CEPHaS VIRTUAL CONFERENCE

Understanding Conservation Agriculture: Soil, Crops & Water Under Climate Change

MONDAY 6 DECEMBER 8:00 – 11:00 GMT
WEDNESDAY 8 DECEMBER 8:00 – 11:00 GMT
FRIDAY 10 DECEMBER 8:00 – 11:00 GMT

BGS · University of Zimbabwe · Rothamsted Research · Liverpool School of Tropical Medicine · The University of Nottingham · ZARI · Kasisi Agricultural Training Centre · UKRI Natural Environment Research Council · GCRF

Strengthening Capacity in Environmental Physics, Hydrogeology and Statistics for Conservation Agriculture Research

Programme

Time (GMT/CAT)	DAY 1: Monday 6th December Theme: CA impacts on soil functions and crop yield
08:00 – 08:20 GMT 10:00 – 10:20 CAT	**Introduction and Welcome** (**Murray Lark** & **Alessia D'Artibale**)
08:20 – 08:45 GMT 10:20 – 10:45 CAT	**Keynote: Prof. Martin Broadley (Rothamsted Research, University of Nottingham)***
08:45 – 09:05 GMT 10:45 – 11:05 CAT	**Soil moisture retention curves under reduced and conventional tillage.** M. Moombe, E. Phiri, G. Musukwa, V. Mbanyele, T. Mtangadura, H. Nezomba, J. Chimungu, A. Gregory, R. Whalley, M. Lark
09:05 – 09:25 GMT 11:05 – 11:25 CAT	**Comparative long-term performance of conservation agriculture and conventional tillage on soil water dynamics and maize (Zea mays L.) yield in semi-arid Zimbabwe.** V. Mbanyele, H. Nezomba, F. Mtambanengwe, T. Mtangadura, A.S. Gregory, W.R. Whalley, P. Mapfumo
09:25 – 09:45 GMT 11:25 – 11:45 CAT	**CA influences on soil organic carbon and aggregate stability.** K. Njira, A. Tye, I. Ligowe, C. Sturrock, V. Mbanyele
09:45 – 10:00 GMT 11:45 – 12:00 CAT	**BREAK (15 min)**
10:00 – 10:30 GMT 12:00 – 12:30 CAT	**Keynote: Dr Christian Thierfelder (CIMMYT)*** **Developing resilient and sustainable cropping systems for a changing climate - the case of southern Africa**
10:30 – 11:00 GMT 12:30 – 13:00 CAT	**CEPHaStat_3: A review and update.** M. Lark, C. Miti, C. Chisanga, J. Chimungu, H. Nezomba

Time (GMT/CAT)	DAY 2: Wednesday 8th December Theme: Soil properties and soil information
08:00 – 08:05 GMT 10:00 – 10:05 CAT	**Welcome**
08:05 – 08:35 GMT 10:05 – 10:35 CAT	**Keynote: Dr David Chikoye (IITA)***
08:35 – 08:55 GMT 10:35 – 10:55 CAT	**Analysis of soil microstructure using X-ray Computed Tomography from CEPHaS Conservation Agriculture field trials.** C.J. Sturrock, I. Sandram, T.J. Mtangadura, A.S. Gregory, W.R. Whalley
08:55 – 09:15 GMT 10:55 – 10:15 CAT	**Pedotransfer functions for Southern Africa: A review and quantitative appraisal and re-parameterization of selected functions.** C. Miti, R.M. Lark, H. Nezomba, J. Chimungu, I. Sandram, N. Magwero, J. Banda, E. Phiri
09:15 – 09:35 GMT 11:15 – 11:35 CAT	**Legacy soil information as a framework to address contemporary challenges. Perspectives from Zambia**. I. Mukumbuta, C. Miti, S. Sichinga, L. Chabala, M. Lark
09:35 – 09:50 GMT 11:35 – 11:50 CAT	**BREAK (15 min)**
09:50 – 10:20 GMT 11:50 – 12:20 CAT	**Keynote: Dr Matthew Mbanga (Foundations for Farming)***
10:20 – 10:40 GMT 12:20 – 12:40 CAT	**Modelling soil hydrothermal regimes under reduced and conventional tillage systems.** E. Phiri, R. Whalley, A. Gregory, A. Tye, C. Chisanga, M. Moombe, M. Lark, C. Miti, P. Lubinga, O. Lungu
10:40 – 11:00 GMT 12:40 – 13:00 CAT	**Long-term trends in rainfall and temperature over Southern Africa: a case study of Chitedze, Domboshava and Liempe.** C.B. Chisanga, E. Phiri, C. Miti, M. Moombe, M. Lark

**abstract not included*

Programme (cont.)

Time (GMT/CAT)	DAY 3: Friday 10th December Theme: Monitoring water in soil, crop and aquifer and capacity strengthening
08:00 – 08:05 GMT 10:00 – 10:05 CAT	**Welcome**
08:05 – 08:35 GMT 10:05 – 10:35 CAT	Keynote: **Ms Marthe Wens (Vrije Universiteit Amsterdam)*** **Managing droughts & floods in the Limpopo basin: Bringing together different types of information and co-creating scenarios** & **Dr Anne Van Loon (Vrije Universiteit Amsterdam)*** **Education, financial incentives and awareness to reduce smallholder farmers' vulnerability to drought: A MODELLING STUDY**
08:35 – 08:55 GMT 10:35 – 10:55 CAT	**Climate-smart agriculture impacts on groundwater recharge estimates.** D. Mudimbu, K. Banda, B. Brauns, D.J. Lapworth, A.M. MacDonald, W. Namaona, R. Owen, M. Sinda
08:55 – 09:15 GMT 10:55 – 12:15 CAT	**Capacity building in multi-disciplinary methods for improved understanding of the impact of conservation agriculture on groundwater resources in Africa.** W. Namaona, T. Chavula, D. Mudimbu, K. Banda, B. Brauns, D.J. Lapworth, A.M. MacDonald, R. Owen, M. Sinda
09:15 – 09:35 GMT 11:15 – 11:35 CAT	**Institutional capacity strengthening within CEPHaS: A mixed methods study.** K. Duda, Justin Pulford
09:35 – 09:50 GMT 11:35 – 11:50 CAT	**BREAK**
09:50 – 10:10 GMT 11:50 – 12:10 CAT	**Imaging geolectrical responses of agricultural soils to rainfall events.** R. Swift, J. Chambers, J. Boyd, P. Wilkinson, C. Inauen, T. Mtangadura, E. Phiri, I. Sandram, P. Meldrum, H. Harrison, P. Mapfumo, P. Nalivata, F. Mtambanengwe, J. Chimungu, C. Chisanga, I. Ligowe, P. Lubinga, N. Magwero, T. Mapangisana, V. Mbanyele, C. Miti, M. Moombe, W. Namaona, H. Nezomba, K. Njira, O. Kuras, A. Watlet, J. Whiteley, M. Cimpoiasu, F. Nguyen, M. Lark
10:10 – 10:30 GMT 12:10 – 12:30 CAT	**Rising groundwater temperatures in Zimbabwe, Zambia and Malawi.** B.Brauns, R. Owen, D. Mudimbu, W. Namaona, M. Sinda, K. Banda, D.J. Lapworth, A.M. MacDonald
10:30 – 10:50 GMT 12:30 – 12:50 CAT	**An Evaluation of labour use in Conservation Agriculture: A case of smallholder farming systems in Zimbabwe.** S. Siziba, F. Mtambanengwe, T. Mapangisana
10:50 – 11:00 GMT 12:50 – 13:00 CAT	**Closing remarks**

**abstract not included*

Soil moisture retention curves under reduced and conventional tillage

Authors: **M. Moombe**[1*], E. Phiri[1], G. Musukwa[1], V. Mbanyele[2], T. Mtangadura[2], H. Nezomba[2], J. Chimungu[3], A. Gregory[4], R. Whalley[4], M. Lark[5,6]

[1]University of Zambia, Lusaka, Zambia
[2] University of Zimbabwe, Harare, Zimbabwe
[3] Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi
[4] Rothamsted Research, Harpenden, UK
[5] British Geological Survey, Nottingham, UK
[6]University of Nottingham, Nottingham, UK
**Correspondence: Miyanda.moombe@unza.zm*

Abstract

Knowledge of soil water retention curves (SWRC) defined as soil water content as a function of soil matric potential (Ψm), is a critical soil hydraulic property and presents a prerequisite to modelling soil water and solutes fluxes in the vadose zone. Its measurement is laborious and often yield a few discrete points of the SWC (ψ- θ) measured values. Parametric models are used to provide continuous representation of the highly non-linear SWRC through mathematical models. Soil moisture retention curves were analyzed from data at the three CEPHaS Project sites in Malawi, Zambia and Zimbabwe. The objective of the study was to evaluate the effects of tillage, reduced (RT) and conventional tillage (CT) on soil moisture retention curves. The water retention experimental data were used to construct and parameterize water retention with van Genuchten model (1980) using inverse modeling to describe a water retention curve. Soil water retention was measured on undisturbed samples in the laboratory using the hanging suction column apparatus and the pressure plate extractor with typical usage suction ranges of 0–30 and 100–1500 kPa, respectively. The results showed that conservation agriculture has had some measurable effects on the SWRC compared to conventional tillage, however the effects appeared to be site-specific. At Liempe, we observed increased water retention under CA when compared with CV while at Domboshava increased water retention was evident at depths 10 – 20 cm, however at Chitedze increased water retention was observed at higher water retention. Information of SWRCs under long-term tillage management is essential for understanding water availability of the tropical cropping systems.

Comparative long-term performance of conservation agriculture and conventional tillage on soil water dynamics and maize (*Zea mays* L.) yield in semi-arid Zimbabwe

Authors: **Vengai Mbanyele**[1*], Hatirarami Nezomba[1], Florence Mtambanengwe[1], Tongai Mtangadura[1], Andrew S. Gregory[1], W. Richard Whalley[1], Paul Mapfumo[1]

[1] University of Zimbabwe, Harare, Zimbabwe
[2] Rothamsted Research, Harpenden, UK
**Correspondence: vengaimbanyele@gmail.com*

Abstract

Rainfed crop production in semi-arid environments of southern Africa is subject to several constraints. These include low rainfall amounts, high rainfall variability on both temporal and spatial scale, and significant moisture loss through evaporation. Conservation agriculture (CA) anchored on reduced tillage and mulching is currently promoted as a way to stabilize yields and improve crop water use efficiency. Performance of CA and conventional tillage on soil water content and maize grain yield were compared in a long-term experiment established at Domboshava Research Station in a semi-arid area of Zimbabwe. The treatments were replicated three times in a randomized complete block design. Soil moisture content was monitored down to 1 m using the PR2 soil moisture probes connected to a data logger that was logging every hour during three consecutive cropping seasons (2018 – 2021). Maize was harvested at physiological maturity and grain weight was measure at 12.5% moisture content. The two practices had no significant effect on seasonal soil water content, although conventional tillage had slightly more soil water content particularly between 20 and 40 cm depths. The practices significantly influenced maize grain yields with CA achieving 4.1, 2.5 and 3.0 t ha^{-1} during 2018/19, 2019/20 and 2020/21, respectively, while corresponding values for conventional tillage were 3.5, 2.2 and 2.3 t ha^{-1}. We conclude that, in the long-term, CA performs better than conventional tillage for maize grain yield although there are no significant differences in soil water content.

CA influences on soil organic carbon and aggregate stability

Authors: **Keston Njira**[1*], **Andrew Tye**[2*], Ivy Ligowe[3], Craig Sturrock[4], Vengai Mbanyele[5]

[1] Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi
[2] British Geological Survey, Nottingham, UK
[3] Department of Agricultural Research Services, Lilongwe, Malawi
[4] University of Nottingham, Nottingham, UK
[5] University of Zimbabwe, Harare, Zimbabwe
**Correspondence: knjira@luanar.ac.mw, atye@bgs.ac.uk*

Abstract

Conservation agriculture (CA) is defined by three key principles: minimum tillage, retention of residues on soil surface and crop diversification/rotations, and is widely promoted across sub-Saharan Africa as a sustainable farming practice that improves adaptive capacity to climate variability and change. Increases in soil organic carbon (SOC) is one potential benefit of CA and could influence soil structure and soil moisture movement. CA field experimental plots at Chitedze research station in Malawi have existed for 15 years. Soil samples were collected in its 11th year to assess whether CA had produced changes in soil organic carbon concentrations, soil aggregation and aggregate stability on two selected treatments. These were a continuous maize in conventionally managed system (without residue retention) (T1) and a minimum tillage (direct seeding) with residue retention treatment (T3). Two sample depths were examined, 0-10cm and 10-30cm.

Organic carbon concentration (%) was found to be higher in the bulk (< 2mm) soils and 1-2mm macro-aggregates in the T3 treatment, with increases in % C at both depths. Treatment: Depth interactions (both P<0.06) were identified, suggesting that a slow increase in SOC was occurring in the T3 treatment. A number of SOC quality indicators were undertaken (Rock-Eval, Laser Florescence (LIFS) and $\delta^{13}C$) to assess the character of SOC in bulk soil and 1-2mm aggregates. $\delta^{13}C$ measurements indicated a significant (P<0.05) enrichment of ^{13}C in the SOC at 10-30 cm. However, the variation in the LIFS and Rock-Eval results suggest that there was no consistent change in SOC quality between the SOC in bulk soil and that in macro-aggregates. Aggregate stability (1-2mm aggregates) was measured using a laser-granulometer based method to calculate disaggregation ratio properties, but no treatment effects were found. Overall, results suggest that the slow increase in SOC concentrations produced by CA are not yet reflected in wider soil aggregate properties.

CEPHaStat_3: A review and update

Authors: **Murray Lark**[1,2*], Chawezi Miti[3], Charles Chisanga[3], Joseph Chimungu[4], Hatirarami Nezomba[5]

[1] British Geological Survey, Nottingham, UK and
[2]University of Nottingham, Nottingham, UK
[3] University of Zambia, Lusaka, Zambia
[4] Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi
[5] University of Zimbabwe, Harare, Zimbabwe
**Correspondence: mlark@bgs.ac.uk*

Abstract

The third version of the CEPHaStat function collection for the R platform is released. The collection makes available a range of tools for analysis of data of particular relevance to the study of soil systems. In this presentation we shall review some of its capability, focusing on the following

- Fitting water release curves, making inferences about treatment effects and interpreting the data quantitatively
- Fitting censored models to data on soil properties.

CEPHaStat_3 will be placed on GitHub at the start of 2022 with its documentation, so this is an opportunity to share it first across the wider community with a view to gathering comments and feedback. The presentation will be, primarily, a live demonstration with code, documentation and example data made available in advance so that users can run them in parallel.

Analysis of soil microstructure using X-ray Computed Tomography from CEPHaS Conservation Agriculture field trials

Authors: **Craig J Sturrock**[1], Innocent Sandram[2], Tongai J Mtangadura[3], Andrew S Gregory[4], W Richard Whalley[4]

[1]School of Biosciences, University of Nottingham, UK
[2]Lilongwe University of Agriculture and Natural Resources (LUANAR), Malawi
[3]Department of Soil Science & Agricultural Engineering, University of Zimbabwe
[4]Rothamsted Research, UK
Correspondence: Craig.Sturrock@nottingham.ac.uk

Abstract

Agricultural management practices can have both positive and negative influences on the structure of the soil. Poor soil structure is linked to loss of pore space which impacts on water infiltration and runoff which can make the soil more susceptible to erosion. However, agricultural management practices that improve soil structure can stimulate soil microbiology and in turn improve aggregate stability. In this talk, X-ray Tomography data will be presented to illustrate differences in soil structure from cores collected from CEPHaS conservation agriculture field trials.

Pedotransfer functions for Southern Africa: A review and quantitative appraisal and re-parameterization of selected functions

Authors: **C. Miti**[1*], R.M. Lark[2,3], H. Nezomba[4], J. Chimungu[5], I. Sandram[5], N. Magwero[5], J. Banda[1], E. Phiri[1]

[1] University of Zambia, Lusaka, Zambia
[2] British Geological Survey, Nottingham, UK and
[3]University of Nottingham, Nottingham, UK
[4] University of Zimbabwe, Harare, Zimbabwe
[5] Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi
**Correspondence: mitichawezi14@gmail.com*

Abstract

Pedotransfer functions (PTFs) for soil hydraulic properties have been little-used in Sub-Saharan Africa despite the scarcity of direct measurements of the soil properties of interest, and the potential to address these with such models. We evaluated to what extent existing PTFs provide a useful tool for the prediction of soil moisture content at field-capacity (33kPa) and wilting-point (1500kPa). Soil property data on soil texture, bulk density, OM and water content (33kPa and 1500 kPa) were collected from legacy data for Zambia, Zimbabwe and Malawi, and thirteen temperate and tropical PTFs were selected for evaluation. Mean error (ME) and components of variance (VC) (within-profile, within-site and between-site) for models which included the mean value as random effect were used to access PTF performance. PTFs with ME close to zero and a corresponding lower sum of VC are considered better performers. At 33 kPa, tropical PTF of Botula *et al.* (2013) was the best performer with lowest ME, 0.02 with confidence interval including zero, and relatively lower sum VC. Furthermore, the low within-profile VC indicates better predictions at profile level than at broader scales. At 1500 kPa, tropical PTFs of Botula *et al. (*2013), Dijkerman (1988), Lal (1979), Oliveira *et al.* (2002) and van den Berg *et al. (*1997) were good performers with ME in the range −0.05 to 0.05 and a relatively low sum of VC. Low within-profile and between-site VCs indicates these PTFs are good for both profile and broad-scale predictions at 1500 kPa. Temperate PTFs generally showed poor performance at both 33 kPa and 1500 kPa. Rawls *et al.* (1982) was the worst performer with significant negative bias and a relatively high sum of VC. However, temperate PTF of Saxton and Rawls (2006) showed comparable and sometimes better performance than some tropical PTFs. Reparamaterisation of PTFs with local data further revealed that coefficients of temperate PTFs of Rawls and Brankensiek (1982), and Rawls *et al.* (1982) are not suited for local settings at both 33 kPa and 1500 kPa. This study showed that PTFs of Botula *et al.* (2013) can be used for predictions at 33 kPa while Botula et al. (2013), Dijkerman (1988), Lal (1979), Oliveira et al. (2002) and van der Berg (1997) can be used at 1500 kPa depending on available data inputs in the study area.

Legacy soil information as a framework to address contemporary challenges. Perspectives from Zambia

Authors: **Ikabongo Mukumbuta**[1*], Chawezi Miti[1], Stalin Sichinga[2], Lydia Chabala[1], Murray Lark[3,4]

[1] School of Agricultural Sciences, University of Zambia, Great East Road Campus, Lusaka, Zambia
[2] Soil Survey Unit, Zambia Agriculture Research Institute, Mt Makulu Central Research Station, Chilanga, Lusaka, Zambia
[3] British Geological Survey and University of Nottingham, UK
[4]University of Nottingham, Nottingham, UK
*Correspondence: ikabongo1@gmail.com

Abstract

Soil information is essential as a basis for planning experimental programmes to study agricultural interventions, and as a basis for implementing these at scale. However, it is costly to obtain, and requires expertise which is often in short supply. That said, most countries have legacy soil information, collected over the last 100 years or so, in the form mainly of conventional soil maps based on pedological principles and soil classification.

In this presentation we shall show some results from the InSTAnZa project, a GCRF project undertaken in Zambia by colleagues from UNZA, University of Nottingham, ZARI and University College London. This project was aligned with CEPHaS, and overlapped in some use of data.

Specifically, we shall discuss the following

i. How different sources of legacy soil information may be compared as part of their assessment
ii. Some of the practical challenges in assembling the legacy of soil survey information
iii. How soil surveys can be assessed quantitatively for comparative purposes
iv. How contemporary stakeholders have reacted to legacy soil information

Modelling soil hydrothermal regimes under reduced and conventional tillage systems

Authors: **Elijah Phiri**[1], Richard Whalley[2], Andrew Gregory[2], Andrew Tye[3], Charles Chisanga[1], Miyanda Moombe[1], Murray Lark[3,4], Chawezi Miti[1], Pathias Lubinga[1], Olipa Lungu[1]

[1] University of Zambia, Lusaka, Zambia
[2] Rothamsted Research, UK
[3] British Geological Survey, Nottingham, UK
[4]University of Nottingham, Nottingham, UK
**Correspondence: ephiri@unza.zm*

Abstract

Limited information is available about the effects of conservation agriculture (CA) practices on soil temperature moderation and distribution of water in the soil profile during crop growth, particularly on the changes in the components of water and energy balance. Information about thermal properties is required for modeling energy, water and nutrient movement in soils. Soil physical properties affecting soil thermal regimes include texture and mineralogical composition of the soil (static properties), soil water content, compaction, organic matter, porosity, etc. (dynamic properties). In the era of climate change and under rainfed conditions, soil and moisture/water conservation, temperature moderation, soil health maintenance increase agricultural productivity. The objective of the study was to assess soil hydrothermal regimes and water and energy balance components in maize (Zea may L) and legume intercropping grown under CA system using the Hydrus-1D model.

Long-term trends in rainfall and temperature over Southern Africa: a case study of Chitedze, Domboshava and Liempe

Authors: **Charles Bwalya Chisanga**[1*], Elijah Phiri[2], Chawezi Miti[2], Miyanda Moombe[2], Murray Lark[3,4]

[1]Copperbelt University, Department of Plant and Environmental Sciences, Kitwe, Zambia 10101
[2]University of Zambia, Zambia 10101
[3]British Geological Survey, UK
[4]University of Nottingham, UK
**Correspondence: charles.chisanga@cbu.ac.zm*

Abstract

Trend analysis of rainfall and temperature data is important for understanding variability in the weather and climate systems in order to develop adaptation and mitigation strategies at the global, national, and local scales In this study analysis has been carried out at monthly and annual time scales for long-term rainfall and temperature trends at three locations in Southern Africa namely Liempe Farm (latitude: -15.396, longitude: 28.470, elevation: 1263 m asl) in Zambia, Chitedze Research Station (latitude: -14.417, longitude: 33.633, elevation: 1146 m asl) inMalawi, and Domboshava (latitude: -17.612, longitude: 31.143, elevation: 700 m asl) in Zimbabwe . The daily rainfall and temperature data from 1982-2020 were extracted from NSA POWER and analyzed at monthly and annual basis. The Trend Free Pre-Whitening Mann Kendall (TFPW-MK) test was used to identify trends in rainfall and temperature at monthly scale. The long-term trend analysis of annual rainfall data showed non-significant statistical changes ($p>0.05$) in rainfall at the three sites. However, temperature analysis showed statistical significance positive trends for monthly (Tmax=0.03^{o}C, Tmin=0.03^{o}C, Tmean=0.02^{o}C) and annual (Tmax=0.03^{o}C, Tmin=0.02^{o}C, Tmean=0.02^{o}C) time series in minimum, maxmimum and mean temperature at Chitedze. The minimum temperature at Domboshava and Liempe exhibited a statistical significant positive trends at monthly and annual scales of 0.02^{o}C. The results indicate that while rainfall remains variable at the three sites in Southern Africa, temperature had an increasing trend from 1982-2020. This has implications for soil water moisture, crop production and management and calls for appropriate climate change adaptation and mitigation measures to be adopted such as conservation agriculture and climate smart agriculture.

Climate-smart agriculture impacts on groundwater recharge estimates

Authors: **Daina Mudimbu**[1*], Kawawa Banda[2], Bentje Brauns[3], Dan J. Lapworth[4], Alan M. MacDonald[5], Willy Namaona[6], Richard Owen[7], and Mabvuso Sinda[8]

[1]Department of Chemistry and Earth Sciences, Faculty of Science, University of Zimbabwe, Harare, Zimbabwe
[2] Department of Geology, School of Mines, University of Zambia, P.O. Box 32379, Lusaka, Zambia
[3] British Geological Survey, Keyworth, NG12 5GG, UK
[4] British Geological Survey, Wallingford, OX10 8BB, UK
[5] British Geological Survey, Edinburgh, EH14 4AP, UK
[6] Lilongwe University of Agriculture and Natural Resources, Malawi
[7] Department of Civil Engineering, School of Engineering, University of Zimbabwe, Harare, Zimbabwe
[8] Department of Soil Science, School of Agricultural Sciences, University of Zambia, P.O. Box 32379, Lusaka, Zambia
**Correspondence: deemudimbu@gmail.com*

Abstract

Conservation agriculture (CA) is a farming system that is being promoted by many countries in the Southern African Development Community (SADC) to counter the negative effects of climate change. Previous studies comparing CA to conventional tillage (CT) have indicated that CA had benefits of higher yield, increased soil moisture and improved soil fertility leading to it gaining support over CT with policy makers particularly in water scarce climates. There is however a general lack of scientific data on the impacts of CA on groundwater recharge even though many studies have implied that CA leads to greater infiltration than CT and therefore greater potential recharge. To fill this gap, as a component of a wider study on the impact of CA on soil moisture and groundwater recharge, groundwater monitoring has taken place in 37 purpose drilled wells at sites in Malawi, Zambia, and Zimbabwe. The objective has been to determine the groundwater recharge rate in unconfined aquifers under CA as compared to CT.

The methods implemented include the use of a combination of monitoring soil moisture through the rooting zone to 1m depth and electrical resistivity tomography (ERT). Methods of groundwater recharge include both chemical and physical methods, namely, the chloride mass balance and water table fluctuation, conducted in monitoring boreholes drilled on previously established agricultural experimental sites in Malawi, Zambia, and Zimbabwe. The monitoring was conducted over a 3-year period. This presentation describes early results from the intensive field monitoring programme and initial insights gained on the differences between groundwater recharge responses in the CA and CT treatment plots.

Capacity building in multi-disciplinary methods for improved understanding of the impact of conservation agriculture on groundwater resources in Africa

Authors: **Willy Namaona**[1*], Thumbiko Chavula[1], Daina Mudimbu[2], Kawawa Banda[3], Bentje Brauns[4], Dan J. Lapworth[5], Alan M. MacDonald[6], Richard Owen[7], and Mabvuso Sinda[8]

[1] Lilongwe University of Agriculture and Natural Resources, Malawi
[2]Department of Chemistry and Earth Sciences, Faculty of Science, University of Zimbabwe, Harare, Zimbabwe
[3] Department of Geology, School of Mines, University of Zambia, P.O. Box 32379, Lusaka, Zambia
[4] British Geological Survey, Keyworth, NG12 5GG, UK
[5] British Geological Survey, Wallingford, OX10 8BB, UK
[6] British Geological Survey, Edinburgh, EH14 4AP, UK
[7] Department of Civil Engineering, School of Engineering, University of Zimbabwe, Harare, Zimbabwe
[8] Department of Soil Science, School of Agricultural Sciences, University of Zambia, P.O. Box 32379, Lusaka, Zambia
**Correspondence: wnamaona@bunda.luanar.mw*

Abstract

Building regional and national inter-disciplinary research teams with enhanced technical and analytical capacities can lead to the development of better-informed government and public policies to address food and water insecurities in water scarce countries of sub-Saharan Africa. With up to 70% of the population in the sub-Saharan countries relying on groundwater resources, the development of groundwater systems is instrumental in food security and access to safe drinking water. Conservation agriculture (CA) has been promoted by many sub-Saharan governments and NGOs over the last two decades as a tool to obtain reliable crop yields through adopting three main principles of minimum soil disturbance or no tillage, crop or surface residue retention and crop diversification or rotation. Despite the reliance on groundwater resources, there is limited understanding on the impacts of the promoted changes in land-use and agricultural systems on groundwater resources. To address this a network of groundwater monitoring boreholes of different depth were drilled in both CA and Conventional agricultural sites. In addition, specific borehole(s) for pumping tests were also installed in experimental sites. Automated data loggers were installed in all boreholes to monitor the fluctuations of water table. Water level data were downloaded and visualised in both tables and graphical presentation in Win Situ 5 software. Water chemistry on groundwater samples were collected on monthly interval and data was used to provide further information for assessing groundwater recharge. Constant pumping tests were also conducted to estimate the hydraulic properties of aquifer in the respective study sites. Establishing and building capacity in multi-disciplinary research teams to collect and analyse data is necessary to build this understanding and better inform policy makers. CEPHaS activities have resulted in a cross-pollination of ideas and the generation of innovative methods and solutions that can better inform policies.

Institutional capacity strengthening within CEPHaS: A mixed methods study

Authors: Kirsten Duda[1*], Justin Pulford[1*]

[1] Liverpool School of Tropical Medicine, Liverpool, UK
**Correspondence: Kirsten.Duda@lstmed.ac.uk; Justin.Pulford@lstmed.ac.uk*

Abstract

The Strengthening Capacity in Environmental Physics, Hydrogeology and Statistics for Conservation Agricultural Research (CEPHaS) Project is a GCRF RCUK Collective Fund project designed to support capacity strengthening in conservation agriculture at select agricultural research institutes in Malawi, Zimbabwe and Zambia. Semi-structured interviews and surveys were used to assess capacity strengthening activities, outcomes and sustainability across each of the consortium partners. Key areas of the evaluation included training and resource provision and the overarching CEPHaS experience. The evaluation was focussed on identifying institutional capacity strengthening, with a particular focus on how individual capacity strengthening may have contributed to institutional capacity strengthening. Results will be used to inform both CEPHaS partners for the sustainability of capacity strengthening activities and future capacity strengthening agricultural conservation consortia.

Imaging geolectrical responses of agricultural soils to rainfall events

Authors: Russell Swift [1, 2], Jonathan Chambers [1], Jimmy Boyd [1, 3], Paul Wilkinson [1], Cornelia Inauen [1], Tongai Mtangadura [4], Elijah Phiri [5], Innocent Sandram [6], Phil Meldrum [1], Harry Harrison [1], Paul Mapfumo [4], Patson Nalivata [6], Florence Mtambanengwe [4], Joseph Chimungu [6], Charles Chisanga [7], Ivy Ligowe [8], Pathias Lubinga [5], Nellie Magwero [6], Toga Mapangisana [4], Vengai Mbanyele [4], Chawezi Miti [5], Miyanda Moombe [5], Willy Namaona [6], Hatirarami Nezomba [4], Keston Njira [6], Oliver Kuras [1], Arnaud Watlet [1], Jim Whiteley [1], Mihai Cimpoiasu [1], Frédéric Nguyen [2], Murray Lark [1, 9]

[1] British Geological Survey, Nottingham, UK
[2] ArGEnCo, University of Liège, Liège, Belgium
[3] University of Lancaster, Lancaster, UK
[4] University of Zimbabwe, Harare, Zimbabwe
[5] University of Zambia, Lusaka, Zambia
[6] Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi
[7] Copperbelt University, Kitwe, Zambia
[8] Department of Agricultural Research Services, Lilongwe, Malawi
[9] University of Nottingham, Nottingham, UK
Correspondence: russells@bgs.ac.uk

Abstract

Near surface soil moisture conditions can change rapidly over time, producing complex patterns of wetting and drying in heterogenous soils. To adequately characterise and understand soil moisture dynamics it is important to make observations at the temporal and spatial resolutions at which they are occurring. Geophysical monitoring, and specifically moisture-sensitive, geoelectrical monitoring using Electrical Resistivity Tomography (ERT) is being investigated for this purpose.

Using PRIME - a low-cost, low-power geoelectrical monitoring instrument developed by the British Geological Survey - we have collected multi-seasonal ERT data at three agricultural observatories in Malawi, Zambia, and Zimbabwe. Using these data, we show the spatial and temporal variabilities in resistivity at the sites, studying both seasonal trends (weeks - months) and short-term variability driven by individual rainfall events (hours – days).

Rising groundwater temperatures in Zimbabwe, Zambia and Malawi

Authors: Bentje Brauns[1*], Richard Owen[2], Daina Mudimbu[3], Willy Namaona[4], Mabvuso Sinda[5], Kawawa Banda[6], Dan J. Lapworth[7], Alan M. MacDonald[8]

[1] British Geological Survey, Keyworth, NG12 5GG, UK
[2] Department of Civil Engineering, School of Engineering, University of Zimbabwe, Harare, Zimbabwe
[3]Department of Chemistry and Earth Sciences, Faculty of Science, University of Zimbabwe, Harare, Zimbabwe
[4] Lilongwe University of Agriculture and Natural Resources, Malawi
[5] Department of Soil Science, School of Agricultural Sciences, University of Zambia, P.O. Box 32379, Lusaka, Zambia
[6] Department of Geology, School of Mines, University of Zambia, P.O. Box 32379, Lusaka, Zambia
[7] British Geological Survey, Wallingford, OX10 8BB, UK
[8] British Geological Survey, Edinburgh, EH14 4AP, UK
**Correspondence: benaun@bgs.ac.uk*

Abstract

In this study groundwater temperatures were recorded over a range of 2 – 3.5 years (2018/19-2021) at agricultural research plots in a total of 37 monitoring boreholes in Malawi (10), Zambia (19) and Zimbabwe (8) that were equipped with automatic pressure and temperature loggers. The monitoring boreholes were located in varying land use systems of conservation agriculture (CA), conventional tillage (CT) and woodland/woodlot. All measured boreholes show an increasing trend in groundwater temperatures ranging from ~ 0.1°C to 0.2°C per year. Air temperatures over the same period show a typical fluctuating seasonal pattern that differs from the steadily rising groundwater temperatures, although there have been increasing air temperatures overall during this period of a lower magnitude. The data also suggests that the land use system, has an impact on the ranges in the groundwater temperature. Moreover, the groundwater recharge mechanism, whether by direct intergranular diffusion through the soil matrix, or through focused recharge via fissure flow, also appears to affect the groundwater temperatures. This is a short time series and further work is needed to assess how these trends change over longer periods and gain a better understanding of the processes that are driving these observations.

An Evaluation of labour use in Conservation Agriculture: A case of smallholder farming systems in Zimbabwe

Authors: **S. Siziba**[1*], F. Mtambanengwe[1], T. Mapangisana[1]

[1] University of Zimbabwe, Harare, Zimbabwe
Correspondence: ssiziba@agric.uz.ac.zw

Abstract

In the face of climate change and concerns for environmental degradation, Conservation Agriculture looks like an appropriate technology response for smallholder farmers. Evidence from several on-farm evaluations shows positive yield responses to conservation agriculture over the conventional practices of smallholder farmers. In addition, positive benefits to the environment such as reduced erosion, and improved soil fertility, increase in groundwater recharge among others have been observed. However, adoption rates of conservation agriculture across many countries in southern African have remained very low and in some cases, dis-adoption has occurred. Among the many causes of poor adoption rates of conservation agriculture, is the complaint from farmers that it is labour intensive. Many studies evaluating Conservation Agriculture do not take into account labour. This study measures the amount of labour that is required for Conservation Agriculture relative to that required for conventional farming. The labour is disaggregated by the tasks done from pre-planting to harvesting. Data was gathered using Focus Group Discussions with two farmers groups in Domboshava, Zimbabwe. Farmers were asked to profile their typical farming practices in the production of maize under the two compared systems. Using the "farmer norms" approach they estimated the number of person-hours required for each task. Farmers were encouraged to thoroughly discuss and reach a consensus before finalizing their response. Each group had a good representation of both male and female farmers. Results show that Conservation Agriculture takes more labour to gather mulch, dig the planting basins and weed. Though farmers are encouraged to adopt herbicides, most farmers were not able to do so because of several reasons including lack of knowledge, "fear" of chemicals and financial constraints. Overall, Conservation Agriculture imposed 20% more labour hours than the conventional plough. In addition, farmers indicated that beyond the labour hours, they also considered the drudgery involved in the task. Farmers indicated that digging planting basins and manual weeding imposed high drudgery on them. Though Conservation Agriculture had higher yields, a partial budget costing the labour shows low overall returns to Conservation Agriculture.

Country leads

Zambia: Dr Elijah Phiri - ephiri62@yahoo.com

Zimbabwe: Prof Paul Mapfumo - paulmapfumo@gmail.com

Malawi: Dr Patson Nalivata - pnalivata@luanar.ac.mw

Principal investigator: Prof Murray Lark - mlark@bgs.ac.uk