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Is Soil Quality Linked to PSNP Graduation in East and West Hararghe, Ethiopia?

Elizabeth Gladding
SIT Graduate Institute

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School for International Training (SIT)

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Table of Contents

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Acronyms

CRGE	Climate Resilient Green Economy
DA	Development Agent
DRM	Disaster Risk Management
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GoE	Government of Ethiopia
GTP	Growth and Transformation Plan
IRB	Institutional Review Board
NRM-	Natural Resource Management
PSNP	Productive Safety Net Program
SOM	Soil Organic Matter
SWC	Soil and Water Conservation

Abstract

Many households in Ethiopia have struggled to remain food secure and meet their nutritional needs. In response to chronic food insecurity the Ethiopian government developed the Productive Safety Net Program (PSNP) to provide support to households in the form of food or cash transfers in exchange for public service work. The idea of the program is that households will develop their livelihoods through the public work and eventually become self-sufficient, food secure and graduate from the PSNP.

Some households graduate from PSNP in a shorter time than others, attributing to many different factors. This study looks at soil quality as a factor influencing a household's ability to graduate and hypothesizes that houses which have already graduated from PSNP will have soil of better quality. The survey was conducted with the University of Maryland's Qualitative Soil Assessment Book indicator table for PSNP graduate, PSNP participant and non-PSNP households. Results of the survey proved that PSNP graduate households had soil of better quality. The follow paper also discusses the need for further research as well as implications for sustainable development.

Keywords: PSNP, food insecurity, soil quality, Ethiopia

Introduction

Ethiopia is one of few African countries which are deeply affected by food insecurity. In any given year one in ten Ethiopians will struggle to maintain sufficient, safe and nutritious food for themselves (Bomba, K. and Glickman, D., 2014). Increases in population growth, destruction of natural resources and reoccurring drought and disasters have impeded the country's achievement toward food security. The average daily energy intake has remained 16 to 20 percent lower than the recommended minimum (FAO, 2006). Despite efforts from both the Ethiopian government and economic support and food aid from foreign governments, the situation has changed nominally.

Throughout its history Ethiopia has experienced periods of drought and famine. Since at least 1980 the country has been structurally food insufficient. Food insufficiency incorporates low food intake, variable access to food, and vulnerability. Vulnerability in this context means livelihoods which generate adequate food in prosperous times but are not resilient to shocks such as drastic economic changes, disasters or climate change. Food insecurity in Ethiopia is often chronic, cyclic and transitory as well as endemic throughout the country. Transitory food insecurity has been spurred on by drought and war throughout Ethiopia's history. Seasonality and regular dry seasons cause cyclical food insecurity. Chronic food insecurity has been caused by structural complications of poverty and environmental degradation. Poverty has been both a cause and consequence of chronic food insecurity and weak institutions complicate household resilience. A lack of access and land tenure systems are the main inadequate institutions, as well as harmful governmental policies (Devereux, S., 2000). Interactions between poverty, environmental degradation, conflict and a myriad of other factors have magnified food insecurity in the country.

The Government of Ethiopia (GoE) has shown a strong commitment in investing in pro-poor sectors and trying to eliminate food insecurity. The GoE's Growth and Transformation Plan (GTP) strives to enhance the productivity of small-holder farmers and pastoralists; link farmers to markets; expand the amount of irrigated land; and ultimately, reduce the amount of chronically food insecure households. Government spending on pro-poor efforts (health, education, agriculture, natural resource management, urban development and road construction) has increased from 52% of government spending in 2003 to 70% of government spending in 2011/12 (Ministry of Agriculture, 2014). The increase in government spending has had a significant positive outcome in bettering the quality of life for many poor households, as is evident by the success Ethiopia has had in reaching the Millennium Development Goals (MDGs). Yet despite the increase in spending on providing greater access for the poor, there are still many households which fall between the cracks. These households are the ones who are often chronically food insecure.

Ethiopia's Productive Safety Net Program

In an effort to combat food insecurity and lessen its impacts on households, the GoE and the World Food Program established the Productive Safety Net Program (PSNP) in 2005 (World Food Program, 2012). As an important contribution to the government's efforts to diminish food insecurity this initiative amounted to 9% of government pro-poor spending and 1.1% of GDP in its first year (Ministry of Agriculture, 2014). The program is designed to enable the rural poor facing chronic food insecurity to become food self-sufficient and break free of food aid. Chronically food insecure households are given the tools to become resilient to shocks and develop assets through multi-annual, predictable transfers of food and cash (World Food Program, 2012). In the Oromia Region the average household receives 39 birr (approximately USD $1.88) a month as a cash transfer or the equivalent in food (Gilligan, D., Hoddinot, J. and Taffesse, A.S., 2008). These transfers are received at times of particular food vulnerability based on the season where the need is greatest, between June and August, in an attempt to prevent households from depleting their productive assets. Households particularly vulnerable to food insecurity receive six months of assistance annually, during the dry seasons. If unpredicted shocks occur during the time outside these six months, the World Food Program extends an additional three months of cash and food assistance under its Risk Financing Mechanism if necessary (World Food Program, 2012).

Beyond just cash and food assistance, able-bodied member of PSNP households must participate in activities to build more resilient livelihoods (Berhane, G., et. al., 2013). Public works are typically undertaken by 80% of PSNP participants (Ministry of Agriculture, 2014). On average participants are expected to work 5 days a month for six months, though actual amounts vary (Gilligan, D., Hoddinot, J. and Taffesse, A.S., 2008). Education and training is given for these activities in land and water resource restoration, developing community infrastructure, rural road

Figure 1 Terracing from PSNP Public Work rehabilitation and construction of schools and clinics. The most common type of public work activities are described as conservation work, including erection of hillside terraces, tree planting and building of rock dams. These activities, especially the use of terraces, prevent soil erosion and limit crop damage. PSNP development agents (DA) claim that soil conservation activities have helped to recover degraded lands, increase productivity and improve livelihoods (Berhane, G., et. al., 2013). Throughout the implementation of PSNP, participants have constructed 600,000 km of soil and stone bunds with the purpose of enhancing water retention and reducing soil and water run-off. They have also protected 644,000 ha of land in area enclosures to increase soil fertility and carbon sequestration (Ministry of Agriculture, 2014). The trainings and program implementation is given by the Ministry of Agriculture's Disaster Risk Management and Food Security Sector, along with regional governments.

Figure 2 Pit for Composting

The ultimate goal of PSNP is for households to become food secure and "graduate" from the program. Graduates are expected to be free of the need for external support, except for during times of national food crises. As families are given assistance they can protect their household assets and grow them instead of surrendering them in dry seasons. To graduate a family must develop their assets to a certain level. These assets include physical assets (tools and livestock), natural assets (land and water) or human capital (mainly labor) (Gebresilassie, Y.H., 2013). Assets are susceptible to being lost when families must take last resort actions and sell their capital to feed themselves when faced with external shocks. Shocks are defined as drought, economic impacts on markets, crop failure, natural disaster, disease or other factors that may result in lifelong reductions in earnings (Gebresilassie, Y.H., 2013). PSNP protects households' assets from being surrendered in the face of such events.

Graduation from PSNP is a voluntary process. When a household no longer needs PSNP transfers for 12 consecutive months and is able to withstand moderate shocks they can chose to voluntarily leave the program. Households usually only chose to voluntarily leave the program when they "have more valuable things to do with their time than participate in PSNP" (Gebresilassie, Y.H., 2013). Once households become food secure and have enough productive assets they are able to earn a higher wage through employment or their own production and their time becomes too valuable to be spent participating in the mandatory public works of PSNP. If households do not chose to leave the program voluntarily they can become ineligible for further transfers when they possess enough productive assets to meet the asset based criteria; exceed the time based criteria where they have not experienced food shortages for three years; or meet the consumption based criteria through diet diversity, daily food consumption and intake more than the nutritional requirements (Gebresilassie, Y.H., 2013).

Literature Review

Food insecurity has been linked to many different causes, from economic insecurity to climate change. Soil, as a vital natural resource for food production, can greatly determine the food security of a region, state or community. The world's arable soils are a finite resource and of these soils only 22% is suitable for agriculture and only 3% for crop production. Today 5 to 7 million hectares of arable land is lost yearly from soil degradation. Twenty three billion tons of topsoil is lost yearly to erosion, 3,770 million hectares are susceptible to desertification and 323 million hectares are affected by salt (Singh, A. and Singh, R., 2008). With the world containing only 12 billion hectares of land (Global Footprint Network, no date) a larger percentage is effected by means of degradation. The study GLASOD, conducted by the UNEP and International Soil Reference and Information Centre (ISRIC) found that global top-soil loss resulting from erosion is far in excess of the natural rate of soil formation (Oldeman, L.R., 1998).

Soils are affected by three different types of degradation: physical, chemical and biological. Physical degradation includes topsoil erosion, desertification, compaction, overgrazing, waterlogging, crusting and various issues that change the physical structure or the water saturation of the soil. Chemical degradation is from acidification, salinization, alkalization, nutrient depletion or runoff and accumulation of toxicants. Biological degradation is a loss of organic matter and soil microorganisms.

Worldwide the main causes of soil degradation are overgrazing, followed by deforestation and agricultural activity (Singh, A. and Singh, R., 2008). As soils are degraded their capacity to produce food is diminished. While developing countries struggle to feed a growing population their ability to increase food production is threatened by hungry and thirsty lands which show evidence of degradation. In such nations a large percentage of the population relies on subsistence agriculture and often does not understand the importance of soil conservation in feeding their families. Since soil feeds us indirectly farmers don't realize that overuse of soil is destroying their ability to produce more. Often because of land tenure issues, farmers simply may not own enough land to manage and conserve their soil use wisely.

The impacts of topsoil erosion, degradation and agriculture have reached a global scale. Crosson (1996) was able to calculate these impacts of soil erosion into on-farm economic costs at a global level. Using data derived from GLASOD on lightly, moderately and strongly degraded land he was able to arrive at an average productivity loss of 4.8% globally (with light degradation at 5%, moderate at 18% and high at 50%). For Africa and Central America the results were even higher, 25% and 36.8% productivity loss respectively. This loss does not go unnoticed in these countries where large portions of their economy are agriculture based. If currently degraded soil is not remediated it can only be assumed that they will progress up the levels of degradation and contribute to more loss of productivity.

A decline in crop yield is expected to be linked to factors such as erosion, fertility decline, improper management, drought, waterlogging, fertilizers, pests, disease and climatic conditions (Odelman, L.R., 1998). Previous studies have shown a relationship between soil erosion and reduced crop yields (Batie, 1983). In a study by Kato, E., et. al. (2009) the employment of soil and water conservation technologies in Ethiopia was found to have highly significant impacts on crop output. Different technologies were found to have a more significant effect on places of high or low average rainfall. These technologies include soil bunds, stone bunds, grass strips, waterways, shade trees, contour, traditional or improved seeds, irrigation and fertilizers. In the Oromia Region soil bunds were found to be most effective. During times of high rainfall in Oromia, stone bunds, grass strips, and improved seeds were found to benefit crop output (Kato, E., et. al. 2009). Most of these techniques are terracing techniques that are generally taught during PSNP training. It is conveyed in this study that soil water conservation work in any capacity is more beneficial for crop output than not engaging in the training exercises.

Benefits of PSNP Soil Water Conservation and Natural Resource Management Activities

PSNP public works activities are found to benefit those households which already have assets by conserving and enhancing them (Berhane, G., et.al. 2013). This reflects the objective of PSNP, which is not to develop household assets but to protect them against shocks. Berhane, G., et. al. (2013) conducted household surveys on perceptions of whether households benefited from public works. In these surveys *perception* of household benefit from soil water conservation (SWC) and natural resource management (NRM) activities were significantly lower than activities such as road construction, water infrastructure and well construction in the Oromia Region.

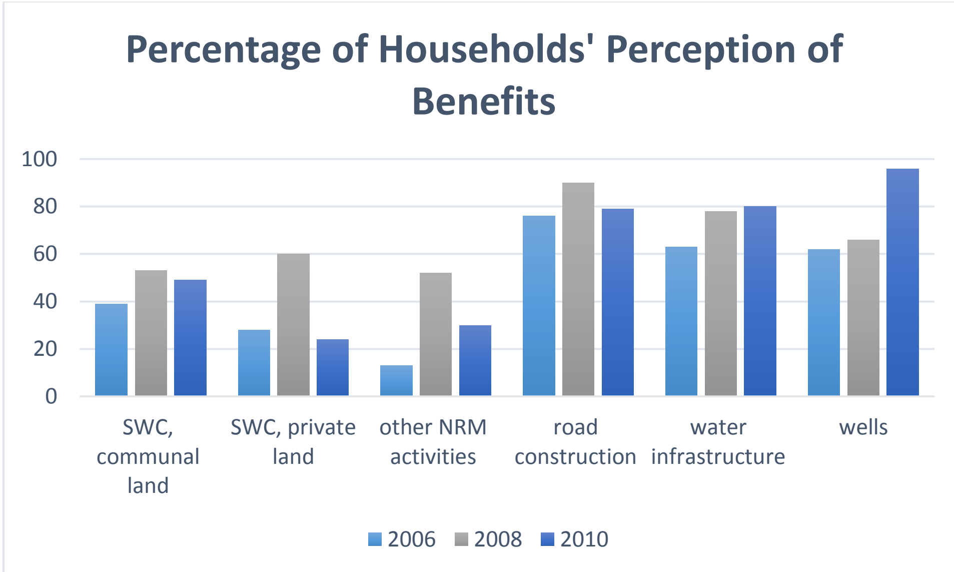

Figure 3 Household Perception of Benefit based upon data from Berhane, G., et. al. 2013

The household survey gives insight into the perception of households as to what PSNP trainings and activities are most beneficial. What the survey doesn't do is successfully analyze what trainings and activities are proven to actually be more beneficial beyond just perception. It is not clear which activities have the longest and most sustainable impact. Water infrastructure or well construction may be immediately beneficial but it may not have the long-term impact that SWC and NRM can have on livelihoods and food production.

Determinants of PSNP Graduation

As mentioned before, very little previous research has been conducted on determinants of PSNP graduation. Some studies have started to look at determining factors in PSNP graduation though none specifically raise the question of soil quality's implication on graduation. In a study of graduation determinants conducted by Gebresilassie, Y.H. (2013) it was found that household participation in an integrated agriculture package raised the probability of a household to graduate. An integrated agriculture package means that the household receives more than just cash and food transfers to include training and participation in agriculture activities and public works. According to these findings the probability of a household which received the integrated agriculture package graduating increased by 0.53 marginal effects, or 53%, if they continued participating in program for more than three years (Gebresilassie, Y.H., 2013). Integrated agriculture packages, including but not exclusive to SWC and NRM, are significantly shown to have a beneficial effect on PSNP graduation.

In a study by Sabates-Wheeler, R., et. al. (2012) 11.8 percent of households in Oromia believe that extension support from development agents (DA) and woreda experts were a critical factor contributing to graduation from PSNP. This DA extension support comes in the form of SWC and NRM trainings as well as educational trainings on various agricultural best practices. These percentages of households which see extension support as a determining factor for graduation is quite low though, when compared with the 82.4 percent of Oromia households which see credit from the food security program as the critical factor. Equal value is clearly not placed in extension support as it is in credit access.

This same study looked to see if soil fertility could be a dependent variable that could change the outcome of graduation. Focus group discussions were conducted to see what type of location-specific constrainers could be affecting graduation. Some of the responses from PSNP participating households were:

> "Land/soil type in the area is different [to other places]
> [it's] sandy, black soil" (Sabates-Wheeler, R., et. al. 2012).

> "In this woreda 19 kabeles have fertile land and 11 kabeles
> do not; the land fertility is very low" (Sabates-Wheeler, R., et. al. 2012).

> “The land is not fertile and [it] is not properly absorbing [applied] fertilizer” (Sabates- Wheeer, R., et. al. 2012).
>
> “The environmental carrying capacity is not matching with the existing population size; productivity of the land is very low” (Sabates-Wheeler, R., et. al. 2012).

Conversely, fertile land was identified in the survey as a location-specific enabler for graduation. Some households interviewed stated that land had been rehabilitated and became more fertile through the help of intensive SWC work and through the application of fertilizers and compost. Households that had already graduated identified productive land and irrigation infrastructure as the most important factor for graduation (Sabates-Wheeler, R., et. al. 2012). This is distinct from still participating households which found cash transfers to be the most beneficial input to lead to graduation.

Hypothesis: Soil Quality and PSNP Graduation

Despite heavy focus on the impacts of Productive Safety Net Program by both the Ethiopian government and non-governmental organizations there has been little research and emphasis on the major graduation determinants of PSNP (Gebresilassie, Y.H., 2013). Of the research that does test determinants of PSNP graduation, there are very little that raise the question of soil quality and its potential correlations with graduation. This research aims to investigate a correlation between soil quality and PSNP graduation, proposing that households that have already graduated from PSNP will have better soil quality than those which are still participating in the program.

Methodology

For this study samples were taken at three village sites that were known to have PSNP participants, PSNP graduates and non-PSNP households. The sites were selected by CARE Ethiopia, a local NGO which carried out food security projects throughout Ethiopia. They were able to identify three villages which met the criteria for all three categories (PSNP participants, PSNP graduates, and non-PSNP households). The zones of East and West Hararghe in the region of Oromia were identified. Within these zones the villages were chosen at random. The three villages are Toutakaneesa, Lynch Wodesa, Odanegaya.

Figure 4 East and West Hararghe Zones in the Oromia Region (image from FEWS NET)

Once sites were selected criteria was needed for measuring soil quality. Due to a constraint in resources and time the most viable option for measurement was to find a set of qualitative indicators. Qualitative indicators were selected from the Maryland Soil Quality

Assessment Book, which is a soil quality assessment book designed by the University of Maryland to help users evaluate changes in soil quality as affected by field management. A copy of the indicator table is shown in Annex I. This indicator table is also used in the Cornell Soil Health Manual.

However, not all indicators from the indicator table were used. Some of them were beyond the financial scope of the study or did not meet time constraints for the data gathering period. Indicators were selected based upon resources and feasibility. Those indicators selected were:

- Organic matter color
- Organic matter roots/ residue
- Subsurface compaction
- Soil tilth mellowness friability
- Erosion
- Crop condition

The indicators selected were rated following the descriptions given in the indicator table on a scale of 1-9. Analysis of the indicators was done qualitatively during a site visit. At each site a plot of land was chosen for PSNP participant, PSNP graduate and non-PSNP on a voluntary basis.

Data was then statistically analyzed using a line regression analysis with STATA software.

Significance of Soil Quality Indicators

The six soil quality indicators were selected from University of Maryland's Maryland Soil Quality Assessment Book which has been proven successful in indicating soil fertility for agricultural purposes. This quality assessment book is a proven reputable source.

Organic matter color shows the quality of the organic matter in the soil, most specifically the top soil. Soil organic matter is the part of the soil that was once living, or plant and animal material such as plant roots and soil microorganisms that are in different stages of decomposition. Soil with a lot of well decomposed organic matter will be a rich and dark color with thick, damp soil and an earthy smell. Soil with high levels of organic matter provides carbon, nutrients and energy for microbes and plants and stores and transmits water better than other types of soil. Because soil high in organic matter has a lower bulk density, it does not compact as much as other soils, is easier to work with, and doesn't erode easily. Soil organic matter (SOM) is often lost through overuse of soil, tilling and erosion (USDA, 1996). SOM can be analyzed qualitatively by looking at the colors found in the first foot of the soil. The darker the soil, the higher the level of well decomposed organic matter. SOM contributes greatly to soils' ability to provide necessary nutrients to support plants and vegetation.

Figure 5 An example of a soil color chart (Munsell, 1974).

The presence of roots and plant residues is another indicator of SOM. Residues and roots will break down into the carbon content of SOM further supplying nutrients to the soil and vegetation. They are an indicator of soil with a healthy level of organic matter for agricultural uses.

Subsurface compaction can be a serious form of soil degradation and results in excessive soil erosion. Subsurface soil compaction is basically when soil particles are pushed into a smaller volume, eliminating pores between particles and water absorption and storage. Soil is often compacted by the use of heavy machinery, overgrazing of an area with livestock, removal of vegetation, and sometimes flooding. In compacted soils plant roots are unable to penetrate the soil layers and become stunted, unable to drive roots deep enough to uptake water in dry times. It also increases the occurrence of flooding, water logging and soil erosion as water cannot pass through soil layers. Soil infiltration is also slowed, increasing the time it takes for roots to uptake water (Alberta Agriculture and Forestry, 2010). Soil compaction is tested by pushing a wire into the soil layers, preferably when wet, to see how far it penetrates. Soil that is extremely difficult to penetrate, especially if the wire bends, it compacted.

Soil friability or tilth is, in its simplest form, the ease of tilling soil. Soil with a good crumbly texture is easy to work with and is considered very friable. It is also characterized by larger clods which fragment easily and smaller soil aggregates which are hard to break. Fine textured soil can be either too cloddy or too finely fragmented during soil preparation. More friable soil is more suitable for agriculture as it easier to develop into a good seedbed with minimum effort (Hansen, J., 2013). This is crucial for smallholder farmers in Africa who often rely on tilling their soil by hand. Friability is measured by crumbling the soil by hand and seeing how aggregates break and how soil clods.

Figure 6 PSNP Graduate with High Friability

Studies have shown that erosion causes the loss of soil on a large global scale which adversely affects the productivity of agriculture (Pimentel and Kounang, 1998; Pimentel, 2001). Soil erosion causes a loss of top soil, where organic matter is found which leads to a loss nutrients, carbon and microorganisms that are critical to plant life. Soil erosion occurs when soil is exposed to wind, rain and other natural elements. It occurs anywhere in the world where humans are removing vegetation and soil is exposed to the elements and eroding at a rate that is faster than the natural processes which make topsoil (Pimentel, D., 2006). Erosion is qualitatively measured by looking for gullies and rills, where you can visualize the effects of water erosion on soil. Larger and deeper gullies and rills expose more severe soil erosion.

Crop condition is clear evidence for soil quality, though not always a guaranteed indicator of good soil. Soil of a good quality is needed for crops to flourish, but just because crops have good soil does not mean they are guaranteed to succeed. Nevertheless, when considered with other indicators crop condition can be a valuable soil quality monitoring tool. Crop condition is qualitatively measured by observing crop color, height, and evenness throughout the field.

Bias and Limitations

Since data is gathered qualitatively there could be natural personal bias when rating soil indicators. There are limitations to my expertise in identifying and rating soil. While I hold a degree in Environmental Science and Management, which included courses on Soil Sciences, I do not have the highest level of expertise in soils. The Maryland Soil Quality Assessment Book could have natural limitations as it was designed in the United States with a very different soil and environmental context than Ethiopia. I could not procure an indicator table that was better suited for Etihopian soils for agriculture purposes.

While in Ethiopia time was a significant limitation on data gathering. More indicators from the table could have been rated if I was able to view the soil in both the dry and rainy season. Water holding capacity and drainage infiltration could only be measured after the rainy season. Access to resources and a laboratory was a limitation that made some soil quality indicators not viable. Nutrient holding capacity and soil pH could only be measured with equipment I did not have access to. With more time and greater access to equipment it would be possible to evaluate all the indicators in the table.

Central Analysis

The data collected from the three village sites is a clear indicator of the link between soil quality and PSNP graduation. The raw data shown in ANNEX II demonstrates PSNP graduates as having better soil across the board and higher ratings for each indicator. PSNP graduates score an average of 2 points higher than PSNP participants on all indicators and an average of 1 point higher than non-PSNP participants on all indicators.

The data was run through STATA statistical software to conduct a line regression analysis and check the significance. A screen-shot image of STATA findings is included.

```
. reg value traininglevel

      Source |       SS       df       MS              Number of obs =      54
-------------+------------------------------           F(  1,    52) =    6.10
       Model |          16     1          16           Prob > F      =  0.0168
    Residual |     136.375    52  2.62259615           R-squared     =  0.1050
-------------+------------------------------           Adj R-squared =  0.0878
       Total |     152.375    53       2.875           Root MSE      =  1.6194

------------------------------------------------------------------------------
       value |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
traininglevel|   .6666667   .2699072     2.47   0.017     .1250583    1.208275
       _cons |   5.083333   .3484487    14.59   0.000      4.38412    5.782547
------------------------------------------------------------------------------
```

Table 1 STATA Regression Analysis

The hypothesis tested was that the independent variables of soil quality will have an impact on the dependent variable of PSNP graduation. The null hypothesis would be no correlation can be determined between soil quality and PSNP graduation. The hypothesis was t-tested where the null hypothesis is $H_0: \mu = \mu_0$. The t-test can then be calculated using the following formula where *s* is the standard deviation of the sample:

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$$

The STATA regression shows the hypothesis to be significant. A *t value* higher than 2 is statistically significant to the 95% level. The null hypothesis is rejected.

The *p value* can also be analyzed from the STATA regression results. The *p value* from the STATA regression analysis is 0.017 showing statistical significance at almost a 99% level and rejecting the null hypothesis. The *p value* is also known as the error rate, meaning 1.7% of the time the samples will not hold true to the tested hypothesis. A *p value* closer to zero is more statistically significant.

Based upon the STATA data and *t-test* and *p values* we can accept the hypothesis holds true: there is a correlation between soil quality and PSNP graduation. The truth of the hypothesis is apparent in the data in ANNEX II. The truth of the hypothesis is also clearly visible when the results are averaged.

The average values of the three villages for each indicator and sample group is shown below. PSNP graduate averages score higher than PSNP participants or non- participants (control group).

Table 2 Averages of Soil Quality Indicator Values

Soil Quality Indicator	PSNP Graduate	PSNP Participant	Control
Organic Matter Color	7.6	6.3	6
Organic Matter Roots/Residue	5.6	4.3	4.6
Subsurface Compaction	7	3.5	5
Tilth/ Friability Mellowness	6.3	4.3	4.3
Erosion	7	4.6	5.3
Crop Condition	7	7	7.6

Discussion

Based on previous research in the field stating that soil quality is a determinant of food security and the statistical significance linking better quality soil to PSNP graduation we can assume that households are able to graduate because their soil is improved. Better quality soil impacts households' ability to feed themselves as well as better their livelihoods. Households that participate in PSNP are usually subsistence, smallholder farmers and so their livelihoods are farming. Because of the significance of soil quality in farming it comes as no surprise that households with better soil would graduate faster than those with lower quality soil. Those who are able to better their soil would be able to grow and produce more on their land. This gives them viable crops to sell as well as food to feed their families with. It is therefore understandable as to why households with better soil quality graduate from PSNP.

The PSNP graduate households ranked higher on average over all soil indicators (see Table 2) except crop condition. The overall elevated ranking means that PSNP graduates have overall better soil. It can be noted that PSNP graduates have richer organic matter both in color and the presence of roots and residues. They also have an average lower rate of erosion. It can be assumed that the lower rate of erosion protects and supports the organic matter, which leads to increased fertility of the soil. The lower rate of erosion can be assumed to be linked with PSNP soil conservation public works such as terracing and tree planting.

Speculations are made that the soil is of better quality because of trainings and public works especially those involving SWC and NRM. Practices such as terracing, planting trees, and building bunds would all conserve soil. It can be extrapolated from the data that soil quality is better among PSNP graduates because of their time participating in PSNP and what they might have learned.

Further Research

While a direct link between soil quality and PSNP graduation has been identified there is still room for further research. The main inquiry for continuing research is whether the high quality soil, which leads to PSNP graduation, is affected by the PSNP trainings, extension or public works or whether those who are graduating already have land with better quality soil. The PSNP graduate households could have been interviewed to see which public works activities they partook in and if any involved NRM or SWC. Research could be conducted to see how effective PSNP public works and trainings are on soil conservation in the long run. It could be tested to see if these trainings and initiatives have a significant impact on the soil quality of a location by rating the soil before PSNP participation and comparing against soil quality after PSNP graduation.

The conceptual framework below shows the links between soil quality and PSNP graduation. High quality soil is the independent variable which affects the dependent variable, PSNP graduation. The conceptual framework also shows the need for potential research testing the independent variables: PSNP agriculture extension, public work or training; or pre-existing fertile land and proper soil conservation practices. These two independent variables would change the outcome of the dependent variable, high quality soil.

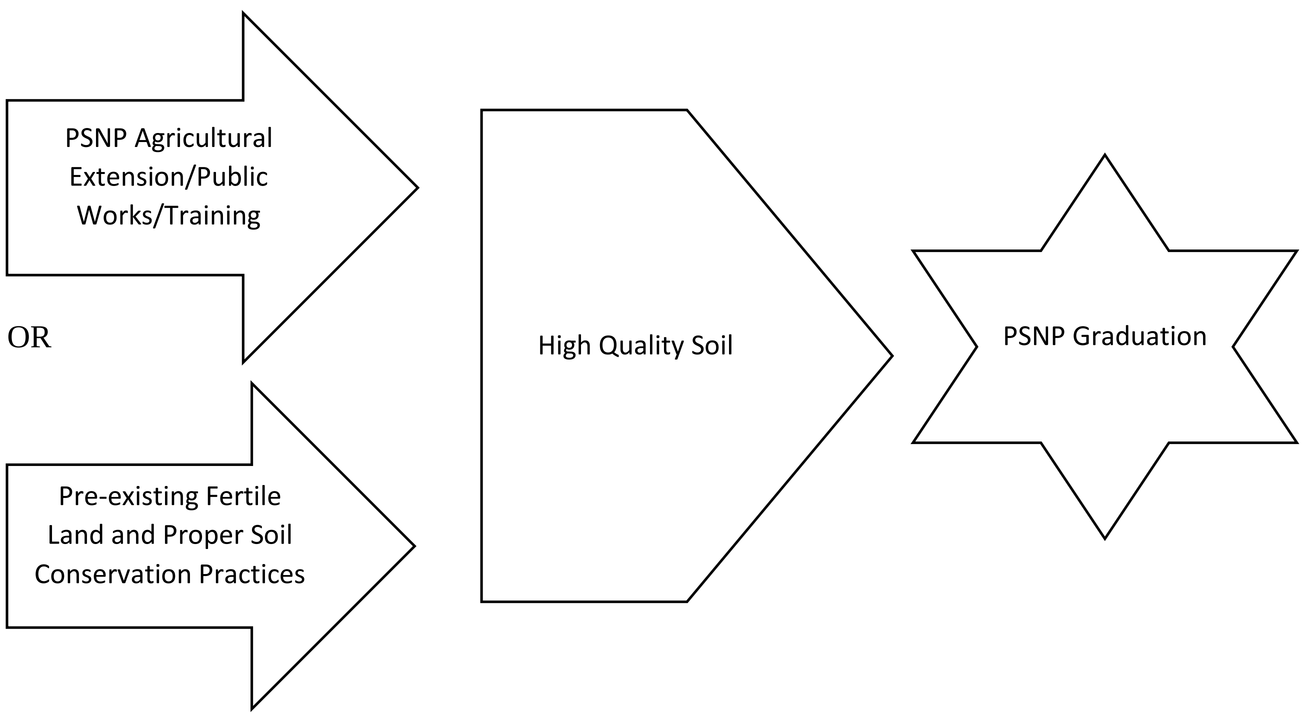

Figure 4 Conceptual Framework of Soil Quality and Psnp graduation

Interviews should have been conducted to see how long PSNP graduates and PSNP participants were enrolled in the program. It is possible that the length of time in the program could determine a household's soil quality or ability to graduate. Perhaps the PSNP graduates had passed a long time in the program, whereas the PSNP participants reviewed were new to the program and had not yet started to benefit.

One could also assume that the PSNP graduate sites should have significantly higher indicator values for crop condition, given the elevated values for organic matter, but crop condition has remained consistent among all three sample groups. It is unclear how PSNP participants and non-PSNP participants rank high in crop condition despite low rankings in organic matter. Further research is needed to determine what role soil quality plays in crop condition.

Implications and Recommendations for Sustainable Development

As the human population grows, the pressures put on the earth to feed this population become ever increasing. Food security has come to be recognized as a global issue of human security and impacts the global economy. The importance of understanding the drivers of food security will raise the earth's ability to increase production at a pace that matches the human population growth.

For many African nations, especially Ethiopia, it is not enough to just focus on economic growth. While Ethiopia's economic growth has been in the double digits for the last 4 years, it does ensure food security and equal access for the whole population. The government of Ethiopia needs to continue to look at development in a sustainable way, beyond just economic development. The Ethiopian government seems to understand the importance of planning for the future in an inclusive way. The government's Climate Resilient Green Economy (CRGE) strategy focuses on green economic growth and complements the country's Growth and Transformation Plan (GTP). The CRGE strategy is aimed at mitigating the country's greenhouse gas (GHG) emissions through sustainable agriculture, reducing deforestation and green industrial practices.

What the CRGE strategy fails to incorporate is the importance of soil conservation to the country's sustainable development. This paper has determined soil quality has direct implications for food security in Ethiopia, but it also is linked the country's agricultural output, GDP and exports. Preserving top soil in Ethiopia should be one of the nation's priorities if it hopes to continue its pattern of economic growth in a sustainable way. Trainings, education, extension and public works on soil conservation techniques should be continued throughout the country and not only for food insecure households but everyone directly involved in agriculture. Focusing on preserving soil quality is a must if the country aims to feed its growing population.

Personal Reflections

Conducting research for this paper brought me to many remote and isolated places to speak with households living off subsistence agriculture. The variations in families' soil quality was so immediately and obviously apparent to me. It was difficult to see families trying to survive off a plot of land that was clearly infertile and not suitable for crop production. While conducting this research I came to realize that there are so many other external independent variables that come into play with a family's ability to sustain and feed themselves beyond just soil quality. While soil quality was found to be statistically significant in its impact on food security, it also became apparent to me that other factors such as land size, access to markets or even a road, gender, or the amount of dependents a family has are all just as important as soil quality. As discussed in the section, further research, it remained to me unknown as to whether all the households visited had received agriculture extension from PSNP DAs which may have changed their soil quality or if they were just benefited from their originally fertile or infertile soil.

It was very difficult in the short three month period to gather all the evidence needed for my research. Some shortfalls and challenges did not become apparent to me until I was in the field and in the short period of time they could not all be remedied. Some of the challenges prevented me from using all of the soil quality indicators such as those which required specialized equipment I did not have. Another challenge when gathering data was that it brought up more questions. Since the nature of my data was to analyze and study soils I did not obtain IRB approval to study human subjects, thereby eliminating the chance that I could use interviews with the households whose lands I was studying. This did not seem to be a challenge going into the research process but once I started to conduct the research in country I realized the reality of the PSNP was different than the previous knowledge I had. I came to realize that not all PSNP participants received agriculture extension or training and that these things could have a significant impact on the quality of the soil or a household's ability to graduate from the program. Since I did not receive IRB approval previously I was unable to interview families as to what level of engagement in public works they had received as well as how long they had been PSNP participants. The ability to interview these families could have had a huge impact on the outcome of my research and made it more thorough and complete.

Despite the challenges I was able to complete my research to the best of my abilities with the tools and timeline I had been given. I owe a lot of my success to the help of CARE Ethiopia and the FSF team who supported me immensely in the site visits for my studies. It was their gracious support that made it possible.

Conclusion

Ethiopia’s PSNP has been an effective tool to raise many households out of poverty and food insecurity. A family’s ability to become food secure and graduate from the program is determined by many factors, one of which is soil quality. As this study proves, soil quality is directly linked to food security and PSNP graduation. Further research should be conducted to determine what impacts the soil quality of PSNP households.

The sustainable development of Ethiopia is contingent on the preservation and conservation of its top soil if it hopes to make the best of its fertile lands. The utilization and protection of these fertile lands will help Ethiopia to feed its growing population and contribute significantly to its economic growth. With a huge percentage of the country’s GDP attributed to the agriculture sector it is imperative that more research and emphasis goes into soil protection before it is too late. Education and training programs can help to slow or reverse the environmental degradation the country is currently experiencing from pressures of population and poverty. Conversely, as poverty affects the environment, the environment affects poverty. Natural resource management and soil conservation should be considered a pro-poor initiative that when targeted can inclusively enhance the well being of the Ethiopian population.

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ANNEX I:

Maryland Soil Quality Assessment Indicator Table

Indicator Table

Indicator	Poor	Medium	Good
Earthworms	0-1 worms in shovelful of top foot of soil. No casts or holes.	2-10 in shovelful. Few casts, holes, or worms.	10+ in top foot of soil. Lots of casts and holes in tilled clods. Birds behind tillage.
Organic Matter Color	Topsoil color similar to subsoil color.	Surface color closer to subsoil color.	Topsoil clearly defined, darker than subsoil.
Organic Matter Roots/Residue	No visible residue or roots.	Some residue, few roots.	Noticeable roots and residue.
Subsurface Compaction	Wire breaks or bends when inserting flag.	Have to push hard, need fist to push flag in.	Flag goes in easily with fingers to twice the depth of plow layer.
Soil Tilth Mellowness Friability	Looks dead. Like brick or concrete, cloddy. Either blows apart or hard to pull drill through.	Somewhat cloddy, balls up, rough pulling seedbed	Soil crumbles well, can slice through, like cutting butter. Spongy when you walk on it.
Erosion	Large gullies over 2 inches deep joined to others, thin or no topsoil, rapid run-off the color of the soil.	Few rills or gullies, gullies up to two inches deep. Some swift runoff, colored water.	No gullies or rills, clear or no runoff.
Water Holding Capacity	Plant stress two days after a good rain.	Water runs out after a week or so.	Holds water for a long period of time without puddling.
Drainage Infiltration	Water lays for a long time, evaporates more than drains, always very wet ground.	Water lays for short period of time, eventually drains.	No ponding, no runoff, water moves through soil steadily. Soil not too wet, not too dry.
Crop Condition (How well it grows)	Problem growing throughout season, poor growth, yellow or purple color.	Fair growth, spots in field different, medium green color.	Normal healthy dark green color, excellent growth all season, across field.
pH	Hard to correct for desired crop.	Easily correctable.	Proper pH for crop.
Nutrient Holding Capacity	Soil tests dropping with more fertilizer applied than crops use.	Little change or slow down trend.	Soil tests trending up in relation to fertilizer applied and crop harvested.

Assessment Sheet

Date__________ Crop_______________
Farm/Field ID______________________
Soil Quality Poor Medium Good

INDICATORS	1	2	3	4	5	6	7	8	9
Earthworms									
Organic Matter Color									
Organic Matter Roots/residue									
Subsurface Compaction									
Tilth/Friability Mellowness									
Erosion									
Water Holding Capacity									
Drainage Infiltration									
Crop Condition									
pH									
Nutrient Holding Capacity									
Other (write in)									
Other (write in)									

Assessment Guide

Indicator	Best Assessed
Earthworms	Spring/Fall Good soil moisture
Organic Matter Color	Moist soil
Organic Matter Roots/Residue	Anytime
Subsurface Compaction	Best pre-tillage or post harvest Good soil moisture
Soil Tilth Mellowness Friability	Good soil moisture
Erosion	After heavy rainfall
Water Holding Capacity	After rainfall During growing season
Drainage Infiltration	After rainfall
Crop Condition	Growing season Good soil moisture
pH	Anytime, but at same time of year each time
Nutrient Holding Capacity	Over a five year period, always at same time of year.

From: "Maryland Soil Quality Assessment Book"

ANNEX II:

Soil Quality Raw Data

Town	Soil Quality Indicator	Group 1	Group 2	Group 3
Toutakaneesa				
		PSNP Graduate	**PSNP Participant**	**Control**
	Organic Matter Color	8.5	7	7
	Organic Matter Roots/Residue	6	5	6
	Subsurface Compaction	6	5	5
	Tilth/Friability Mellowness	6	5	4
	Erosion	8	7	5
	Crop Condition	8	8	9
Lynch Wodesa				
	Organic Matter Color	7	7	6
	Organic Matter Roots/Residue	6	4	4
	Subsurface Compaction	8	3.5	7
	Tilth/Friability Mellowness	7	5	6
	Erosion	6	6	6
	Crop Condition	7	7	7
Odanegaya				
	Organic Matter Color	7.5	5	5
	Organic Matter Roots/Residue	5	4	3
	Subsurface Compaction	7	2	3
	Tilth/Friability Mellowness	6	3	3
	Erosion	7	1	5
	Crop Condition	6	6	7