= 0.41). This result agreed with the findings of Gelaye et al (2009), who reported no significant association between bovine FMD and age of cattle. This might be because of unequal involvement of different age groups in our sampling where majority of our study animals were young animals due to accessibility. However, contradicting our present finding Mohamoud et al (2011), Molla et al (2010), Gebretsadik (2009) and Kibore et al (2013), reported from different geographical areas that sero-prevalence of bovine FMD was statistically associated with the age of animals. Radostits et al (2000), indicated that young animals are relatively more susceptible than adult animals even though, the present study indicated that higher sero-prevalence in adult (between 4 and 10 years age) than both young (≤4years) and old (≥10years) (table: 2). This variation might be because of the adults and old cattle were acquired the infection through repeated exposure to the different serotypes of the virus and close contact with other animals due to uncontrolled animal movement at market place and communal pasture grazing area, however, young cattle were herded around homesteads and hence may have less chance of exposure to the virus and additionally the prevailing passive maternal immunity may give them protection against the disease (Megersa et al 2009).

The previous findings of Mohamoud et al (2011), in Awbere and Babille districts of Jijiga zone, Somalia Regional State, Eastern Ethiopia; Gelaye et al (2009), from Bench Maji zone, southwestern Ethiopia and Megersa et al (2009), in indigenous cattle in Southern Ethiopia indicated there is no significant difference between sexes in sero-prevalence of FMD in cattle. Supporting these findings our present study also showed statistically no significant difference between sexes in sero-prevalence of bovine FMD (table 2). However, Hailu et al (2010), reported from northwest part of Ethiopia that the incidence of sero-prevalence of bovine FMD was statistically higher in females than in male in cattle. In our present study such variation might be resulted from a very small female to male sampling ratio.

In the current study, though there was no statistical difference (P= 0.45) in sero-prevalence of bovine FMD among the origins of animals, the highest sero-prevalence was found in animals from Borena (12.2%) than animals came from Adama, Harar, Walo and Bishoftu. This might be due to the fact that Borena is found in pastoral area where animal movement is highly uncontrolled. Attributing to this finding Megersa et al. (2009), also reported sero-prevalence of bovine FMD was higher in animals originated from pastoral areas in Ethiopia. The variation in the sero-prevalence of bovine FMD in relation to the origin of animals in this study might be due to differences in animal's production and management system at their geographical origins and also due to the uncontrollable movement of cattle from one border of the country to other border of the country.

The difference in prevalence among the group of animals where sample were collected was statistically significant (P= 0.002) (table1). The highest prevalence was recorded in animals from Abattoirs (15.5%) and the lowest prevalence was recorded in animals from Clinics (6.17%). This variation might be due the fact that animals brought to export abattoirs and feedlot were come from different geographical areas of the country where there was a chance of contact among animals from different zones and districts whereas animals brought to the Clinic come from kebeles surrounding or nearby the study areas.

VI. Conclusion and Recommendations

The present study indicated that, the overall sero-prevalence of bovine FMD at the study area was 10.88%. The highest sero-prevalence was found in cattle slaughtered at abattoirs in Bishoftu than animals include in the study from Veterinary Clinics, and Adama feedlot. Age, sex and origin of the animals were statistically insignificant with sero-prevalence of bovine FMD. The occurrence of bovine FMD in the study area may cause restriction on the trade of animals and animal products internationally. Therefore, Special attention should be given to those areas with higher sero-prevalence of bovine FMD by designing appropriate control measure, including vaccination and restriction of animal movements to minimize further transmission of the disease, animals brought to export abattoirs and feedlots from different localities have to be transported separately in accordance with their geographic origins and further study on FMD virus distribution and transmission should also be conducted.

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References

1. Abunna F, Fikru S and Rufael T 2013 Sero-prevalence of Foot and Mouth Disease (FMD) at Dire Dawa and Its Surroundings, Eastern Ethiopia. Global Veterinaria, 11 (5): 575-578 http://idosi.org/gv/gv11(5)13/13.pdf.
2. Alemayehu G, Zewede G and Admassu B 2014 Sero-prevalence of foot and mouth disease and associated economic impact on central Ethiopia cattle feedlot, Journal of Veterinary Medicine and Animal Health. 6 (5): 154-158. http://www.academicjournals.org/journal/JVMAH/article-full-text-pdf/9F0BA5543875
3. Alexandersen S, Oleksiewicz M B and Donaldson A I 2001 The early pathogenesis of foot-and-mouth disease in pigs infected by contact: A quantitative time course study using Taq Man RT-PCR, Journal General Virology, 82 (4): 747–755. http://jgv.microbiologyresearch.org/content/journal/jgv/10.1099/0022-1317-82-4-747.
4. Alexandersen S, Zhang Z, Donaldson A I and Garland A J 2003 Review the pathogenesis and diagnosis of foot-and-mouth disease. Journal of Comparative Pathology, 129: 1-36.
5. Asseged B 2005 Review of foot and mouth disease. An in depth discourse of Global, Sub-Saharan and Ethiopian status; Addis Ababa university faculty of veterinary medicine, Research and Graduate studies. Debre Zeit, Ethiopia, Pp 3-49.
6. Bayissa B and Bereda A 2009 Assessment of Veterinary Service Delivery, Livestock Disease Reporting, surveillance systems and prevention and control measures across Ethiopia/Kenya Border. Enhanced Livelihoods in Southern Ethiopia (ELSE) project. CIFA Ethiopia/CARE Ethiopia.
7. Bedru H 2006 Sero-prevalence study of foot and mouth diseases in export bulls of Borena and Jimma origin, Ethiopia. DVM thesis, Faculty of Veterinary Medicine, Addis Ababa University, Bishoftu, Pp: 18
8. FAO 2007 EMPRES and EUFMD commission. Foot and Mouth Disease distribution worldwide and major epidemiological event in 2005-2006. FAO animal health manual, 1: 1-9.
9. Gebretsadik Z 2009 Study of seroprevalence of foot and mouth disease in Tigray Regional state, Northern Ethiopia. DVM thesis, Faculty of Veterinary Medicine, Haramaya University, Ethiopia. Pp: 12.
10. Gelaye E, Ayelet G, Abera T and Asmare K 2009 Seroprevalence of foot and mouth disease in Bench Maji zone, Southwestern Ethiopia. J Journal of Veterinary Medicine and Animal Health, 1 (1): 005-010. http://www.academicjournals.org/journal/JVMAH/
11. Gelaye E, Beyene B and Ayelet G 2005 Foot and Mouth Disease in Ethiopia, Ethiopia. Veterinary Journal, 9 (1): 75-80.
12. Hailu M, Mengistie T, Negussie H, Alemu S and Asaminew T 2010 Incidence of foot and mouth disease and its effect on milk yield in dairy cattle at Andassa dairy farm, Northwest Ethiopia. Journal of Agricultural and Biological Science. 1: 969-973.
13. James A D and Rushton J 2002 The economics of foot and mouth disease. Revue scientifique et technique-office international des epizooties, 3: 637-644.
14. Jenberie 2008 Participatory epidemiology and sero-prvalence of foot and mouth diseases in Afar pastoral region, Ethiopia, MSc thesis, Faculty of Veterinary Medicine ,Addis Ababa University, Bishoftu, unpublished, Pp: 15-20.
15. Kibore B, Gitao C G, Sangula A and Kitala P 2013 Foot and mouth disease sero-prevalence in cattle in Kenya. Journal of Veterinary Medicine and Animal Health, 5(9): 262-268. http://www.academicjournals.org/journal/JVMAH/article-full-text-pdf/
16. Kitching R P 2002 Clinical variation in foot and mouth disease: Cattle. OIE Scientific and Technical Review, 2 (3): 513-517.
17. Megersa B, Beyene D, Abunna F, Regassa A, Amenu K and Rufael T 2009 Risk factors for foot and mouth disease seroprevalence in indigenous cattle in Southern Ethiopia: the effect of production system. Tropical Animal Health Production, 41 (6): 891-8. http://link.springer.com/journal/11250/41/6
18. Mekonnen H, Beyene D, Rufael T, Feyisa A and Abunna F 2011 Study on the prevalence of foot and mouth disease in Borana and Guji Zones, Southern Ethiopia. Veterinary World, 4 (7): 293-296. http://www.veterinaryworld.org/Vol.4
19. Mohamoud A, Tessema E and Degefu H 2011 Seroprevalence of bovine foot and mouth disease (FMD) in Awbere and Babille districts of Jijiga zone, Somalia Regional State, Eastern Ethiopia. African Journal of Microbiology Research, 5 (21): 3559-3563.http://www.academicjournals.org/journal/AJMR/article-full-text-pdf/025A68E13323
20. Molla B, Ayelet G, Asfaw Y, Jibril Y, Ganga G, and Gelaye E 2010 Epidemiological Study on Foot-and-Mouth Disease in Cattle: Seroprevalence and Risk Factor Assessment in South Omo Zone, South-western Ethiopia. Trans-boundary and Emerging Disease, 57 (5): 340 347.
21. NMSA 2011 National Metrological Service Agency. East showa branch, A. Report. Pp. 11-19.
22. OIE 2004 Manual of diagnostic tests and vaccines for testerial animals (mammals, birds, bees). 5ed.OIE, Paris, France Volume I Pp. 111-128.
23. Radostits O M, Gay C C, Blood D C, Hinachcliff K W 2000 Veterinary medicine, a textbook of the

diseases of cattle, sheep, goats, pigs and horses, foot and mouth Disease,9th ed., California, Elsevier, Pp: 1059-1064.
24. Rufael T, Catley A, Bogale A, Sahle M and Shiferaw Y 2008 Foot and Mouth Disease in Borana Pastoral system, Southern Ethiopia. Tropical Animal Health and Production, 40 (1): 29 38. http://link.springer.com/journal/11250/40/1.
25. Rweyemamu M, Roeder P, Mackay D, Sumption K, Brownlie J, Leforban Y, Valarcher J F, Knowles N J, Saraiva V 2008 Epidemiological patterns of foot-and-mouth disease worldwide. Trans-bound Emerging Diseases, 55: 57-72.
26. Sahle M 2004 An epidemiological study on the genetic relationships of foot and mouth disease viruses in east Africa. University of Pretoria, South Africa, Pretoria, PhD Thesis. Pp: 84-107.
27. Sangare O 2002 Molecular epidemiology of foot-and-mouth disease virus in West Africa. PhD thesis, University of Pretoria, South Africa, Unpublished.
28. Shao J, Hui-Yun C, Guang-Qing Z, Guo-Zheng C, Jun-Zheng D, Tong L, Shan-Dian G, Ji-Jun H, Xiang-Tao L, Ji-Xing L and Jin-Liang G 2010 Rapid Detection of Foot-and-Mouth Disease Virus by Reverse Transcription Loop-mediated Isothermal Amplification (RT-LAMP) Journal of Applied Research in Veterinary Medicine 8 (2): 133-140. http://www.jarvm.com/articles/Vol8Iss2/.
29. Tesfaye R 2006 Participatory Appraisal and Seroprevalence study of FMD in Borana Pastoral system, southern Ethiopia, MSc Thesis, Faculty of Veterinary Medicine, Addis Ababa University, Bishoft, Ethiopia.
30. Thrusfield M 2005 Veterinary Epidemiology. 2ed, UK, Blackwell Sci. Pp. 228-247.

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Impact of Boloso-1 Taro Production on Livelihood Security of Farming Communities in Kindo Koyisha and Duguna Fango Woredas, Wolaita Zone

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Abstract- Root crops in general and taro in particular are the main food crop, the only and livelihood dependant highly productive and multifunctional crop that used for as livestock feed supplement and human food item in southern Ethiopia, but its role in food and nutritional security had not been studied and well documented, consequently less attention was given in development agenda of the country. Hence, the study was aimed to undertake investigation in livelihood role Improved taro variety that helps in generation information on role of improved taro for farming communities in the district. The study was undertaken in Kindo koisha Woreda and Duguna Fango Woreda of Wolaita zone Administrative. The study revealed that the contribution of taro on the overall livelihoods of the beneficiaries is significantly high. The impact of Boloso-1-Taro ranges from saving life to reduction of migration and school dropout rates. It has also diversified income for the beneficiary farmers in general and able to generate income from selling taro production that empowered women and changed the family's living status.

Keywords: *bolos 1 taro, food crop, livelihood, productive.*

GJSFR-D Classification : *FOR Code: 070199*

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Impact of Boloso-1 Taro Production on Livelihood Security of Farming Communities in Kindo Koyisha and Duguna Fango Woredas, Wolaita Zone

Zekarias Bassa [α], Bereket Zeleke [σ], Tessema Erchafo [ρ] & Ashenafi Mekonin [ω]

Abstract- Root crops in general and taro in particular are the main food crop, the only and livelihood dependant highly productive and multifunctional crop that used for as livestock feed supplement and human food item in southern Ethiopia, but its role in food and nutritional security had not been studied and well documented, consequently less attention was given in development agenda of the country. Hence, the study was aimed to undertake investigation in livelihood role Improved taro variety that helps in generation information on role of improved taro for farming communities in the district. The study was undertaken in Kindo koisha Woreda and Duguna Fango Woreda of Wolaita zone Administrative. The study revealed that the contribution of taro on the overall livelihoods of the beneficiaries is significantly high. The impact of Boloso-1-Taro ranges from saving life to reduction of migration and school dropout rates. It has also diversified income for the beneficiary farmers in general and able to generate income from selling taro production that empowered women and changed the family's living status. Hunger and complete poverty has been eradicated from the project sites mainly due to taro intervention. The study also confirmed that the improved taro variety played a significant role in price stabilization in the district, which justified by the market price reduction of common food crops after intervention in the district. Taro overrides most common crops interims of yield per hectare, adaptability to different areas, price stability, drought tolerance, scalability, climate resilience, multifunction nature (human food and livestock supplement). Regression result of factors determining the productivity of improved Boloso 1 taro indicated that the productivity of the specific crop varies across farming community due to social, cultural, natural and environmental capability of the households. From explanatory variables used in the regression, attendance in formal education, extent of family drop outs, quantity of farm tools the household own, yield of other major crops and market distance to farmers' residence significantly affected productivity of improved taro. Attendance in formal education, farm tools owned, other major crops yield positively affected the productivity, while the extent of family drop outs and market distance negatively influenced the extent of improved taro yield collected per households. The study result confirmed that enabling the farming communities to attend formal education, owning adequate farm tools and improving the farm management capabilities ought to be the major assignment for the projects and other agricultural development programs working in the district. One of the challenges exist in the study area is lack adequate of improved taro seed, erratic rain fall, untimely supply of the seed, awareness problem in value addition practices using taro as livestock supplement, which is pertinent for improvement of yield and efficient utilization of the resources thereby improve the food and nutritional security of farming communities in sustainable manner. Hence, adequate and timely improved taro seed dissemination, adoption of value chain development cattle fattening, milling and linking producers to market benefit and scaling up believed further optimize the crop productivity there by play a significant role in nutritional and food security improvement of the communities. The policy implication of study result indicates that strong policy support and due consideration is need for root and tuber crops that is comparable to their role in the livelihoods of farmers in southern Ethiopia.

Keywords: *bolos 1 taro, food crop, livelihood, productive.*

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I. Introduction

a) Background and justification

In Southern Ethiopia, root and tuber crops are one of the traditional food crops. As they are alternatives to cereals, their contribution to food-self-sufficiency, income generation and soil based resource conservation is indispensable. Among those root and tuber crops grown in Ethiopia, enset, potato, sweet potato, taro and cassava are the principal crops (Yared, 2014; Tewdros, 2013).

Taro is a highly prized and dominant staple food in the subsistent sectors; and an important source of cash income when marketed locally. Unlike other root crops, taro performs well under water logged conditions and can stay for prolonged period of time after harvest without damage. Because of this nature of the commodity, its production is becoming massive and has been contributing a lot for areas under chronic food insecurity (Yared and Tewdros .,2014;African Bioscience Challenge Fund, 2012).

The most important feature of taro is its good adaptability, resistant to different diseases and produce high amount of yields in different areas especially on tropical environments (Tewodros, 2013). The consumption of both taro and sweet potato is threefold:

human food, animal feed and the production of alcohol and starch. Yared. D and Tewdros. M. 2014).

Seasonal food shortage is amongst the principal problems of farmers in mid-altitude areas of Southern Ethiopia. Taro is important part of food security packages. Globally, taro is grown over a wide range of environments from 1,300-2,300m.a.s.l.; mostly by the resource poor farmers. Its compatibility with various types of limited input farming systems (versatility) and reliability under conditions such as drought, high rain fall, and low soil fertility have made it attractive crop to farmers (Yared.et.al, 2014).

To overview the level of introduction and adoption of taro technology, to analyze its economic, livelihood and nutritional and food security role for farming community, identify opportunities and challenges, it is indispensable to carryout and follows the multi-sectoral institutions approach to implement this research. Therefore, this study is planned to undertake investigation on impacts of improved taro variety on food and nutritional security in Kindo Koyesha and Duguna Fango woredas of Wolaita zone.

b) Rationale of the assignment

i. *Provision of Improved Taro Boloso-1variety – new technology*

The project entitled 'creating resilience through integrated multi-sectorial approach in emergency prone areas of Wolaita Zone' has been implementing in Kindo Koysha and Duguna Fango woredas of Wolaita Zone in collaboration with small-holder farmers, GOs and other stakeholders since 2012. The principal objective of this project was to contribute to the improvement in nutritional status of vulnerable households in Wolaita zone through building their resilience to future shocks. Among the different tasks of the intervention in the district, enhancing nutritional and food security of target households was one of the major aims of the project. As part of the planned activity in this sector, Concern worldwide distributed improved Taro Boloso-1 variety seed to target households.

Taro production has been covering large proportion of the area at the target Woreda. But its impact on household's livelihood, its production constraints and opportunities were not studied documented and well documented. Therefore, Concern Worldwide in partnership with Areka Agriculture Research Centre planned to conduct this study on the impact of taro on target households. This study aimed to assess contribution of taro production and marketing on the project's targeted household's livelihoodn in Kindo Koysha and Duguna Fango woredas of Wolaita zone. It is also planned to develop strong evidence-base in-depth information on the seeds contribution in food and nutrition security of target households. In addition, synthesizing knowledge and lessons learned as a base to scale up these interventions and use as a guide for future programming was also another goal of the study.

c) Objectives

General Objective

- The overall objective of this study was to conduct impact assessment of taro dissemination on food and nutrition security of project's target HHs.

Specific objective

- To assess factors affecting productivity of Improved taro
- To examine impact of improved taro variety production in food and nutritional security of targeted households.

II. Methodology

a) Site description

The Wolaita zone is one of the thirteen zones of the Southern region of Ethiopia covering an area of 4471.3 km2. For administrative purpose it is divided in to twelve woredas (districts) namely; Boloso Bombe, Boloso Sore, Damot Gale, Damot Weydie, Damot Pulasa, Damot Sore, Diguna Fango, Humbo, Kindo Koysha, Kindo Didaye, Offa and Sodo Zuria. The study was carried out in two Woreda namely Duguna Fango ad kindo Kosha(CSA,2014).

In southern Ethiopia, the root crop area coverage meher cropping season was more than 90,000ha in 2014 and its productivity per ha of land estimated to be more than 302 quintal, which was higher than other food crops in the country. Root crop coverage of Wolaita zone was more than 32 000 ha and its productivity estimated to be greater than 336 quintal/ha, which was higher than the region average (CSA, 2014.)

Data Collection and sampling techniques

The two main data collection techniques used were focus group discussion (FGD) and formal survey techniques. FGD process was guided by checklist that was drafted by the researchers and commented by Concern officials and experts for improvement. For FGD, farmers, youth, women, kebele leaders and DAs were selected purposively representing different age and gender groups based on the involvement of individuals in the process of Taro seed dissemination and utilization. The major challenges of production and productivity of root crops comprised of untimely and inadequate seed distribution for farming communities, erratic rain fall, lack of scientific information on impact of improved taro variety and its role in food and national security of beneficiary farmers. Hence, the investigation on role of Boloso 1 Taro variety in food and nutritional security believe help a lot in generation scientific and timely information, characterize the opportunity and challenges of taro production and identify determinants of productivity of the crop.

Total of four FGD were carried out in two kebeles per each woreda partaking 15 individuals per FGD in average at the beginning of the study.

Information gathered during FGD created the basic map of the intervention and helped to verify the data collected with survey. It also helped as important resource to develop structured questionnaire for formal survey.

Nine experienced enumerators were hired and trained in administering the structured questionnaire for two days. Filled questionnaires were also examined by the researchers and appropriate comments were forwarded to enumerators for better quality of collected data on the first days of survey.

The formal survey was carried out on 180 beneficiaries with the help of trained enumerators. The approach by Kothari (2004) was employed to determine appropriate sampling size of taro beneficiaries for the study: n=z2pq/d2: Where n = the sample size z = 1.96, P = Population proportion (the proportion of taro producer in Kindo Koisha and Duguna Fango. d = the significance level set at 95% confidence level. This corresponds with a z value of 1.96. q = is a weighting variable computed as 1-P.

Primary data was collected by focusing on overall impacts of the Taro technology intervention through evaluating socioeconomic characteristics of beneficiaries, contribution of taro on their livelihood in terms of income, food security and market stability, volume of production per farmland with taro and other major crops (maize, cassava, sweet potato, sorghum, potato and teff).Before and after intervention bases. The impact is also evaluated on bridging food gaps in different months, nutritional security and food diversification in household, perceptions of beneficiaries on what has been done, success stories, opportunities and constraints of utilizing taro were collected from farmers, traders and other participants involved in production and marketing of taro. Role of other actors including development agents, community workers, agricultural officers and project implementers and supervisors were also assessed to differentiate cumulative and individual (Concern Worldwide) contributions in the study area.

Information from secondary sources such as Areka Agricultural Research Center (AARC), Concern-Worldwide (ECHO I end line survey report, Assessment reports, PPDM reports, annual reports, proposal and DIP), Central Statistical Authority (CSA), Wolaita zone and both woreda agricultural offices is also utilized as a complement and reference for our study. All monitoring data from concern worldwide which is collected since the beginning of the project, annual action plans and reports, quarter progress reports, baseline and end line survey reports, assessment reports, project proposal, log frame and M&E plan were reviewed.

b) Data Analysis

Descriptive statistical analysis was used to define mean, mode, percentage and standard deviation of important economic variables considered in collecting information. In addition to descriptive analysis method, econometric analysis was employed to identify factors affecting productivity and contribution of improved taro variety for livelihood of farming community. Linear Regression Model was employed to analyze the econometric relationship between explanatory and dependant economic variables.

III. Results and Discussion

Table 1 : School drop outs, migrations before and after the intervention

Years of technology intervention	2003/4EC		2006/7EC	
Statistical variable	Mean	Std. Dev.	Mean	Std. Dev.
Age of the respondent, in years	42.75	9.80		
Male No. of school drop outs < 15 years	.15	.46	0.07	.34
Male No. of school drop outs 15 to 65 years	.25	.54	.07	.34
Male No. migrated < 15 years	.04	.19	.02	.18
Male No. migrated 15 to 65 years	.17	.42	.07	.34
Female-No. of school drop outs < 15 years	.06	.22	.01	.09
Female No. of school drop outs 15 to 65 years	.19	.48	.02	.14
Female-No. migrated < 15 years	.03	.17	.01	.08
Female-No. migrated 15 to 65 years	.11	.33	.02	.13

The average age of framers in the study district was 43 and the age of respondents to other farmers varies in 10 year. The result shows that there is a big difference on the rate of school drop outs and migration between 2011 and 2014. 26% of male students aged 15-65 left their study before the end of academic year in 2011 but it slides down to only 9% in 2014. It dropped from 14% to 2% in the case of female students at the same age range. When the farming communities able to secure food security, they engage their children fully in education and the study results confirmed this. The main reason for declining of drop outs for both male and female are improvement in food security and infrastructural development. In comparison to males, the extent of decline in drop outs in females is higher than that of males. This is because of opening of new education centers at the vicinity of communities and other infrastructural development. Introduction of

productive variety of taro contributed a lot in facilitating the education process through assuring food security. When the migration level is examined, it descended from 17% to 8% for 15-65 age male and 11% to 2% for women. The major causes of migration listed by farming communities are food insecurity, lack of income and search of jobs. When the farming communities are able to secure food at household level, their level of participation in agriculture actively improved and, consequently, their probability to migrate from place to place decline immediately equipments from 2011 to 2014.

Table 2 : Farm and communication tools ownership before and after the intervention

Years of technology intervention	2003/4EC		2006/7EC	
Statistical variable	Mean	Std. Dev.	Mean	Std. Dev.
Radio-No. Owned	.05	.22	.24	.43
Tape recorder-No. owned	.06	.33	.05	.21
Phone (mobile)-No. owned	.04	.20	.31	.49
Hoe No. owned in	1.08	.63	1.49	.98
Spade-No. owned in	.42	.58	.70	.69
Ox plough (set)-No. owned	.71	.73	.84	.73
Sickle-No. owned	1.16	1.20	1.58	1.43
Animal cart No. owned	.00	.00	.05	.29

The result in above table indicates that improved taro beneficiaries have got improvement in access and utilization to communication tools and farm implements when compared to the base year (2003/4EC) in 2006/7EC. Since the interview beneficiary farmers are poor in wealth status at the intervention period, the improvement in agricultural and communication tool was the outcome of dissemination of improved Taro variety to the farmers. This study result indicates that dissemination of improved taro variety made the targeted farmers to develop more farm and communication tools and, consequently ownership of this equipments played a positive role in improvement in food and nutritional security.

Table 3 : Roofing materials of beneficiary houses before and after the intervention

Woreda	Keble	Roofing material of the main house in 2003/4EC(2011)			Roofing material of the main house in 2006/7EC (2014)		
		Grass	Iron sheet	Total	Grass	Iron sheet	Total
Kindo Koysha	Bade Woyde	43	7	50	22	29	51
	Fechena	39	10	49	16	33	49
Duguna Fango	Fango Humbo	38	6	44	26	18	44
	Dendo Offa	26	1	27	14	12	10
Total		146	23	170	78	92	170

It is concluded that the roofing material used in housing can be evidence for the income and livelihood status of a household in the study areas. Only 13.5% of the beneficiaries had a roofing material of iron sheet before the multi-sectoral resilience building project intervention in which provision of improved Taro was one of the activities. It moved up to 54.11% in 2014.

Impact of Improved Taro Dissemination in ownership of Livestock

The result shows that the rate of ownership for all oxen, cow, heifers, calves, sheep, goats, poultry, bee hives and donkey has boosted after the intervention in study Woreda. Different ownership rates are seen among small and large ruminants. For instance, goats were owned by only 18% of the respondents in 2011 but now around 75% of the respondents have at least one goat. This can be explained by the fact that goats are tough animals which can survive drought challenges and land shortage for grazing through browsing leafy plants that are not preferred by other animals. In the other hand, even if the enhancement rate of oxen and cow ownership is below that of goat, it has been improved from 19% and 61% to 42% and 91%, respectively. Oxen are used mainly as a ploughing of the farms. Improvement of cow ownership is a good ownership is a great opportunity for a family to have milk in a dish that diversifies their food sources. Moreover, availability of milk in a dish means a better nutritional security in household.

Table 4 : Livestock ownership of farmers in two various years

	2014		2011	
	Mean	Std. Dev.	Mean	Std. Dev.
Oxen-No. owned	0.42	0.60	0.19	0.43
Oxen-shared	0.20	0.42	0.11	0.36
Cow No. owned	0.91	0.66	0.61	0.68
Cow shared	0.55	0.67	0.24	0.47
Heifers -No. owned	0.28	0.49	0.06	0.23
Heifers –shared	0.10	0.34	0.02	0.14
Calves -No. owned	0.28	0.48	0.03	0.21
Calves -shared	0.21	0.44	0.01	0.12
Sheep -No. owned	0.49	0.79	0.13	0.50
Sheep –shared	0.20	0.55	0.01	0.17
Goats-No. owned	0.75	1.09	0.18	0.64
Goats-shared	0.21	0.55	0.06	0.35
Poultry -No. Owned	0.67	1.59	0.06	0.23
Poultry –shared	0.14	0.62	0.01	0.12
Bees hive -No. owned	0.03	0.24	0.00	0.00
Donkey -No. owned	0.17	0.39	0.01	0.08

The yield of local taro is 2 qt per timad in average but 7 qt yield can be harvested from Boloso-1-taro variety in farmer's field condition. Even if this result is far below the documented potential of improved taro, it still surpasses the local variety by 250% or above three fold. The local taro was consumed continuously for a maximum of 2 months as a sole crop but the improved variety can be used for up to 5 months.

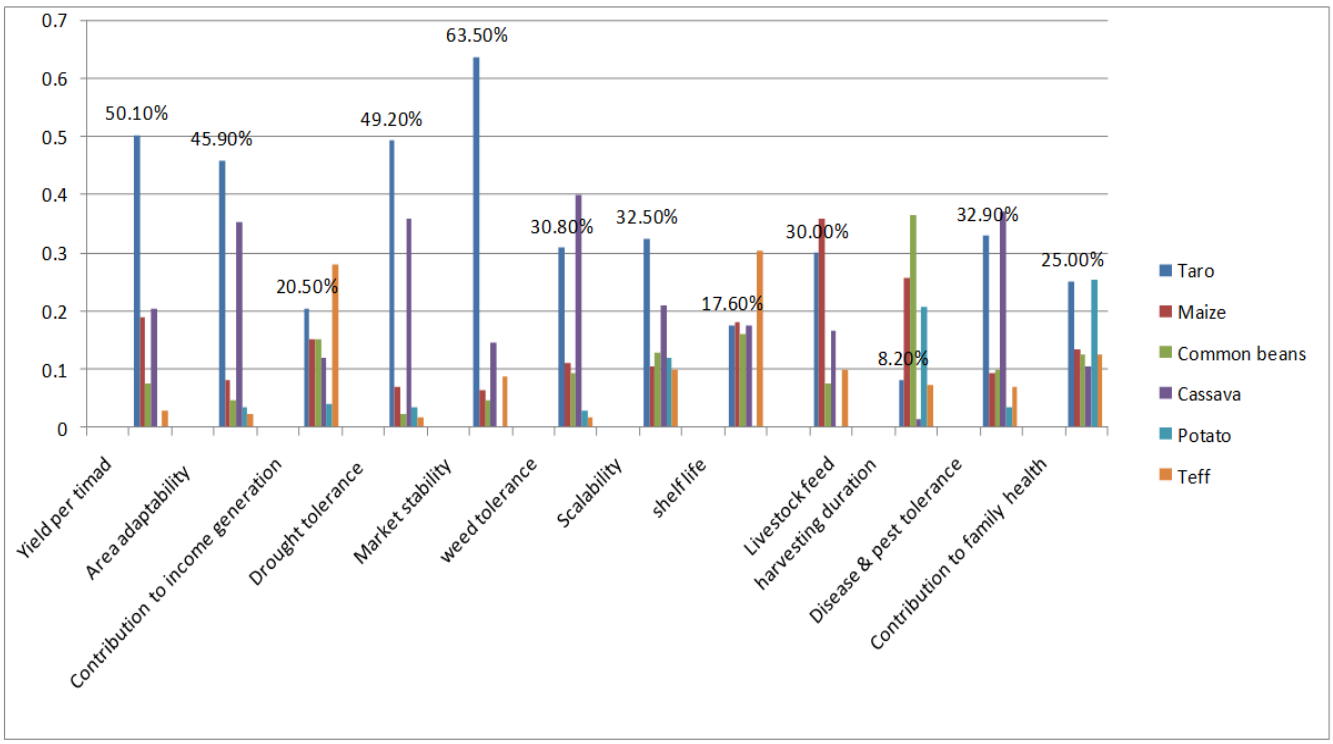
Table 5 : Taro Variety, production and Market pattern

	Local Taro Variety production and Market pattern				Boloso 1 Taro variety Production and Marketing pattern			
	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.
Land Area (Timad) in 2006/07	0.00	1.00	0.06	0.16	0.10	3.00	0.64	0.53
Yield (qt) in 2006/07	0.00	50.00	2.07	9.32	0.50	50.00	6.86	8.17
Consumed (qt) in 2006/07	0.00	50.00	3.74	12.9	0.00	50.00	4.05	7.17
Sold (qt) in 2006/07	0.00	1.00	0.02	0.15	0.00	180.0	3.02	16.14
No. of months the crop consumed 2006/07	0.00	8.00	0.57	1.45	0.00	12.00	4.68	2.41
Quantity Used as a seed (qt) 2003/4	0.00	20.00	0.47	2.46	0.00			
Land Area (Timad) in 2003/4	0.00	25.00	0.63	2.51	0.00			
Yield (qt) in 2003/04	0.00	50.00	3.65	9.66	0.00			
Consumed (qt) in 2003/4	0.00	40.00	2.15	4.96	0.00			
Taro local-Sold (qt) in 2003/4	0.00	5.00	0.48	0.81	0.00			
Taro local-No. of months the crop consumed	0.00	12.00	1.88	2.31	0.00			
Taro local-Used as a seed (qt) 2003/4	0.00	50.00	0.99	5.01	0.00			

Table 6 : Role of Gender in Taro production and marketing

Activities	Gender	N	Percentage
Planting, Earth up and weeding	Husband	130	76.5%
	Wife	15	8.8%
	Son	16	9.4%
	Daughter	9	5.3%
Harvesting	Husband	117	70.1%
	Wife	22	13.2%
	Son	20	12.0%
	Daughter	8	4.8%
Feeding the livestock	Husband	46	27.9%
	Wife	81	49.1%
	Son	30	18.2%
	Daughter	8	4.8%
Marketing of taro	Husband	7	4.4%
	Wife	135	84.9%
	Son	3	1.9%
	Daughter	14	8.8%

The study revealed that due to an introduction of Boloso-1, an improved taro variety, women have got access to get cash from the crop. According to the survey, 84.9% and 8.8% of the respondents responded that surplus taro products from the total production in the household were marketed by wife and daughter. This implies that, in the study area, taro production has empowered women by enabling them by diversifying their cash source. But the majority of the production activities were covered by male. According to this study planting, earth up, weeding and harvesting activities of taro production were covered by male, but marketing of taro product and feeding livestock by taro feed were undertaken by women(see the above table). In general, in the study area, taro production and marketing has contributed a lot to women through empowerment by marketing and to earn income better than other crops.



The major crops namely maize, common beans, cassava, potato and taro are compared by respondents for different parameters indicated in the above figure. The criteria were yield per ha, adaptability to their agro-ecology, income generating ability, drought tolerance, market stability, weed tolerance, scalability, shelf life, livestock feed, harvesting duration, and disease and pest tolerance. According to the study, taro is ranked first by most parameters such as yield per ha, adaptability to different areas, drought tolerance, market stability, scalability, disease and pest tolerance and contribution to family health. The harvesting duration of Taro is longer than most major crops except cassava. The relative advantage of producing taro on stabilizing the market has been mentioned by 63.5% of the total respondents.

Farmer's General Perception on Taro

The study revealed that Boloso-1, an improved taro variety, has contributed more to crop productivity improvement, increased farm income, reduced migration, generate employment opportunities and improvement in nutritions at household level, but majority of the respondents responded that they are indifferent about the contribution of taro to women empowerement. Accordingly, the graph below shows the general perception of the respondents on the contribution of the taro for livelihood improvement in the study area hence majority of the respondents were strongly agreed that Boloso-1 has contributed to poverty reduction at household level. But some of the respondents were responded that they don't know about contribution of taro to poverty reduction.

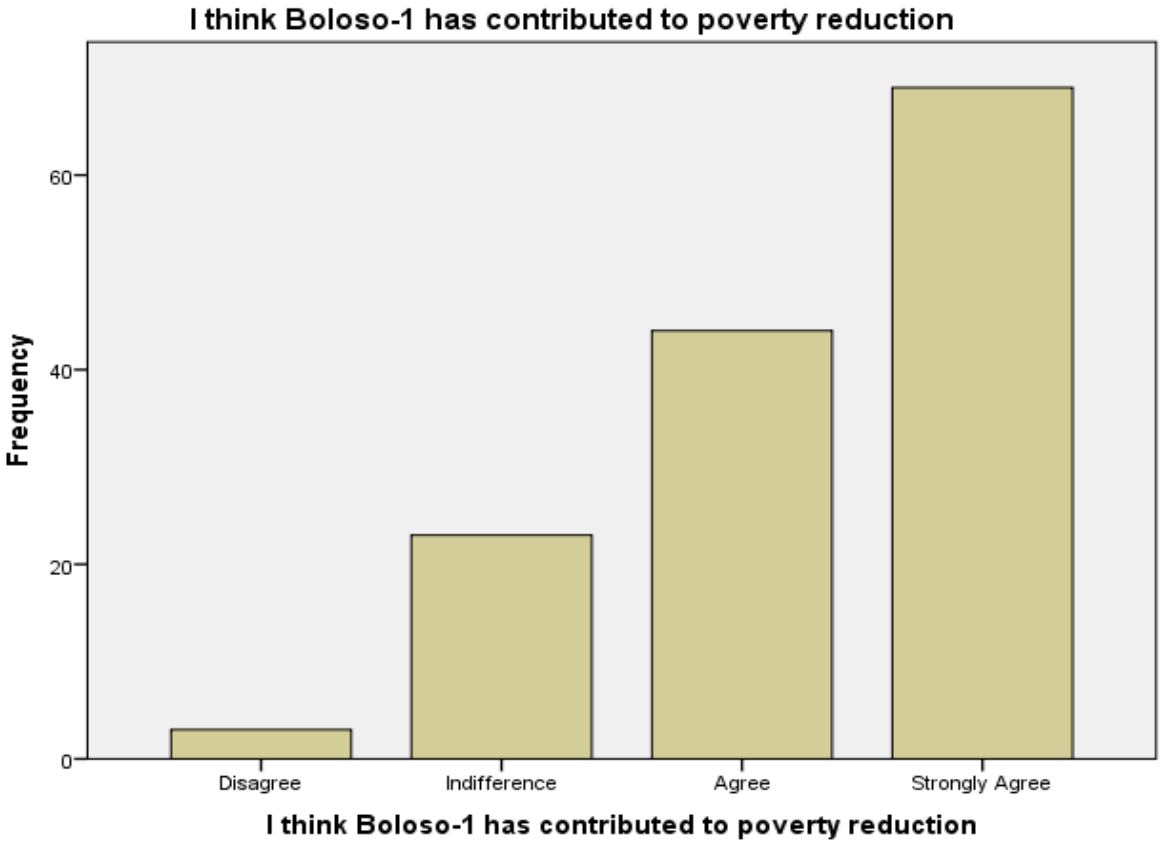


Fig. Graphical presentation of farmers' perception on contribution of taro for poverty reduction

This study revealed that most of the taro producers have knowledge about the contribution of taro to living standard improvement at household level in the study area. According to the survey undertaken more than 60% of the respondents responded that they were strongly agreed with the contribution of taro to improvements in living standards of the community in the study area.

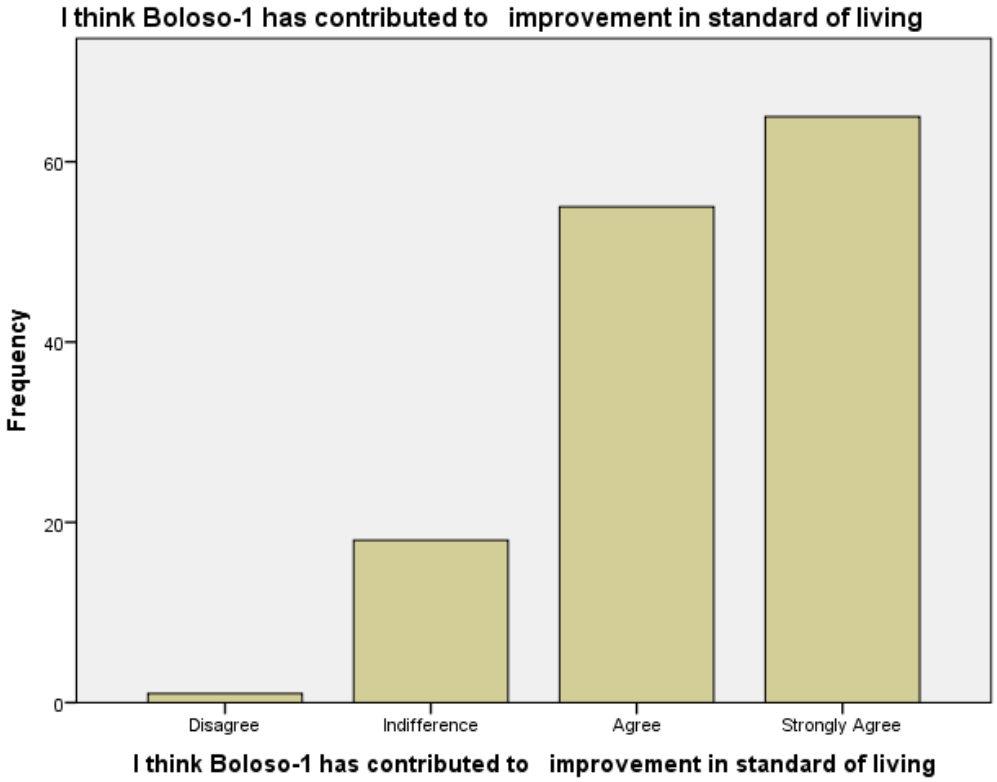


Fig. Graphical presentation of farmers' perception on contribution of taro to living standard improvements

According to the study, because of the introduction of Boloso-1, an improved taro variety, in the study area the average nutrition level was increased at household level as the have got access to incorporate taro food items their family's daily meal. As the study revealed majority of the respondents strongly agreed that their households' average nutrition level is increased due to taro introduction.

Success stories

Ato Moges Mota is one of Concern worldwide beneficiaries in Damot Shinka Kebele of Duguna Fango Woreda. He took 2 quintals of taro seed from Concern worldwide in March 2013. He planted it on quarter hectares of land and harvested 10 quintals of taro product. He sold six qt, used two qt for home consumption and two qt saved as a seed. By using money from selling taro, he bought a donkey, which is very important animal commonly used to transport his agricultural inputs to his farm and farm products to markets at woreda center and nearby kebeles. Then, he planted his taro seed in the same farm in 2014 and got 500 birr by selling some part of taro product. He bought sheep and started rearing it. This diversified his farm as additional livestock component and contributed to building household asset. Sheep is raised mainly to be sold as income source during public festivals and it can also be consumed in home for holidays or slaughtered as additional food for mothers when they deliver a baby. Similar stories are common in both project woredas.

W/ro Almaz Meskele is also a farmer and a woman household head in Duguna Damot Shinka Kebele of Duguna Fango Woreda. She was not able to feed and educate her children due to her low economic status; therefore, two of her sons were migrated to Bitena and Wolaita Soddo towns to look for better life. After receiving the same amount of Taro seed in 2013, she collected eight quintals. Then, she sold four, consumed two and kept two qt as a seed. Then, she brought her children back to home and started life together with them. She bought clothes and important educational items for her children. Now they are students in grade 5 and 7. She is also so proud to witness the market stabilizing effect of Boloso -1- Taro and nonexistence of mal-nutrition problem in the area after introduction of taro seed by Concern worldwide. She said "every food commodity becomes cheaper in Taro harvesting months and diseases related to food shortage are almost forgotten". "We lost almost 50% of newly born children before few years, but now it has been history".

W/ro Mogite Pola is one of woman household heads in Borkoshe Kebele of Kindo Koysha Woreda. She was the poorest person who had nothing to eat before taking a part in Concern interventions. She took 2.5 quintals of Boloso 1 Taro at the beginning of interventions. She was not able to plant all Taro seed provided to her on her own land since she has a challenge of land shortage. Then, she took the remaining taro seed to farmers who are not involved in the project. She planted it there with a consensus to share the product. She saved 80% of the taro product as a food source and the remaining is deposited as a seed. Now she is free from extreme hunger and very glad for that. She said, 'Boloso 1 Taro is a Blessing as it is locally named 'Bereket' by farmers indicating the better yield and its power to fill household consumption demand". This story is shared by many beneficiaries in Kindo Koyisha.

Table 7 : Results of Linear Regressions Analysis (dependant variable Yield of Bolos 1 Taro collected in 2006)

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-.153	3.180		-.048	.962		
sex 1M2F	.038	.212	.009	.182	.856	.882	1.134
Age	.066	.062	.065	1.069	.288	.565	1.771
formal edu/not	1.66	.978	.087	1.696	.094*	.800	1.249
total Family siz	-.228	.377	-.059	-.606	.547	.222	4.508
Family indepdsiz	.216	.451	.048	.478	.634	.208	4.809
family drop outs 2006	-2.152	.898	-.151	-2.397	.019**	.528	1.893
HH Migration 2006	.281	1.518	.010	.185	.854	.695	1.439
Extent of agricultural facilities	1.88	1.078	.098	1.746	.085*	.667	1.499
Extent of market info. facilities	-.175	.410	-.025	-.427	.671	.600	1.668
crop yield 2006	.368	.019	.972	18.903	.000***	.797	1.254
total cattle 2006	.222	.289	.042	.767	.446	.693	1.444
shot 2006	.042	.333	.007	.126	.900	.739	1.352
chicken 2006	-.186	.450	-.021	-.413	.681	.815	1.227
market dist	-.389	.121	-.177	-3.201	.002***	.686	1.457
Income from taro 2006	.001	.003	.011	.200	.842	.747	1.339
remittance income 2006	.014	.018	.047	.787	.434	.594	1.683
Model summary	R	R Square	Adjusted R square		Std.error of the estimate		
	.944	0.891	0.868		6.413		

*Significance level: ***,** and * justifies significany at 1%,5% and 10% respectively.*

The econometric approach employed was linear regression Model to sort out institutional, social and biological factors that contributes for improvement in the yield of improved taro disseminated by the Project to targeted beneficiaries. From the explanatory variables employed, market distance in km, other major crop yield, quantity of household information facilities (radio, tape recorder and mobile) owned, attendance in formal education and extent of family drop outs significantly affected the yield of improved taro collected per household.

Attendance in formal education: Attendance in formal education was one of explanatory variable affect significantly the level of taro production in 2006EC fiscal year and defined as 1 for those attended formal education and 0 (zero) otherwise. Attendance of formal education for small scale farmer increases the probability of taro yield obtained per households in 1.6 times, holding the other explanatory variables constant. The Attendance in formal education improved the awareness of the small scale farmers in following improved cultivation techniques and enable to share experience from others, the households that attended formal education own better yield of the taro, in comparison to households that did not attended formal education,

Extent of Family drop outs: This is one of the estimates that affected negatively the level of taro productivity in the household in the study district. The coefficients of the specific independent variables was -2.15.The regression result confirmed that when the number of family drop outs increase by one unit, the extent of taro yield decreased by more than 2 unit, keeping other independent variables constant. Since the family members dropped out the education move to other area in search of jobs and income earning activities, their contribution for taro production becomes zero inform of seed preparation, land cultivation, weeding and harvesting tasks that have high value in productivity of the specific crop, consequently the number of family drop outs negatively affected the productivity.

Quantity of farm tools owned: The coefficients of the predicator was 1.88. This indicates that havening one extra agricultural facilities such as hoe, ox plough set and spade, induces increment in the yield of Taro productivity at household level, keeping the other explanatory variable constant. Since owning farm tools helps to cultivate, earth up, weed and harvest the crop, it has positive role in productivity of taro in the district. Hence, enabling the small scale farmers to have adequate farm tools could promote the productivity of cropping and needs project support for provision.

Yield of other major crops cultivated: The coefficients of the estimate was .368. The result implies that the yield obtained from other major crops such as cassava, teff, sorghum and common bean own positive role in the yield of Taro. The extent of care taken for one major crops provokes production cares to be taken for other crops cultivated ,consequently, the yield collected form one crop induces farmers to cultivate, weed and harvest in better manner and to earn more from the subsequent crops.

Market Distance: The parameter estimate for variable market distance was -.389. This indicates that the farming communities that located nearest to market point collect better yield of taro in comparison to farmer that found distant away from marketing point, given all other independent variables fixed. The research finding confirmed that the informal institution the so called market have significant role in the productivity of taro in the study district. Hence linking the improved taro variety producer to the market, adoption of value chain development in form of cattle fattening, milling and branding the powder of the crop could optimize the productivity and support in food and nutritional security of the farming community.

IV. Conclusion and Recommendations

The study reveals that the contribution of taro on the overall livelihoods of the beneficiaries is significantly high. The impact of Boloso-1-Taro ranges from saving life to reduction of migration and school dropout rates. It has also diversified income for the beneficiary farmers in general and able to generate income from selling taro production that empowered women and changed the family's living status. Hunger and complete poverty has been eradicated from the project sites mainly due to taro intervention. The interviewed farmers also confirmed that the improved taro variety played a significant role in price stabilization in the district, which justified by the market price reduction of common food crops after intervention in the district. Taro is better than most common crops interims of yield per hectare, adaptability to different areas, market stability, drought tolerance, contribution to family health and scalability. In relation climate resilience, higher productivity per ha ,multipurpose function of the improved taro variety for both human food and livestock supplement and adaptability to various range of weather, adequate and timely Improved taro seed dissemination, adoption of value chain development cattle fattening, milling and linking producers to market benefit and scaling up believed further optimize the crop productivity there by play a significant role in nutritional and food security improvement of the communities.

Regression result of factors determining the productivity of improved Boloso 1 taro indicated that the productivity of the specific crop varies across farming community due to social, cultural, natural and environmental capability of the households. From explanatory variables used in the regression, attendance in formal education, extent of family drop outs, quantity of farm tools the household own, yield of other major crops and market distance to farmers' residence significantly affected productivity of improved taro. Attendance in formal education, farm tools owned, other major crops yield positively affected the productivity, while the extent of family drop outs and market distance negatively influenced the extent of improved taro yield collected per households. The study result confirmed that enabling the farming communities to attend formal education, owning adequate farm tools and improving the farm management capabilities ought to be the major assignment for the projects and other agricultural development programs working in the district.

One of the challenges exist in the study area is lack adequate of improved taro seed, erratic rain fall, untimely supply of the seed, awareness problem in value addition practices using taro as livestock supplement, which is pertinent for improvement of yield and efficient utilization of the resources thereby improve the food and nutritional security of farming communities in sustainable manner.

References Références Referencias

1. African Bioscience Challenge Fund. 2012. Viruses infecting the food crop Taro (Colocasia esculenta L.) in Ethiopia. National Agricultural Biotechnology Laboratory, Holetta Research Centre, Ethiopian Institute of Agricultural Research (EIAR), Ethiopia.
2. CSA (Centeral Statistical Agency).2014. Federal Democratic Republic of Ethiopia Central Statistical Agency, Agricultural Sample Survey 2014/15 Volume I Report On Area and Production of Major Crops. 578 Statistical Bulletin. Ababa, Ethiopia. P125.
3. CSA (Central Statistical Agencey).2014.Federal Democratic Republic of Ethiopia Central Statistical Agency, Population projection of Ethiopia for all regions at Woreda level from 20114-20117.Addis Ababa, Ethiopia.p118.
4. Kothari, C.R. (2004). Research Methodology. Methods and techniques. (2nd ED): New Age International. New Delhi. India.
5. Tewodros Mulualem, Getachew WeldeMichael and Kifle Belachew.2013.Genetic Diversity of Taro (*Colocasia esculenta* (L.) Schott) Genotypes in Ethiopia Based on Agronomic Traits. Time Journals of Agriculture and Veterinary Sciences Vol. 1(2). Jimma Agricultural Research Centre, Jimma, P.O. Box 192, Ethiopia.
6. Yared Dagne, Tewodros Mulualem, Asfaw Kifle.2014. Development of High Yielding Taro (Colocacia esculenta L.) Variety for Mid Altitude Growing Areas of Southern Ethiopia. Journal of Plant Sciences. Vol. 2, No. 1, 2014, pp. 50-54. doi: 10.11648/j.jps.20140201.19.
7. Yared Dagne1, Tewodros Mulualem.2014.Exploring Indigenous Knowledge and Production Constraints of Taro (*Colocasia esculenta* L.(SCHOTT)) Cultivars Grown at Dalbo Watershed, Wolaita Zone of South Ethiopia.Areka Agriculture Research Center, P.O.Box-79, Areka, Ethiopia. Jimma Agriculture Research Center, P.O. Box- 192, Jimma, Ethiopia.

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Once FARSB title is accorded, the Fellow is authorized to organize a symposium/seminar/conference on behalf of Global Journal Incorporation (USA). The Fellow can also participate in conference/seminar/symposium organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent.

You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The FARSS can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSS, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

The FARSS will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSS member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.
Once you are designated as FARSS, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website https://associationofresearch.org which will be helpful to upgrade the dignity.

The FARSS members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

The FARSS member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.

The FARSS is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSS can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSS member can decide its price and we can help in making the right decision.

The FARSS member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN SCIENCE (MARSS)

The ' MARSS ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The "MARSS" is a dignified ornament which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., MARSS or William Walldroff, M.S., MARSS.

MARSS accrediting is an honor. It authenticates your research activities. After becoming MARSS, you can add 'MARSS' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

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MARSS designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSS, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSS member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSS, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

AUXILIARY MEMBERSHIPS

Institutional Fellow of Global Journals Incorporation (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Process of submission of Research Paper

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.

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Page Size: 8.27" X 11'"

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- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
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- Two Column with Equal Column with of 3.38 and Gaping of .2
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- Paragraph before Spacing of 1 pt and After of 0 pt.
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- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
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You can use your own standard format also.
Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

1. GENERAL

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

Scope

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global

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The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the findings.

2) Drafting the paper and revising it critically regarding important academic content.

3) Final approval of the version of the paper to be published.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

Appeal of Decision: The Editorial Board's decision on publication of the paper is final and cannot be appealed elsewhere.

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3. SUBMISSION OF MANUSCRIPTS

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.

To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

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Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

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Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

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Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

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www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

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The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

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Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

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Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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