Improving Organic Resource use in rural Ethiopia (IPORE)

7-11-2017. Overview of Research activities

Partners

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Project Summary

The shortage of organic resources in rural Sub-Saharan Africa (SSA) for improving long term energy, food and water provision is one of the region's greatest challenges. This project aims to increase our understanding of the interactions between food, energy and water associated with organic resource use in Southern Nations, Nationalities and Peoples' Region in Ethiopia (SNNPR). Using a range of multi and transdisciplinary methods it will help identify appropriate locally adapted solutions to improve community sustainability and resilience.

In two different districts of SNNPR, in wet and dry seasons, we collected data on water availability, soil characteristics and households and on how communities adapt their governance approaches to emerging environmental and demographic challenges. The data collected was used in detailed environmental modelling of changes in water availability, soil organic matter and nutrients. This was combined with socio-economic data to determine the economic attractiveness of alternative options at various levels, the impact of water availability on organic resource use, with data on the governance of common resources, providing insights into the conditions under which different technologies and techniques might be successful, and how changes in technologies, climate or livelihoods might require institutional adaptation. The process of data collection and analysis was shaped by engagement with policy makers and other stakeholders.

Main Activities

Kick off Project Meeting. Awassa, Ethiopia, , 19-23 July 2016. In a series of meetings the UK and Ethiopian partners reviewed the project aims and objectives and planned project activity. The two districts (Kebele) to be used for data collection were determined after a field visit and discussion with local officials. (Participants Aberdeen (4), Southern Agricultural Research Institute (3), Hawassa University (4). The PI also had discussions in Addis Ababa with (Bori) IMWI during this visit.

Survey Design and Testing. July-September 2016. During this period the partners designed the baseline Household questionnaire and biophysical data collection and agreed the protocols for biophysical data analysis. All data collected within the project uses Open Data Kit (ODK) software (http://opendatakit.org) to enable efficient data collection and processing, and this also requires significant effort prior to data collection to transform the questionnaire into the Data Tablet form and testing the processes of data upload work efficiently.

Base Household Data Collection and Analysis. October-November 2016. Full Data collection started later than originally planned due the declaration of a state of emergency in Ethiopia. After piloting the full Household Base Data collection of 163 households was successfully completed (Tefera and Lemma) by the beginning of November, with initial analysis completed (Albanito and Lemma) by the end of November.

Governance November 2017

Fischer (James Hutton Institute) spent one week in November in the study sites to identify the most suitable focus for the empirical work on common pool governance, participating in ongoing data collection (interviews and focus group discussions) by Hawassa University that involved subsistence farmers from three kebeles in Halaba Woreda (district). Candidate foci included access and governance of water (both drinking water from pumps and water points, and surface water from purpose-built ponds and Bilate river) and the governance of common-pool organic material in restoration areas and other, but largely heavily degraded, publicly accessible areas.

Stakeholder Workshop. 29 November 2016, Hawassa University. The workshop involved local and regional government, farmer and women group representatives, plus all project partners. It was held jointly with NERC-DfiD funded BREAD project and was conducted in Amharic. The workshop reported on the analysis of the Base Household Data Survey and helped identify the most important potential of methods of improving organic resource use for stakeholders, the barriers to use and how they might be overcome, and framed the discussion by the academics during the subsequent set of meetings of the project partners.

Partner Project Meeting. Awassa, Ethiopia, 28 November -1 December 2016. A series of meetings took place between 1) all UK and Ethiopian partners and 2) within the teams responsible for each main task. These reviewed progress so far drawing, where appropriate on the Stakeholder workshop discussions. The review of the Household data survey identified the areas which the subsequent data collection should focus on. Drawing on the focus group discussions led the partners to a draft work plan to focussing on the governance of common-pool organic material in restoration and other areas. Some issues raised by SARI concerning methods of soil testing were addressed with demonstration of experimental techniques from Hallett (Aberdeen) and in the use of the ODK system by Phimister.

Biophysical soil and water data collection. January-February 2017

Across two Kebele (Andegna Cheroko and Konicha) samples taken by SARI (Yakob, Boke and Habte) on a subsample of 36 farms interviewed within the household survey. During January and February, 2017 344 Soil samples (cores) were taken on the farms, across 3 zones on each farm (home, near and far) based on the distance from the homestead (as this is known to affect the level of organic material applied to the soil).

In addition, monthly observations were also taken on soil water at the 36 sites (starting in October 2016), while Hawassa University (Tefera) sampled water quality bi-monthly at a number of sites, (local well, communal and private ponds, River Blate)

Biophysical soil and water data analysis. June – October 2017

The soil samples have been analysed for carbon, nitrogen, mineral nitrogen, soil pH and soil water characteristics. Originally, it had been expected to run these tests at SARI in Ethiopia. However, ultimately they decided that they did not have the capacity to undertake these, and hence the project team decided to transfer the soil samples to University of Aberdeen, where the tests have been conducted. This was done partly via DHL and partly with Aberdeen staff members bringing back samples associated with their visits to Awassa. This and the need to organise and employ short term laboratory technician support did delay the start of this activity. However preliminary results of analysis were presented at the Stakeholder workshop in Halaba in early October.

Household Survey: Second Round Design January- February 2017

The partners reviewed the outcomes from the baseline Household questionnaire and finalised the design for second round household survey. As planned the survey was focussed on capturing seasonal differences in household time use. In addition, a range of other questions identified as important in for the modelling were also included e.g. when households marketed their crops.

Household Survey: Second Round Data Collection. March-April 2017. Data on 161 households was successfully completed by Hawassa University (Tefera and Lemma) by the beginning of April. Matching households surveys and data analysis was undertaken (Phimister)

Governance March-April 2017

Following on the decision taken at the partner meeting in December 2016, to focus the governance analysis on the common-pool organic material in restoration and other area, Fischer (James Hutton Institute) and Lemma (Hawassa University) undertook a week of stakeholder meetings discussions in early April 2017 with representatives of the Woreda (regional) agricultural office and other relevant individuals at the Woreda level, agricultural extension workers in the Kebeles (district) and other relevant individuals. In addition, two focus groups with male and female farmers were undertaken in Konicha district. These discussions in these meeting focussed on how the actors "felt the governance of common land might be improved such that people could obtain more fodder from these, and what the implications might be?"

Sub-project Meeting (Awassa, 29 March-3 April 2017, Fischer, Lemma, Phimister, Tefera).

Following the December workshop and April stakeholder and focus group discussions, the group of researchers undertaking the economic and social science research met. The importance of governance of common-pool organic material in restoration and other areas was acknowledged. In addition, it was recognized that the delays in the timings of the household surveys reduced the likely usefulness of a third update survey focussing simply on time use. Hence, it was decided it would be more beneficial to develop and adapt the third survey to focus on what local people preferred in terms of the local exclosure area management (common degraded woodland areas) using a discrete choice experiment. This would provide valuable input for key scenarios in the economic and biophysical modelling, and also provide a better basis for advice to the Woreda's Bureau of Agriculture and to the

participating kebeles on how they might change the way the exclosures are managed to improve how they meet the needs of the community.

Governance Discrete Choice Experiment Design April-June 2017

Via both email, and meetings in Aberdeen in April (Fischer, Phimister, Tefera) and in Kampala in July (Lemma, Phimister, Tefera), the team finalized the desired attributes, levels and instructions for the discrete choice experiment for the third survey (drawing on advice from DCE experts at the Health Economics Research institute at Aberdeen and Bori (IWMI)). After translation to Amharic, the questionnaire was pre-tested in late August. The final implementation was delayed by new political instability in the region. However, the collection of the DCE in the field was completed in early October.

Environmental and Economic Modelling. October 2016 – October 2017

A comprehensive, but simple, decision support tool was developed (by Smith) that assesses the use of organic resources and land management in Ethiopia's Awassa region, determining the impacts in terms of soil fertility, crop and animal production, water and energy use. This has be extended to allow for on– and off-farm labour and household consumption (Phimister, Albanito). This systems model, known as ORATOR (Operational research assessment tool for organic resources), is run using readily available soils and climate data, and information about land use, animals, energy and water sources on the farm. It quantifies the changes in resources associated with different management practices, and recommends practices that can be used to increase soil organic content.

The model provides a mechanism thought which the different strands of research within the project are brought together. The biophysical and household data collected is used to initialise the model, while the governance research provides valuable input for model scenarios such as whether livestock as a blessing or a burden for organic resource use.)

Development of Initial Key Results and Messages August – September 2017

A series of meetings took place in Aberdeen and in Awassa to develop and refine the initial key messages arising from the project in preparation for the second stakeholder workshop. These first involved the UK based partners (Aberdeen and James Hutton Institute), and Ethiopian based partners (Hawassa University, IWMI, SARI) meeting separately and then included a visit by Aberdeen partners to Awassa in September) (Nayek and Phimister). From these meetings, a series of workshop presentations and short key message summaries were produced for the Second Stakeholder workshop and translated for workshop participants (see appendix)

October 2017 Stakeholder workshop 3 October 2017, Halaba, Ethiopia

Halaba is the main town in the study region in Southern Nations, Nationalities and Peoples' Region in Ethiopia. This was part of a 2 day joint workshop drawing on outcomes of IPORE, BREAD (DfiD-NERC), and ALTER (DfiD) projects). It was conducted in Amharic and included as participants the Woreda (Area) Administration, Head from the Woreda Agricultural and Natural resources office, and the Head of Water, energy and electricity, Head of Environment, Forestry and climate change and Head of Livestock and Fishery, Kebele (district) development agents:, administration managers and Kebele chairpersons, community members (women, youth, men), plus representatives from the project team from Hawassa University, SARI and IWMI (Bori) plus members of senior management from Hawassa University and SARI. The workshop reported on the emerging results of the project, with participants helping to critically evaluate the results and their implications. In particular how applying Nexus thinking to the localities can change organic resource use, improve long term sustainability and resilience, and how scaling up of the approach developed might be achieved.

Outputs to date

Model

- Decision support tool that assesses the use of organic resources and land management (ORATOR)

Survey Instruments

Data

- Household Survey: Socio-economic data on individual time use, land allocation, cropping, marketing, organic resource use (crop residues, dung, wood), wealth, preferences on exclosure management
- Biophysical: Soil carbon, nitrogen, mineral nitrogen, soil pH and soil water characteristics from subset of Socio-economic survey households. Bi-monthly water quality at a number of sites, (local well, communal and private ponds, River Blate)

*Stakeholder Workshop Presentations & Key Message Summaries (**see appendix**)*

Stakeholder Workshop Reports

Poster provided for GCRF-ESRC Communications

Reports

Smith, J., Nayak, D., Phimister, E., Brand, A Albanito, F, Byg, A, Novo, P Tefera, T and G Yakob 'An Operational Research Assessment Tool for Organic Resources – Africa'

Example Key Message Summaries Provided to Participants Stakeholder Workshop, Halaba 2 October 2017

1) Status of Organic Resources

Methods

In a number of kebele we have collected biophysical and socio-economic data which provide a picture of the status of organic resources and their use in these areas. The Southern Agricultural Research Institute has been taking soil samples from farms across four Kebele's in Halaba (Choroko, Konicha, Asore and Lay Arisho). At each farm samples were taken in the most intensively managed region near to the home (Home field), nearby where management intensity decreases (Near field) and furthest away where management is least (Far). We have taken these soils to the University of Aberdeen to analyse their health by how much carbon and nutrients they hold, as well as their ability to supply water to crops. In Konicha and Choroko we have undertaken a survey of 161 households in two surveys in October 2016 and April 2017 asking each household questions covering their crop residue, dung and wood use, their access to water and how farming and household activities constrain their time across the seasons.

Soil Information

Carbon is a building block of soil that binds together soil particles into more stable aggregates, holds onto water and provides food for organisms that cycle nutrients that are used by crops. Depleted soil carbon is one of the greatest threats to soil health in the world. Conflicting uses of the carbon for fuel and animal feed in Halaba restricts the amount of residue that is available to return to soils to build carbon. Home fields, where more carbon may be returned to soil to produce more valuable food crops, more carbon is consistently found in all Kebeles that were sampled. There was a large spread in the amount of carbon held in the soils, so we are currently investigating the cause. This could be due to the properties of the soil or its management.

Many of the same substances that provide carbon to soil also provide other nutrients. Nitrogen is the major nutrient that will affect your crop yield, which can be provided by both organic residues and added fertilisers. The amount of nitrogen found in Halaba soils from different areas from the home follows the same trends as carbon. Nitrogen is much greater in the home fields than in fields further away, with major differences between Kebeles. We are currently analysing how much of the nitrogen in the soil is available for the crop to use, as some will be in forms that plants cannot access.

Another dominant soil property affecting its productivity is acidity or alkalinity described by pH. Crops have optimal pH ranges for productivity that vary between species; e.g. maize pH 6-7, coffee pH 6-6.5. In Halaba many soils have a good pH to produce a range of crops (Figure 4), but there are instances where pH is outside of the optimal range.

Household Information on Organic Resource Use

In both Konicha and Choroko, the primary uses for maize and teff crop residues were firstly feed and then fuel, with sorghum residues used for construction. Dung was collected (often daily) by around 80% of households in both kebeles at some point during the year, although the number of households collecting dung was significantly less (particularly in Choroko) in the period January- March. The primary use of dung was as direct fertilizer to improve the organic matter in the soil, although a significant amount is also used for fuel. There was limited evidence of composting although its importance did appear to rise in the January- March period for those households who were collecting dung during that period, particularly in Choroko. The main energy sources used for cooking in both areas were wood followed by crop residues and then to a significantly lesser extent, dung. In Choroko, there was also some use of charcoal. The extent to which a variety of energy sources is used appears to fall during the period January- March relative to the July-September. In Konicha, there appears to be an increased use of dung in the January- March period. For all households, wood was obtained from own and communal sources although a small minority of households (around 10% in Konicha) also made purchases.

The results on allocation of time within households suggest that women in both areas spend their time cooking, collecting water and firewood, and (during the growing and harvest periods) undertaking agricultural activities. Adult men spend most time on agricultural activities and livestock supervision. Children spend most time collecting water and wood although female children also have responsibilities for cooking and dung collection whereas male children spend time supervising livestock and on other agricultural activities.

There are significant seasonal effects, some of which appear to differ across the two areas. For example, adult men in Konicha play a more significant role in water collection during the dry season whereas during the wet season and in Choroko, they spend little time on water collection. Similarly, in contrast to men in Choroko, the time spent supervising livestock increases in the dry season, whereas that for male children falls. Overall there is little difference in the time spent for women across the two areas, but men in Konicha spend more time on the various activities than men in Choroko (although this remains smaller than the amount spent by women).

These differences would appear to reflect the significant differences in accessibility to water across the two Kebele. Both water points for drinking water and livestock are much more distant and take longer to get to in Konicha than Choroko. For example, for drinking water, water points in Konicha are twice as far and take twice as long to get to than Choroko. These differences are particularly acute during the dry season. In addition to the larger role that adult men play in Konicha in water collection, the frequency with which livestock are taken to water during the Bega season drops considerably in Konicha.

Improving Soil Fertility: Potential Questions

How could Soil fertility of further fields be improved?

Could more crop residues & dung be used for soil fertility?

Could use of composting be increased?

2) Management measures to improve household resources in Halaba, Ethiopia

Soil water - Soils with higher carbon contents can absorb more water when it rains, and so will take longer to dry out and reduce crop yields. Soils of Halaba typically contain 1.52 - 1.69% carbon. After a heavy rainfall, the soils at the bottom end of this range hold 1 - 5% less water than the soils at the top of the range. Depending on the composition of the soil, adding 0.1 - 2.5% carbon would have delayed drying out in the 2015 drought by at least one month. This can be done by incorporating animal dung before the crop is sown; an extra 50 quintals added each year to every hectare of land could increase the carbon content of the poorer soils in Halaba by 2.5% within 10 years.

How increasing soil carbon can reduce drought impact across the farm - The average carbon content of soils in Halaba is higher in home gardens (1.95%), than near (1.51%) or far fields (1.33%). Because, teff and wheat are usually grown in far fields, they are often grown on soils with lower carbon contents. If the soil had been improved by applying 50 quintals of animal dung each year to a hectare of land, in the drought of 2015 the loss of crop yield compared to a non-drought year could have been reduced by approximately 36% for maize, 58% for teff, 56% for pepper, 24% for sorghum and 51% for wheat. Assuming farm gate prices in Table 1, applying this amount of dung could provide extra revenue in a drought year of 144 ETB for maize, 928 ETB for teff, 1400 ETB for pepper, 249 ETB for sorghum and 234 ETB for wheat from the area of land that yields 1 quintal of produce in a non-drought year. Assuming typical yields in Halaba for crops without extra fertiliser as given in Table 1, this equates to extra revenue from each hectare of land of 1400 ETB for maize, 5700 ETB for teff, 3800 ETB for pepper, 1500 ETB for sorghum and 2100 ETB for wheat.

Value of applying dung in terms of saved fertilizer - Animal dung also contains nutrients that help the crops to grow. Depending on the weather conditions and the quality of the feed given to animals, applying animal dung can provide between 0.03 and 0.04 quintals of nitrogen in the first year for every quintal of dung applied. The amount of this nitrogen that is captured by the crop depends on the rainfall, length of growing season and depth of roots, but assuming the price of nitrogen fertiliser is 1200 ETB per quintal, the nitrogen provided by one quintal of dung has a value of between 36 and 48 ETB. If 50 quintals of animal dung were applied to every hectare of land, this would provide between 1.5 and 2.0 quintals of nitrogen, with a value of 1800 to 2400 ETB. In Halaba, the most common method of manure application is surface application to the soil. Ploughing in the manure could reduce nitrogen losses to the atmosphere and improve crop production by 5 - 15% [e]. Assuming farm gate prices and typical yields for Halaba in Table 1, ploughing in dung instead of leaving it on the surface could provide extra revenue per hectare of 500 - 1600 ETB for maize, 800 - 2500 ETB for teff, 600 - 1800 ETB for pepper, 600 - 1700 ETB for sorghum and 800 - 2500 ETB for wheat in a non-drought year. In a drought year, this benefit would be reduced to 300 - 1000 ETB for maize, 400 - 1100 ETB for teff, 300 - 800 ETB for pepper, 400 - 1100 ETB for sorghum and 500 - 1500 ETB for wheat. Field trials in Halaba showed that combining applications of dung with inorganic fertilizers could further increase maize and teff yields by 52 - 66% and 35 - 76% respectively [b].

Costs of using dung for soil incorporation - If there is unused dung available on the farm, it could be incorporated into the soil to improve resilience to drought and increase the nutrients available to crops. However, dung is often used for other important purposes, such as to provide a household fuel; households in Halaba typically obtain 15% of household cooking fuel from dung. Every quintal of dung provides the same amount of energy as 0.4 to 1.0 quintals of woodfuel, so if 50 quintals of dung is applied to the soil instead of using it as a fuel, an extra 20 – 50 quintals of woodfuel will need to be collected or purchased. Households in Halaba typically require 3 - 6 hours to collect one bundle of woodfuel, weighing 0.2 quintals [f], so this equates to an extra 300 – 1500 hours spent collecting

woodfuel each year. The average cost of purchasing one bundle of woodfuel in Halaba is 30 ETB [f], so buying this amount of extra woodfuel would cost 3000 – 7500 ETB.

Use of crop residues - The amount of dung needed can be reduced by composting it with other organic wastes before applying it to the soil. Most crop residues should not be incorporated without composting it first because the early phases of decomposing materials with a low nutrient concentration can cause nutrients to be locked away from crops resulting in temporary nutrient deficiency. Composting reduces the amount of dung needed to increase soil carbon and adjusts the composition of the crop residues so that the nutrients they contain can quickly be released to the crops.

Soil and water conservation measures - If the field is on sloping ground and there are high levels of erosion during wet periods, another way to increase soil carbon is by reducing the losses in eroding soil. Soil and water conservation measures can be used to reduce runoff and erosion. Measures that are appropriate to agricultural land include mulching with crop residues or compost, and construction of physical structures, such as bunds along field contours, to improve water availability for crop production. Sediment loss from soils in Ethiopia has been observed to be reduced by 40 to 66% by installing soil bunds [g], depending on the slope and soil type; for the soils of Halaba, this is equivalent to a reduced loss of carbon of 0.6 - 1.1% or 1.5 – 6.8 quintals from each hectare of land every year, and would be offset by applying an extra 20 - 37 quintals of dung per hectare. A proportion of the field is taken out of production by constructing a soil water conservation structure, but the productivity of the remaining land can be significantly improved over the long term by providing crops with better access to water and nutrients.

Summary – Applying dung to soils can improve crop yields, depending on the amount of dung applied and the composition of the soil. In a non-drought year, the minimum costs of replacing 50 quintals of dung used as fuel (3000 ETB) exceeds the benefits to crops (1800 - 2400 ETB in saved fertiliser) unless the dung is ploughed in. Ploughing in provides a maximum benefit per hectare of 400 ETB for maize, 500 ETB for teff, 200 ETB for pepper, 500 ETB for sorghum and 1000 ETB for wheat in a non-drought year. In a drought year, the benefits increase due to soils retaining more water to 1500 ETB for maize, 5800 ETB for teff, 3700 ETB for pepper, 1600 ETB for sorghum, 2500 ETB for wheat.

Table 1. Farm gate price and typical yield for major crops in Halaba

Crop	[a] Farm gate price of produce (ETB per quintal)	Typical yield with no fertiliser (quintals per hectare)
Maize	400	[b] 26.4
Teff	1600	[b] 10.5
Pepper	2500	[c] 4.9
Sorghum	692	[d] 16.4
Wheat	650	[b] 25.1

[a] SARI records; [b] SARI field trials for ALTER project; [c] Shumeta, 2012, Trends Ag Econ, 5, 83-95; [d] Abebe, 2015, MSc thesis, Haramaya University; [e] Adekiya & Adbebe, 2016, J Saudi Soc Ag Sci, doi:10.1016/j.jssas.2016.01.006; [f] Moges, pers.comm; [g] Gebremichael & Yakob, 2016, J Nat Sci Res, 6, 77-86.