Agriculture *for* Development

Tropical Agriculture Association

Special Issue on Soils

A longer, closer look at land degradation

Managing soil carbon

Soil erosion and conservation

Ecological restructuring of agriculture

Soil fertility in sub-Saharan Africa

Healthy soil: for healthy people and landscapes

New ways of looking at the soil profile

No. 24, Spring 2015

Guidelines for Authors
Agriculture for Development

The editors welcome the submission of articles for publication that are directly related to the aims and objectives of the Association. These may be short communications relating to recent developments and other newsworthy items, letters to the editor, especially those relating to previous publications in the journal, and longer papers. It is also our policy to publish papers, or summaries, of the talks given at our meetings.

Only papers written in English are accepted. They must not have been submitted or accepted for publication elsewhere. Where there is more than one author, each author must have approved the final version of the submitted manuscript. Authors must have permission from colleagues to include their work as a personal communication.

Papers should be written in a concise, direct style and should not normally exceed 3000 words using Times New Roman font, 12-point size for the text body, with lines double-spaced and pages numbered. Tables, graphs, and photographs may take a further 1 page plus, but we try to keep the total length of each paper to 3-4 pages of the Journal. Good quality photographs are particularly welcomed, as they add considerably to the appearance of the contents of the Journal. We prefer high resolution digital images.

Format

- An informative title not exceeding 10 words.
- Authors listed, usually with first name and surname.
- A short biographical note about the author(s) is included, preferably with a photograph of the author(s). If still working, indicate your position and email address. If retired, your previous job (*eg formerly Professor of Agriculture, ABC University*).
- For papers longer than 1500 words, a short abstract (summary) of 150-200 words.
- A short introductory paragraph is useful describing, succinctly, the current state of work in the relevant field.
- Système International (SI) units should be used. Others should be related to SI units at the first mention.
- No full stops should be used with abbreviations such as Dr or Prof, or *eg*, *ie*, *status quo*, *viz*, and *inter alia*. Acronyms such as GFAR, FAO, IFPRI, and GDP do not have full stops or spaces between the letters. Acronyms should be presented in full at their first mention.
- Thousands should be indicated by a comma and no space *eg* 12,400.
- Commercial equipment and products referred to should name the product and company, but addresses should be omitted.
- State any statistical methods used *eg* analysis of variance (ANOVA) and ensure that the analysis method chosen is appropriate for the data. Data tables presenting, for example, mean values should include the appropriate standard errors (SE) and degrees of freedom (DF).
- Results should be presented in an orderly fashion and make use of tables and figures where necessary.
- Discussion should focus on the work presented and its relationship with other relevant published work.
- Sources of funding should be listed in the acknowledgements.

References

- Key references should be quoted, but these should be kept to a minimum.
- Only papers accepted for publication or published may be cited.
- In the text, cite by author's surname and date: (Waller, 2009) or Waller (2009) in chronological order. Use '&' between names of 2 authors; use '*et al*' for 3 or more authors.
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<u>*Journal (article):*</u> Uphoff N, Kassam AH, 2009. System of Rice Intensification. *Agriculture for Development* **6**, 10-14.

<u>*Journal (online):*</u> Osborne K, Dolman AM, Burgess S, Johns KA, 2011. Disturbance and the dynamics of coral cover on the Great Barrier Reef (1995–2009). *PLoS ONE* http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0017516

<u>*Book:*</u> Brammer H, 2012. *The physical geography of Bangladesh*. Dhaka, Bangladesh: University Press Ltd.

<u>*Book (edited):*</u> Fuglie KO, Sun Ling Wang, Ball E, eds, 2012. Productivity growth in agriculture: an international perspective. Wallingford. UK: CAB International.

<u>*Book (chapter):*</u> Warner K, 1997. Patterns of tree growing by farmers in eastern Africa. In: Arnold JEM, Dewees PA, eds. *Farms, trees & farmers: responses to agricultural intensification*. London: Earthscan Publications, 90-137.

<u>*Conference proceedings (published)*</u>: McIntosh RA, 1992. Catalogues of gene symbols for wheat. In: Miller TE, Koebner RM, eds. *Proceedings of the Seventh International Wheat Genetics Symposium*, 1987. Cambridge, UK: IPSR, 1225–323.

<u>*Agency publication:*</u> Grace D, Jones B, eds, 2011. *Zoonoses (Project 1) Wildlife/domestic livestock interactions*. A final report to the Department for International Development, UK.

<u>*Dissertation or thesis:*</u> Lenné JM, 1978. *Studies of the biology and taxonomy of Colletotrichum species*. Melbourne, Australia: University of Melbourne, PhD thesis.

<u>*Online material:*</u> Lu HJ, Kottke R, Martin J, Bai G, Haley S, Rudd J, 2011. Identification and validation of molecular markers for marker assisted selection of Wsm2 in wheat. In: Plant and Animal Genomes XIX Conference, abstract W433. [http://www.intl-pag.org/19/abstracts/W68_PAGXIX_433.html]. Accessed 20 April 2012.

Tables

- Self-explanatory with an appropriate legend <u>above the table</u>, without abbreviations.
- Number with arabic numerals, *eg* Table 2.
- Refer to tables in the sequence in which they are presented.
- Use lower-case letters, *eg* a, b and c, for footnotes.

Figures

- Self-explanatory with an appropriate legend <u>below the figure</u>, without abbreviations
- Number in a separate series from the tables.
- Use arabic numerals in the text, *eg* Figure 2.
- Subdivisions within figures should be labelled with lower-case letters, *eg* a, b and c

Submission

Your paper should be submitted ready for editing and publication.
Accepted text file types: Word (.DOC or .DOCX), Rich Text Format (.RTF) or Postscript (.PS) only.
Accepted figure file types: .TIF, .EPS or .PDF.
No lecture notes or PowerPoint presentations, please. If the paper is a presentation from a TAA meeting, please let us have this or as soon as possible afterwards so that there is no last minute rush in trying to meet the next publication deadline.

Send submissions via e-mail to coordinator_ag4dev@taa.org.uk preferably in an attached file.

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Cover images

High quality colour images, suitable for the cover of *Agriculture for Development*, are welcomed and should be sent to the Coordinating Editor (coordinator_ag4dev@taa.org.uk)

Cover photograph: A 250m trench cut through a hill near Luki in what was then the Belgian Congo as part of the field excursion of the 5th World Congress of Soil Science in 1954. According to Dr Charles Kellogg '…a pedological extravaganza' (quote and photo: Dr Peter Le Mare)

Contents

The TAA is a professional association of individuals and corporate bodies concerned with the role of agriculture for development throughout the world. TAA brings together individuals and organisations from both developed and less-developed countries to enable them to contribute to international policies and actions aimed at reducing poverty and improving livelihoods. It grew out of the Imperial College of Tropical Agriculture (ICTA) Association, which was renamed the TAA in 1979. Its mission is to encourage the efficient and sustainable use of local resources and technologies, to arrest and reverse the degradation of the natural resources base on which agriculture depends and, by raising the productivity of both agriculture and related enterprises, to increase family incomes and commercial investment in the rural sector. Particular emphasis is given to rural areas in the tropics and subtropics and to countries with less-developed economies in temperate areas. TAA recognises the interrelated roles of farmers and other stakeholders living in rural areas, scientists (agriculturists, economists, sociologists etc), government and the private sector in achieving a convergent approach to rural development. This includes recognition of the importance of the role of women, the effect of AIDS and other social and cultural issues on the rural economy and livelihoods.

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Editorial

Special Issue on Soils

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Soil is never far from the thoughts of agriculturalists, generally about six feet. This special issue of *Agriculture for Development*, celebrating the UN International Year of Soils, brings it to our closer attention. An experienced international team leads off with an updated global assessment of land degradation that draws on 33 years of consistent satellite data. The results are not comforting but, now that we can zoom in seamlessly from the intangible coarse resolution of the original study to the scale where we can distinguish individual shrubs, there is no excuse for any responsible government to be unaware of the situation on the ground – where action is needed.

What to do about it? A thoughtful contribution from the President of the International Society of Soil Sciences, Rattan Lal, puts real numbers and a realistic time-scale on the potential for better management of arable soils in terms of carbon sequestration to mitigate and adapt to climate change. Not a silver bullet but, surely, a win-win option that offers immediate soil and water conservation benefits. Lal argues for more effective policy initiatives to enable farmers to do the right thing; and Francis Shaxson and Amir Kassam provide an update on the steady uptake of Conservation Agriculture, even without much official encouragement.

Boris Boincean supplies detailed evidence of the benefits of more ecological farming systems, using data from long-term field experiments in Moldova. But these are the best arable soils in the world: the article by Wim Andriesse and Ken Giller injects a whiff of scepticism. They also draw on experimentation, this time in African farmers' fields, and point out that it's not all the same out there; some soils and landscapes are so depleted of plant nutrients that recycling is not enough to yield viable returns on the farmers' efforts. These soils and these farmers need a helping hand if they are to be lifted out of poverty. They need fertilisers. For most farmers, these fertilisers are unaffordable, and the necessary technical support is not available because current donor and government strategies are not paying enough attention to the management of the land. This is one of the messages of the latest report by the eminent Montpellier Panel - *No ordinary matter: Conserving, restoring and enhancing Africa's soils*, which is reviewed by Stephanie Brittain.

An open letter from the CEOs of the World Vegetable Centre (AVRDC), CABI and the International Fertilizer Development Centre strikes a positive note on farmers' uptake of Integrated Soil Fertility Management – that is, combining improved germplasm, mineral fertilisers and locally-available organic amendments such as crop residues, compost and green manure to replenish soil nutrients. Dyno Keatinge, Trevor Nicholls and Amit Roy argue that a big part of the answer must lie in improving communication channels and methods. There are not enough extensionists to support the world's farmers, but mobile technology can help fill the gap; no or low literacy and language barriers can be overcome with the help of mobile agro-advisory services, for instance voice messages.

The cover photo commemorates soil science as we knew it. Hugh Brammer, who contributes his reminiscences, is one of the ant-like figures poring over the landscape with little more than bare hands and keen eyes. Keith Virgo, who cut his teeth with Hunting Technical Services, lends further insights. As a foil to these backward glances, Alfred Hartemink contributes an optimistic, futuristic note on digital morphometrics. Do not be deceived: Alfred learned his field skills the traditional way. And finally: editorials do not often draw attention to book reviews, but Robert Brinkman's review of *Economics of salt-induced land degradation and restoration* reminds us that there is still a lot of work for soil science to do in land reclamation and improvement – and, if it is well done, it can pay back society handsomely.

David Dent
Guest Editor

A longer, closer, look at land degradation

Zhanguo Bai, David Dent, Lennart Olsson, Anna Tengberg, Compton Tucker, Genesis Yengoh

Zhanguo Bai is a senior researcher at ISRIC-World Soil Information, specialising in GIS, remote sensing and radionuclide tracers applied to land and water management, land degradation and conservation. He has contributed to the Global Assessment of Land Degradation and Improvement, the WOCAT soil and water conservation network and, most recently, Green Water Management & Credits for China.

David Dent is a soil surveyor.

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Anna Tengberg is an independent consultant, Research Associate in the School of Business, Economics and Law at the University of Gothenburg, and Adjunct Professor at LUCSUS. Formerly, she was Senior Program Officer for UNDP and UNEP/GEF covering land degradation and sustainable management across Africa and the Asia-Pacific region.

Corresponding author Compton (Jim) Tucker (compton.j.tucker@nasa.gov) is Senior Biospheric Scientist at the NASA/ Goddard Space Flight Center and Adjunct Professor at the University of Maryland, USA. He pioneered the use of time-series satellite data to study global photosynthesis, land cover, famine early warning, and ecologically-coupled disease outbreaks — most recently Ebola. Amongst many awards, he received the Vega Medal from the Swedish Society for Anthropology and Geography in 2014.

Genesis Yengoh is post-doctoral fellow at LUCSUS, gaining his doctorate on the yield gap in subsistence farming in Cameroon and, now, researching the consequences of land use change for access to and use of land resources in sub-Saharan Africa using multispectral remote sensing and field studies of agricultural production and food security.

Summary

Arresting land degradation, not to mention remediation, requires long-term investment. Budgetary constraints mean that we have to prioritise, so decision makers need know exactly where and how severe is the degradation, and they need early warning to act in good time. The first global assessment using actual measurements was based on 23 years of Advanced Very High Resolution Radiometer (AVHRR) Normalised Difference Vegetation Index (NDVI) data at 8km resolution. Its aim was to identify black spots that should be investigated in the field – but hardly anybody did. The dataset now extends to 33 years, revealing both long-term trends and many reversals of trend.

The areas hardest hit are sub-equatorial Africa, with outliers in the Ethiopian highlands and the Sahel; the Gran Chaco, Pampas and Patagonia; southeast Asia; the steppes from Moldova eastwards into Central Asia; the Russian far east and northeast China; and swaths of high-latitude forest. Since 2000, it has been possible to seamlessly scale up the coarse-resolution picture to 250m resolution using data from the Moderate-Resolution Imaging Spectroradiometer (MODIS) and to 30m resolution with Landsat. Now, thanks to commercial satellite data, we can zoom in, anywhere in the world, with 5m-resolution.

A proxy measure of land degradation

Land degradation is contentious: its extent, severity, cost and impact on food security and the environment uncertain. So it is not at the top of the policy agenda and the investments needed to arrest it are not being made – they are not even known[1]. Questions include: is land degradation a global issue or a collection of local problems?; which places are hardest hit?; is it mainly a problem of drylands?; is it mainly associated with farming ... or with poverty?

How can we answer these questions in a scientifically justifiable way? Land resources surveyors have always made good use of new technology intended for other purposes; the title of a paper in *Advances in Space Research* says it all: *'The exciting and totally unexpected success of AVHRR in applications for which it was never intended'* (Cracknell, 2001). AVHRR is the Advanced Very High Resolution Radiometer carried by National Oceanic and Atmospheric Administration (NOAA) weather satellites since 1981 – actually very low resolution, even compared with Landsat data available at the time, but its broad field of vision and daily global coverage are ideal for global monitoring. And, by chance, the ratio of red to near-infrared radiation measured by the radiometer – the Normalized Difference Vegetation Index (NDVI) — is a good measure of photosynthetic capacity[2] so NDVI shows where plants grow and where they do not (Figure 1). All sorts of applications are possible thanks to time-series data at spatial resolutions from 8km to 30m and recent advances in data collection, quality assessment and processing (Yengoh *et al*, 2014).

[1] The Economics of Land Degradation Initiative http://eld-initiative.org/ is trying to answer this question, initially using the GLADA interpretation of GIMMS AVHRR data up to 2003 — but these data are now superseded.

[2] Chlorophyll absorbs blue and red light strongly and reflects strongly in the near-infrared.

If we define land degradation as a loss of ecosystem function and productivity from which it cannot recover unaided (UNEP, 2008), then NDVI trends can be taken as a proxy. But a decreasing trend doesn't necessarily mean land degradation, or an increasing trend improvement: primary production depends on climate, especially rainfall; land management; large-scale ecosystem disturbances such as fires; and fertilisation by increasing atmospheric CO_2 and nitrate deposition. Globally, climate is paramount, but it is hard to disentangle the effects of climate and management. As a rule of thumb, in drylands, where vegetation dynamics are driven by rainfall, declining rain-use efficiency (RUE, calculated as NDVI divided by rainfall) is correlated with land degradation; in humid areas, where vegetation is not as strongly driven by rainfall, NDVI itself is strongly correlated with vegetation dynamics and may be taken as a proxy for land degradation and improvement, provided that potential false alarms are accounted for.

There is an issue of credibility. Translating satellite measurements of reflected solar radiation into the information that policy makers want (loss of production and environmental services, action needed to arrest these losses, and the economic and political payback for this action) requires leaps of deduction – some might say imagination.

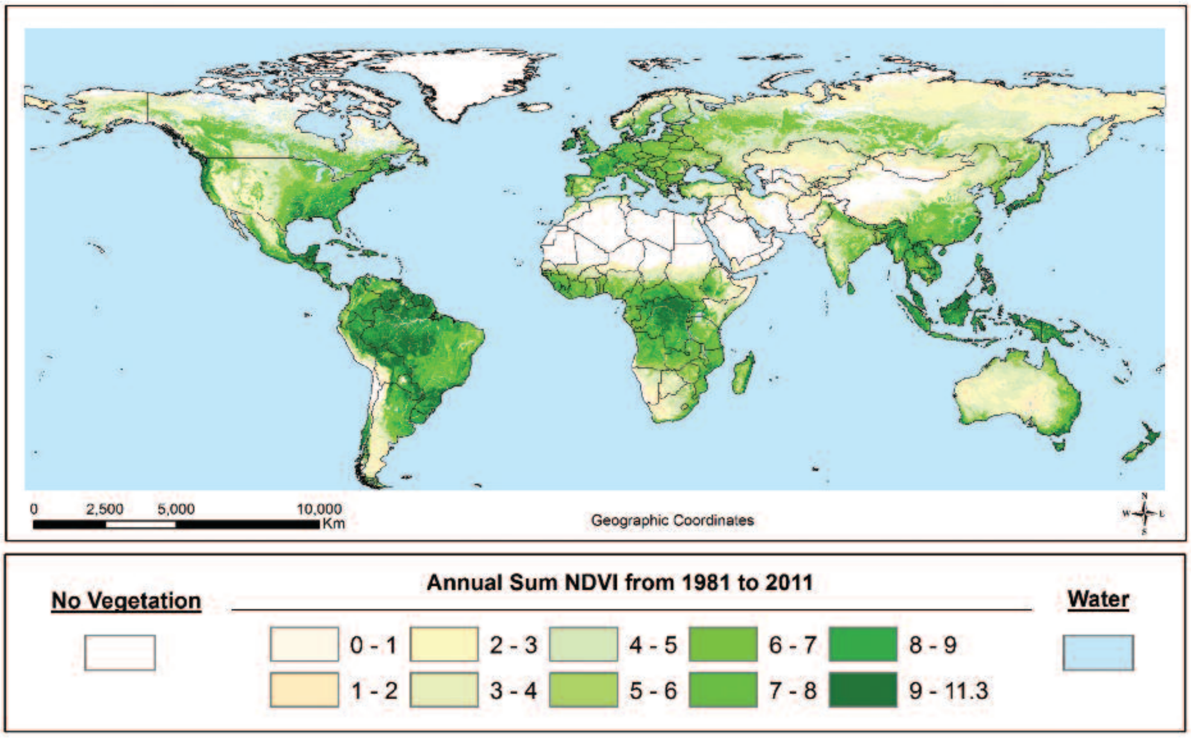

Figure 1. Global photosynthetic capacity, 1981-2011

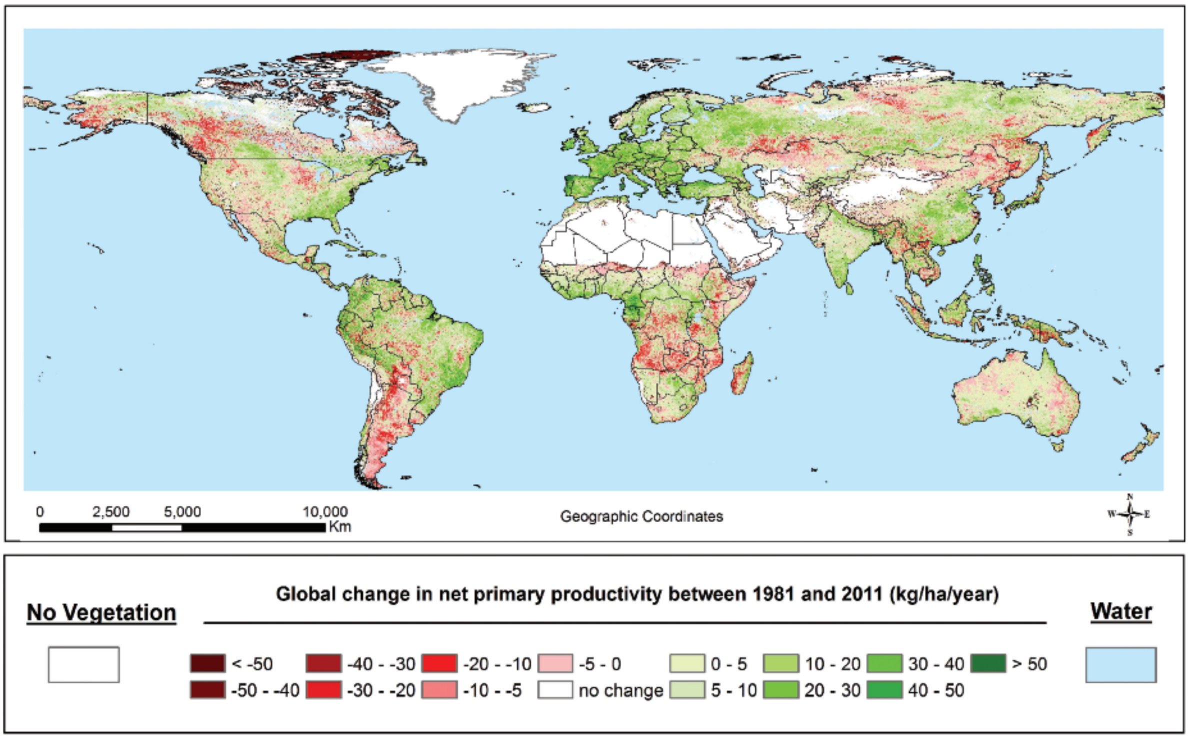

Figure 2. Global change in net primary productivity, 1981-2011

A longer look at land degradation

The first global assessment of land degradation (GLADA) to use actual measurements (Bai *et al*, 2008) applied linear trends of RUE-adjusted NDVI drawing on the Global Inventory Modelling and Mapping Systems (GIMMS) database of AVHRR data for 1981-2003, corrected for instrument calibration, orbital drift and volcanic eruptions; cloud and haze effects were minimised by taking the highest fortnightly value within composite 8km^2 blocks of pixels (Tucker *et al*, 2004).The results contradicted received wisdom that reckoned degradation was worst in the Amazon, the Sahel and, more generally, in drylands: nearly all the usual suspects showed improvement. This intelligence was met with the usual reaction to a new truth: *'It's not true!'* Later: *'It's against scripture.'* We are still waiting for the final accolade: *'We knew it all along'*.

Figure 2 is an update of that analysis using GIMMS data up to 2011 translated into net primary productivity (NPP) by correlation with Moderate Resolution Imaging Spectoradiometer (MODIS) NPP data for the overlapping period 2000-2011. It differs from the original, not only because of the longer run of data but, also, because of changes in processing to correct bias introduced into the earlier time-series by the procedure for matching of data from successive AVHRR sensors. Linear trends analysis is highly sensitive to anomalies at either end of the series; the new calibration (Pinzon & Tucker, 2014) does not assume *stationarity* (*ie* that there is no long-term change in average NDVI values), so the new data more accurately reveal the underlying trends. Changes like this in the fundamental data do nothing for our credibility, but we should be right from now on. Other datasets do not have the benefit of this correction.

We can now give some answers to our original questions.

- *Land degradation is a global issue*. Our calculations indicate that about 22 percent of the land has been degrading over the last thirty years, corresponding to a loss of carbon sequestration of about 150 million tonnes, but an order of magnitude greater loss of soil organic carbon.
- *The areas hardest hit* are sub-equatorial Africa with outliers in the Ethiopian highlands and the Sahel; the Gran Chaco, Pampas and Patagonia; southeast Asia; the steppes from Moldova and Ukraine eastwards through Russia to Kazakhstan; the Russian far east and northeast China; and swaths of high-latitude forest.
- *All kinds of land use are afflicted*. Cropland comprises 13 percent of the global land area but 15 percent of degrading land; rangeland 29 percent of the land area but 42 percent of degrading land; forest occupies 23 percent of land but 37 percent of degrading land.
- *Comparison of rural population density with land degradation shows no simple pattern*. Taking infant mortality and the percentage of young children who are underweight as *proxies for poverty*, there is some correlation, but we need a more rigorous analysis.
- *Fourteen percent of land shows an increasing NDVI trend, which may indicate improving conditions*.

Changing trends

Over the last thirty years, most parts of the world have experienced both increasing and decreasing NDVI trends (de Jong *et al*, 2012) and contrasting trends may cancel out each other. For instance in China, there was a dramatic turnabout between 1996 and 1998 (Figure 3a, b). We see (at 90 percent probability) dramatically decreasing NDVI across the northeast; and a loss of impetus in intensively farmed areas, in spite of the increasing application of synthetic fertiliser (from 7 million tonnes in 1977 to more than 58 million tonnes in 2012). Over the period 1981-1996, 2 percent of the country suffered degradation but 18 percent was improving (80 percent showed no significant change or was barren): since then, 13 percent of the land has been degrading and only 10 percent improving. Drought explains 15 percent of negative trends in the raw data; increased rainfall explains 20 percent and increased temperature 38 percent of the positive trends. What remains – the climate-adjusted NDVI shown here – may be attributed in some measure to land use and management.

It is not all bad news. China is one of the few places in the world where land reclamation can be seen from space: in North-western China, stretching from Inner Mongolia to Xinjiang, investments in sustainable land management in the last 10 years amounted to almost US$27 billion (Tengberg *et al*, 2014); and Figure 4 shows that NDVI trends for five southern provinces, that were declining, have been reversed since 1995, potentially as a result of the Grain-for-Green initiative where farmers on marginal land were paid in sacks of grain for converting to more-sustainable land use (Deng *et al*, 2014).

Zooming in

The long time-series of AHVRR data is well-suited to detect global trends and, importantly, changing trends; but the 8km pixel size precludes meaningful checks of the current situation on the ground, let alone the situation 33 years ago. However, since 2000, we have imagery at 250m resolution from NASA's MODIS (Zhao *et al*, 2005) as well as Landsat data at 30m resolution. And now, thanks to commercial satellite data, we can zoom in with 5m-resolution imagery to establish the situation on the ground or, at least, focus our fieldwork.

Figure 5 depicts land degradation extending across the steppes from Moldova in the west through Ukraine and Russia into Central Asia. The degrading area coincides with chernozem soils, not so long ago the breadbasket of Europe, and their dryland cousin, kastanozem. Figure 6 integrates AVHRR and MODIS NDVI values from the first of March to the end of October, as NDVI-days, to arrive at a measure directly related to gross primary production over the growing season.

All the NDVI data suggest a recent change in vegetation dynamics that is not explained by rainfall variability. Taking winter wheat as a representative arable crop, and comparing the national average yield with wheat grown in rotation after an early-harvested predecessor on *Typical chernozem* at the Selectia Experimental Station in the north of the country, we see no downward trend in experimental yields but a dramatic

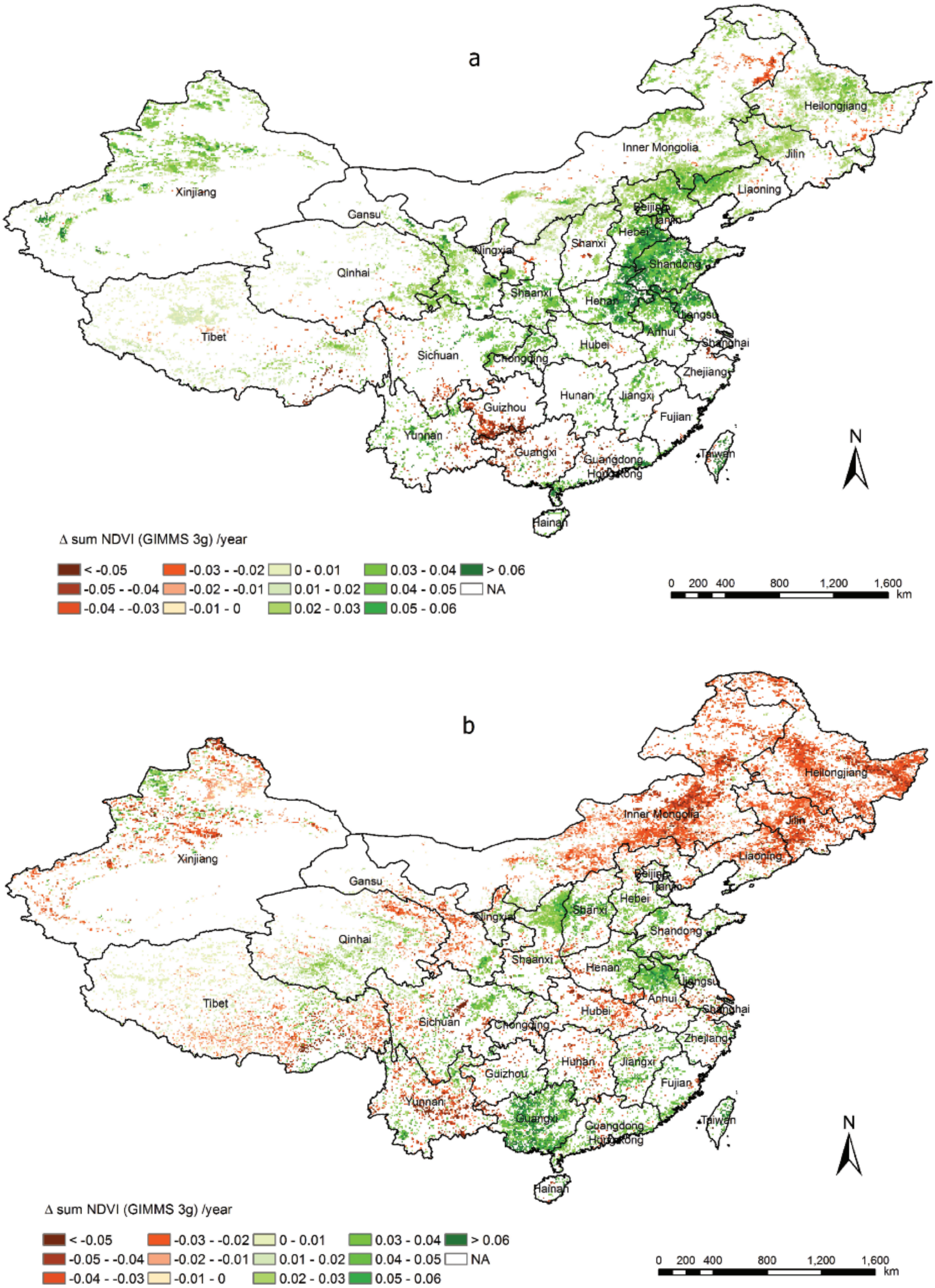

Figure 3. China: changes in annual sum NDVI, 1981-2011 (a: 1981-1996; b: 1996-2011)

fall in national averages. The national yield was 78 percent of the experimental-station yield over the period 1981-1992: excluding the severe drought years 1996 and 2003, national yields were only 51 percent of the experimental-station yield from 1994-2012. The downturn illustrated in Figure 7 may be related to the dismantling of the industrial-scale farming system of the former Soviet Union and redistribution of the land in small plots to the entire rural population, beginning in 1992 (Boincean, 2015 in this issue of *Ag4Dev*).

This is not to say that all was well under the previous system. During a hundred years of increasingly intensive farming, chernozem lost 30-40 percent of their organic carbon (c40 tonnes/ha, Krupenikov *et al*, 2011). Probably, they are at the limits of their resilience; untimely operations and withdrawal

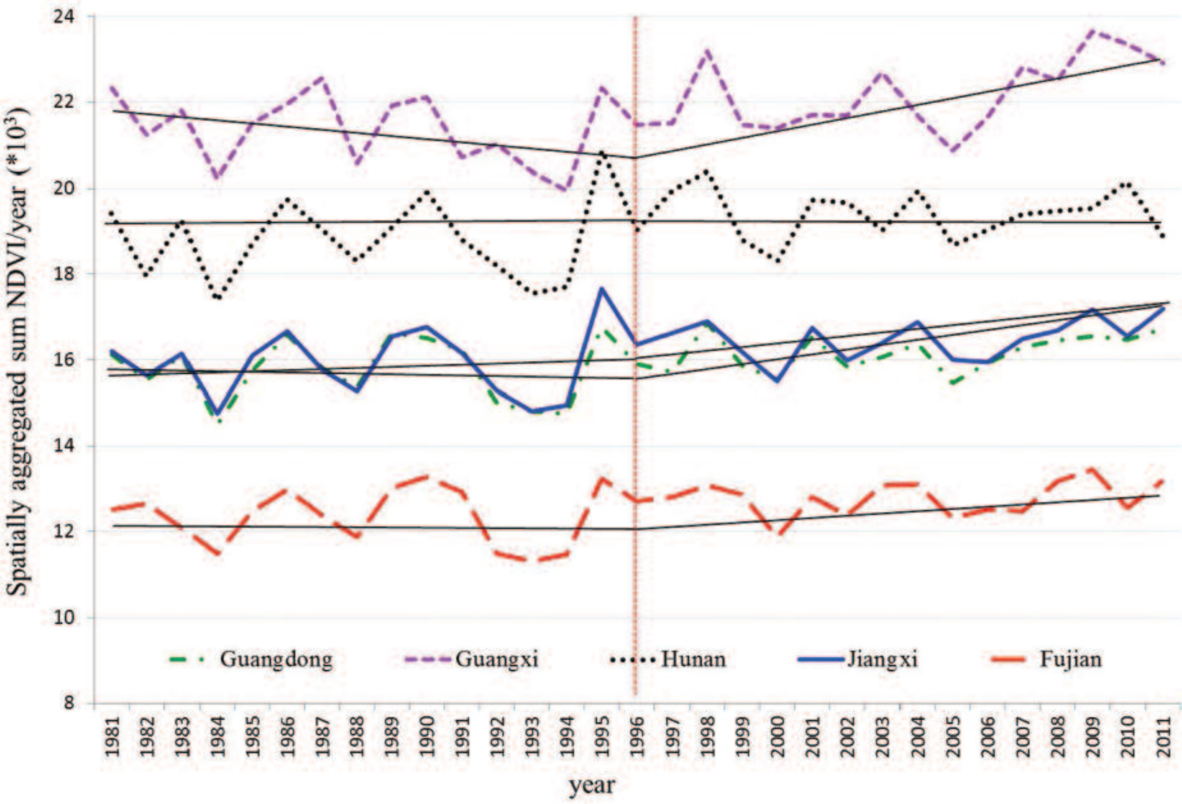

Figure 4. China: NDVI trends in five southern provinces, 1981-2011

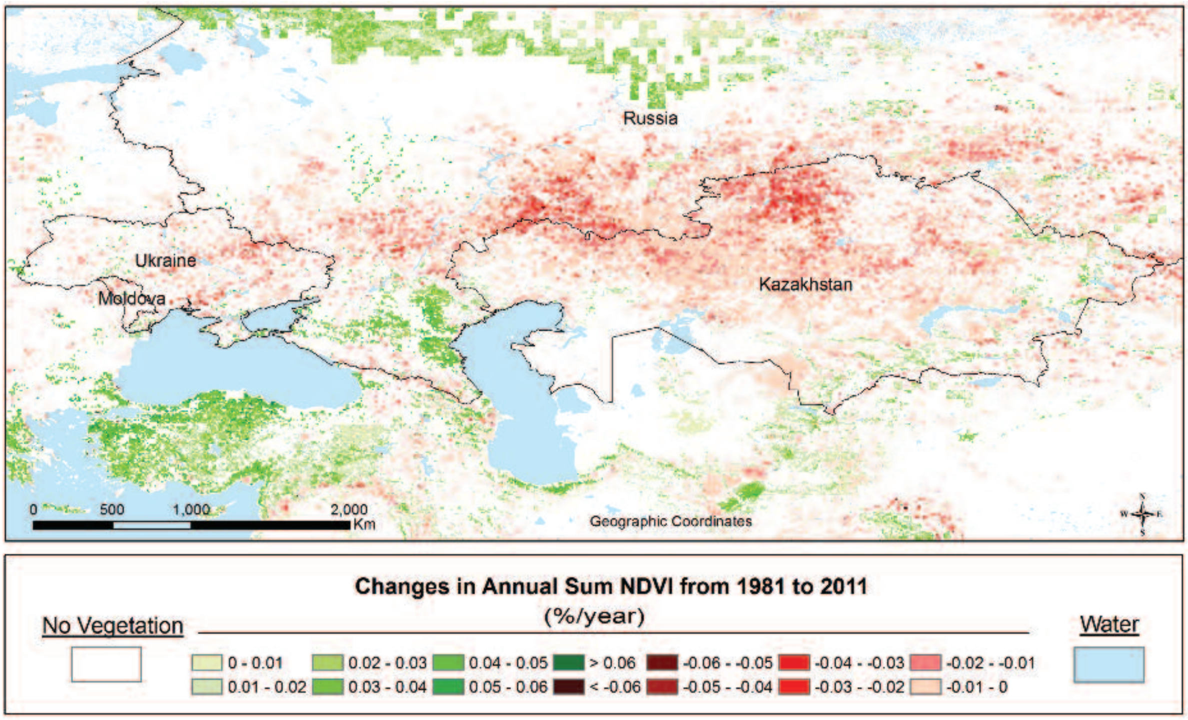

Figure 5. Changes in RUE-adjusted annual sum NDVI across the steppes from Moldova to Kazakhstan, 1981-2011

of inputs may explain the recent collapse. A parallel situation with a similar NDVI signature (Figure 8) may be seen after breakup of commercial farms in Zimbabwe. Closer inspection with high-definitional satellite imagery (Figure 9a, b) illustrates the change on the ground.

The original GLADA assessment aimed to identify land degradation blackspots to be followed up on the ground. Hardly anyone did. However, for the Gourma region of Mali, we are fortunate to have field data confirming degradation of the more sensitive soils (Dardel *et al*, 2014) and social data that reveal a widening gap in subsistence production bridged by emigration and off-farm income (Hiernaux, personal communication).

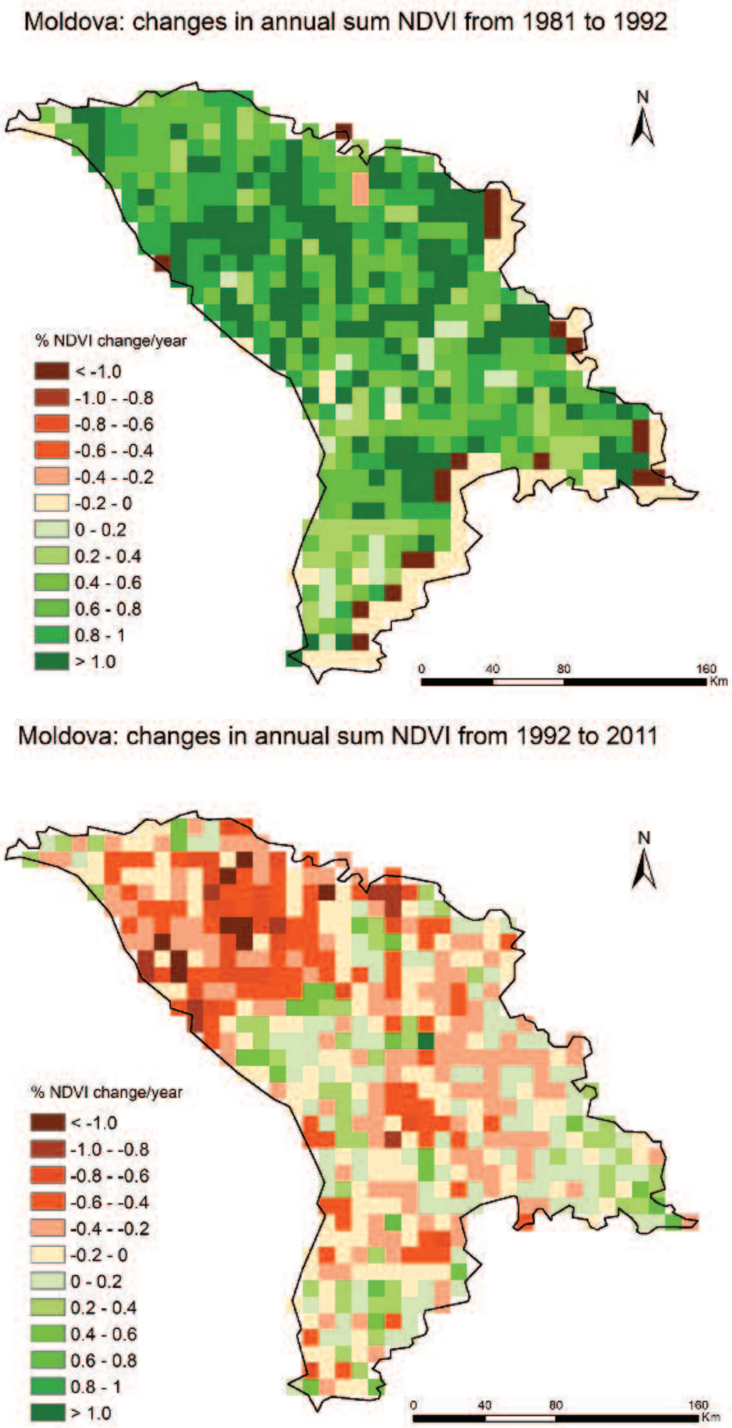

Figure 7. Moldova: NDVI trends before and after 1992

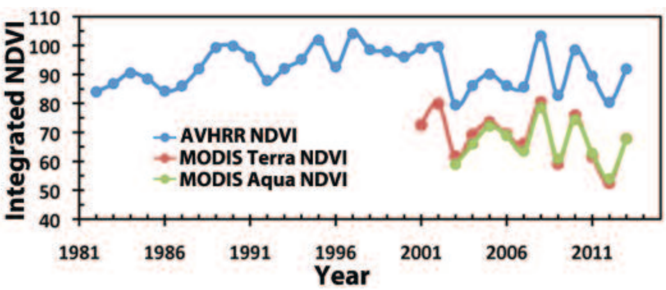

Figure 6. Integrated NDVI over the growing season for part of Moldova

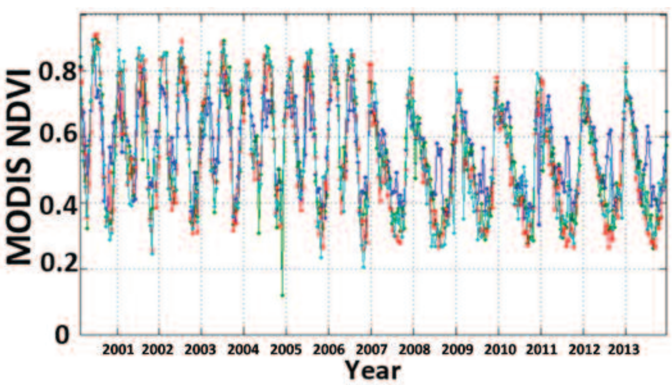

Figure 8. MODIS NDVI data from Zimbabwe at 18.934° S 30.082° E. Changes in the frequency domain reflect a change in 2007 from a double-cropped intensive agriculture to single cropping subsistence agriculture

(a)

(b)

Figure 9. Close-up of the abandonment of irrigated multiple cropping in Zimbabwe, 2005 (a) and 2013 (b)

Applications

If there is anybody out there who takes land degradation seriously, then this kind of information has value. Reliable assessment of land degradation and improvement can contribute to policy and project development worldwide; in particular, sub-km data can be applied in state-of-the-land reporting to the UN Convention to Combat Desertification (UNCCD) and the post-2015 development agenda embodied by the Sustainable Development Goals[3]. The Global Environment Facility (GEF), the World Bank and other investors also need to monitor the progress or otherwise of interventions on the ground. The GEF, as a financial mechanism for the UNCCD, already uses the GLADA analysis in allocating resources within its Land Degradation focal area; there is further potential to use NDVI for the Land Use, Land Use Change and Forestry (LULUCF) and Reducing Emissions from Deforestation and Forest Degradation (REDD+) component of its Climate Change focal area. Similar funds could also use NDVI to monitor their global impacts; and the Green Climate Fund, recently replenished to the tune of US$10 billion for investments in climate change mitigation and adaptation in developing countries, will monitor forest area under improved management, rate of deforestation and forest degradation, and area of agricultural land made more resilient, drawing on measurements already recommended under the UNCCD and the UN Framework Convention on Climate Change (UNFCCC). So the use of NDVI for land degradation and land cover monitoring and assessment has the potential to influence investments of billions of dollars.

However, the main action against land degradation will have to come from individual countries. AVHRR, MODIS and Landsat data are free and the archive of high-definition imagery can also be made available. However, data processing requires specialist skills; the assessments we describe are not straightforward. They need to be undertaken at the national level to provide credible interpretation of the data – which demands local knowledge; and for the sake of ownership of the information – more so when the intelligence is unwelcome. While remote sensing is invaluable in the assessment of land degradation, it can only measure proxies – the drivers remain beyond the reach of remote sensing; biophysical analyses need to be combined with relevant socio-economic data of matching time and detail. All this will require a significant training programme to equip local staff with the necessary skills.

[3] Especially SDG15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

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News from the Field

Promoting sustainable farming methods in Malawi: the Tyeni method

Introduction

(This article is based on a presentation made to the TAA SW Group AGM on 8 January 2015.)

Tiyeni in Chewa, the national language of Malawi, means *'Let's go!'* and this refers to the aim of this small UK charity that punches way above its weight.

Malawi is the 5th poorest country in the world, added to which it has few natural resources. It is a beautiful country at the southern end of the Great Rift Valley of Africa with a very productive lake and a kindly, peaceful population. Its people, its soil and its water are its natural resources. Unfortunately, with a growing population, limited land resources, and falling fertility, disaster is never far away – the worst of all disasters – a whole country unable to feed itself.

The World Bank made a study of Malawi in the 1990s and reported that, on average, each hectare of farmed land loses 20 tons of topsoil a year – and things have hardly improved since then. The soil just does not produce the crops it used to. There are not enough replacement nutrients being put back into the soil, so it is becoming increasingly unproductive. The population has doubled in the last 30 years, and is set to double again in the next 30 years.

Full-scale erosion can be seen on virtually every farm in Malawi, and whenever there is rain the rivers run thickly with mud and silt from the upper lands. Thin and sickly crops can be seen in every district of Malawi and, although farmers complain of lack of rain and fertiliser, it is clear that the reason for these failed crops is the way the land is being farmed (Figure 1).

Figure 1. Weak crops on eroded land

In November 2013, the UK donated US$22,000,000 to alleviate hunger in Malawi. This was blamed on climate change and failed rains, but with proper farming methods much of this would have been unnecessary.

How Tiyeni was born

About 10 years ago, John Crossley realised that this was a one-way street to food poverty and something must be done about it. He looked at the huge numbers of agricultural charities that are doing so much good work in Malawi and he realised that the two core problems were not being challenged. He took analyses from a well-known agronomist who had worked in Malawi for many years, Francis Shaxson, and a Malawian horticulturist, S C M Kabuba, who was doing excellent work in a farming project in Karonga, Malawi.

Francis's long term and highly regarded work addressed soil structure and the way that many forms of farming damage the structure on which the crops rely. This particularly addressed the issue of soil compaction. With heavy machinery or constant treading, layers of many types of soil become so compacted that water cannot penetrate it and nor can crop roots. Mr Kabuba's work centred upon mulching, composting, rainwater harvesting and companion planting. This focussed on depleted soils and how to rebuild fertility. If you take out more than you put in (be it organic material, water or fertiliser), fertility will fall continually. If you do the reverse, then it will rise continually. If you balance inputs and outputs, you have a truly sustainable soil. In summary: *'look after the land and it will look after you.'*

These two farming technologies were brought together to solve the two key farming problems in Malawi:

- erosion resulting in loss of topsoil on the slopes and flooding and silting in the valleys;
- falling fertility and failing crop yields.

The Tiyeni system and how it works

In order for any project to be sustainable, it is critical that the participants own the project. There are many disastrous, but well-meaning, initiatives which have been imposed on people. Due to what afterwards looks like bribes, these succeed until just after the bribes stop coming in and then all goes back to square one. Well thought-out schemes do not do this, so the following successful physical elements of the Tiyeni system will be ineffective unless the sociological elements work correctly.

Physical elements

One begins by very accurately digging a 0.5 m bank along the contour line with a ditch 0.5 m deep uphill of it. Using a line level, it is important to ensure that the bank is exactly on the contour. The end of this holding ditch is closed so that the water stays in it and percolates through the subsoil instead of running off the surface. Vetiver grass is planted into the top of the bank to strengthen it. This becomes a marker ridge and there will be others down the slope at intervals depending upon gradient.

Next, the hardpan underneath the old ridges and in the furrows is broken up, to a depth of about 0.5m. The soil is then banked into permanent raised beds that are 1.0m wide. The land is then ready for planting.

Each single maize seed – not the normal practice of putting three seeds into each hole – is planted at the correct intervals, with a little Bockash (a mixed compost with various elements carefully measured and mixed; plus a small amount of fertiliser) to help it on its way. Organic material is laid on the soil surface, or initially it can be dug in, particularly if it is still moist and green. The key thing from now on is to always keep mulch on the surface – pull the weeds out by hand and lay them on the surface (ideally at the beginning of the day so that the sun dries out the roots), never use burning methods on old vegetation, and never tread on the beds again.

This is the core of the system to which should be added the important elements of compost, animal manure, inter-planting of sweet potato, ground nuts and legumes, and consecutive planting as the maize grows to shade the land or just as it is harvested (with the stems and leaves of the maize being folded in the soil or laid on top as mulch). In addition, crop rotation is essential.

Figure 2. Tevious Banda with her farm showing deep beds and water retention

The results

The Tiyeni system:

- stops water running downhill, keeping it in the holding ditches (Figure 2);
- allows water to percolate into the subsoil where the crop roots are;
- replenishes the water table (aquifers);
- allows roots to grow deep and reach for the subsoil (Figure 4);
- allows termites to take dry cellulose down into the ground and fertilise it;
- lowers the day temperature of the soil in the beds;
- reduces evaporation though lower surface area and the cloaking effect of mulch;
- prevents or substantially reduces flooding and silting in the stream and river valleys;
- stops soil from being carried downhill and into the rivers;
- builds fertility in the soil;
- helps to prevent disease through rotation of crops;
- puts nitrates back into the soil by inter-planting legumes;
- increases crop yields very substantially and continually (Figure 3);
- reduces labour input after the first year due to reduced digging;
- spreads the workload across the whole family by all pulling the weeds and mulching;
- encourages all the farmers nearby to adopt the system to increase their food security.

Figure 3. Eldah Manda and her husband showing Tyeni Farmed (TF) and non-TF (left) maize plots

Figure 4. Cob lengths differ between non-TF (28 cm) and TF (41 cm); root length is also improved with TF

The sociological elements

The entire Tiyeni staff is Malawian and they are all born and bred in the area. Their job is to educate, train and support local villagers and individual farmers who take on the Tiyeni method. They do not, and they will not, preach unasked to farmers or go out into the communities to lecture farmers uninvited, on the Tiyeni method. Indeed, all of them consider that this would be counterproductive and reminiscent of the unpopular colonial style of preaching about farming methods.

Adoption of Tiyeni by a village

For a village to adopt the Tiyeni method, they have to approach the Tiyeni staff, at which point there is a meeting in the village. The village will have to provide land for a demonstration garden, plus 15-20 volunteers including a Chair, Secretary, Treasurer and a committee with a good gender balance. They must undertake to establish and maintain this demonstration garden for as long as they want guiding support from Tiyeni staff (Figure 5). They also must agree that much of the produce from the demonstration garden will go to feed the orphans in the village and also to feed the pupils at any nursery school that is constructed later.

Figure 5. A village group showing their very productive demonstration garden near Mzuzu

Tiyeni in the village

In return, Tiyeni will agree to carry out the training of the farmers, provide pickaxes, hoes, a line level and the first year's seeds and fertiliser, and provide continual and regular guidance to the group. Once the demonstration garden is well established, each village will be provided with a pig sty and a pig, and the dung from this will be used in the demonstration garden. When the pig farrows, the piglets will be distributed around the village by the committee.

The staff will also offer continued support and training for Extension Farmers who want to take the Tiyeni method onto their own land. A few of these Extension Farmers, who excel on their own farms and who have good communication skills, become Lead Farmers whose job it is to assist other Extension Farmers and to help occasionally at Tiyeni training courses. The village centre keeps a supply of spare pickaxes, hoes and line levels to lend out to new Extension Farmers in the area surrounding the village. In some cases, where specific sponsorship is given by donors, Tiyeni will be able to organise the building of a nursery school in the village, and to pay for a teacher.

Once the Tiyeni 'contract' between the village and Tiyeni is in place, the next two years are critical for the development of the relationship, but more important is the sociological change that is engendered in the village. At the end of the two years, the village continues a relationship with Tiyeni staff on the basis of monitoring or advice. In the 16 villages active in 2014, the following was noticed:

- A very strong village *'esprit de corps'* evidenced by harmonious work being undertaken by the villagers in developing and maintaining the demonstration garden.
- An increasingly higher crop yield from the garden, with much of the crop being used to help the orphans and young children in the village.
- A steady growth of Extension Farmers taking the Tiyeni method of husbandry into their own farms and asking for guidance and monitoring from Tiyeni staff.
- Lead farmers coming forward from the Extension Farmers who become spokespersons for the Tiyeni method to others villages and outlying farmers.
- An increasing number of villages and farmers approaching Tiyeni to request training in the Tiyeni method in their areas.

The Future

The technology works and the results are impressive:

- yields more than double in the first year, and in most cases continue to increase thereafter;
- less work is necessary because digging is not needed after the first year;
- huge demand for training from farmers who have seen the results;
- enthusiastic farmers promoting the method to their neighbours.

However, it is essential that the farmers 'stay on message' because the Tiyeni system works by bringing *all* the elements of the system together. Get one of the elements wrong and it does not work so well. Tiyeni must be vigilant to ensure that, when farmers say they have adopted the Tiyeni method, they are doing it properly. Farmers must *'do it all or not at all'*.

This means that Tiyeni must manage growth to ensure that the Tiyeni system is not weakened by poor practices creeping in. So the aim of Tiyeni is *not* to train every farmer in Malawi but to promote the method of land husbandry to other organisations and government. This programme is now underway and will include:

- setting up demonstration gardens in Ministry of Agriculture centres and running training courses there;
- running open days for any farmer or interested party to come and learn about the Tiyeni method;
- running specific four-day courses for local and regional farmers to learn the detail of how to set up a demonstration garden and why;
- running courses for other organisations interested in land husbandry;
- running courses at University and Colleges to promote the Tiyeni method;
- partnering other organisations and colleges for joint studies into subsistence farming in Malawi;
- linking with wet-land and agro-forestry organisations to manage the whole functional landscape.

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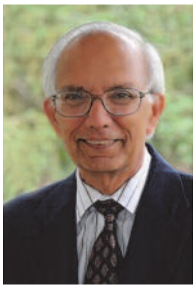
Managing soil carbon through sustainable intensification of agro-ecosystems



Rattan Lal

Dr Rattan Lal is President of the International Union of Soil Sciences, a distinguished University Professor of Soil Science, and Director of the Carbon Management and Sequestration Center at Ohio State University. Before appointment at OSU, he served as Soil Physicist at IITA, Ibadan, from 1969-87. His current focus is climate-resilient agriculture, soil carbon sequestration and sustainable resource management – particularly in the tropics. Surely the most prolific and highly cited soil scientist of our time, and serving on innumerable national and international bodies, he is included in Thomas Reuter's 2014 list of World's Most Influential Scientific Minds.

Summary

Compared with natural ecosystems, the carbon content of cultivated soils is depleted by 30-40 tonne/ha. Restoration of soil carbon stocks is essential to restoring soil performance and ecosystem services – including climate change adaptation and mitigation. This can be achieved through sustainable intensification (SI) of agro-ecosystems – producing more from less land, water, fertiliser, energy, and other inputs. The strategy is to increase biomass carbon, decrease losses by erosion, mineralisation and leaching, and reduce emission of greenhouse gases. Technological options include conservation agriculture, cover crops, agroforestry and integrated nutrient management. Restoration of soil carbon over 5 billion ha will sequester 150-200 Pg C, drawing down atmospheric CO_2 by 40-50 ppm. This is a no-regret option because of its ancillary benefits. Rather than trading C credits, payments for ecosystem services may be a practical incentive for adoption of SI.

Introduction

The UN has declared 2015 the International Year of Soils to enhance awareness of the importance of soils in several global issues: food and water security, biodiversity, pollution and climate change. The links between soil and climate are not to be ignored: soil is the largest terrestrial carbon pool; it affects and is affected by the atmospheric C pool – the co-evolution of soil and climate is evident in every landscape; and as the climate changes, soil and its C pool change with it.

Extreme events (droughts, storms, heat waves and intense cold) indicate changing climate patterns: globally, 2014 was the hottest year on record; the severe drought in the summer of 2012 affected crop yields and even economic growth in the USA. Extreme cold and snowfall, uncontrollable wildfires and outsize tropical storms are also more common and are hazardous to life, infrastructure, shipping and aviation. The train that will deliver global warming of >2°C this century has already left the station. It cannot be recalled, so innovative strategies are needed; re-carbonisation of the biosphere by various means including sustainable intensification (SI) of agro-ecosystems is a natural and cost-effective option (Lal *et al*, 2012). Sequestration of C in soil has its dos and don'ts but, despite questions about the magnitude of the C sink, the rate of sequestration by different practices (Powlson *et al*, 2014), and uncertainties about the permanence of C fixed in soil, soil C sequestration is an important, immediately available option.

Another realm of soil C, also closely linked to climate change, is food and nutritional security. Indeed, extreme climatic events exacerbate food insecurity. Most food-insecure people live in South Asia and sub-Saharan Africa where high and increasing population density is aggravating land degradation. In this context, soil organic carbon (SOC) sequestration through SI of agro-ecosystems simultaneously mitigates climate change and restores soil quality and food/nutritional security. The objective of this article is to explore the opportunities and challenges of so doing, focusing on the processes and options of managing soil C through integrating science and management, and elaborating the strategy of farming C, which necessitates assessment of its societal value.

Climate change, pedological processes and soil health

Projected climate change will impact pedological and biotic processes, including cycling of carbon, nitrogen and water, by altering inputs and outputs and changing the storage capacity of the soil (Figure1).

Atmospheric CO_2 concentration, 400 ppm in 2013, is projected to be 700-900 ppm by 2100. This may increase soil CO_2 efflux, probably because of an increase in the labile C pool in the soil (Hofmockel *et al*, 2011), and CO_2 and CH_4 efflux from wetlands. Warming may also enhance microbial decomposition and nutrient mineralisation in the soil (Melillo *et al*, 2011). More-intense rainfall may impact water-use efficiency (Brooks *et al*, 2011) and increase runoff and soil erosion (Eamus, 1991). Increase in frequency of extreme events can aggravate soil degradation by leaching, acidification and truncation; and trigger landslides (Band *et al*, 2011), debris flow (Cannon *et al*, 2010) and other severe forms of land degradation. Wild fires, caused by extended drought, can also increase the risks of soil erosion (Pierce *et al*, 2004). Severe soil degradation can aggravate sediment transport and delivery (Collins & Bras, 2008; Goode *et al*, 2011) and adversely affect the dynamics of soil moisture (Istanbulluoglu & Bras, 2006). The vicious cycle of soil degradation set in motion by global warming has self-reinforcing feedbacks with declining trends in soil and ecosystem C budget (Figure 2). Alterations in vegetation and

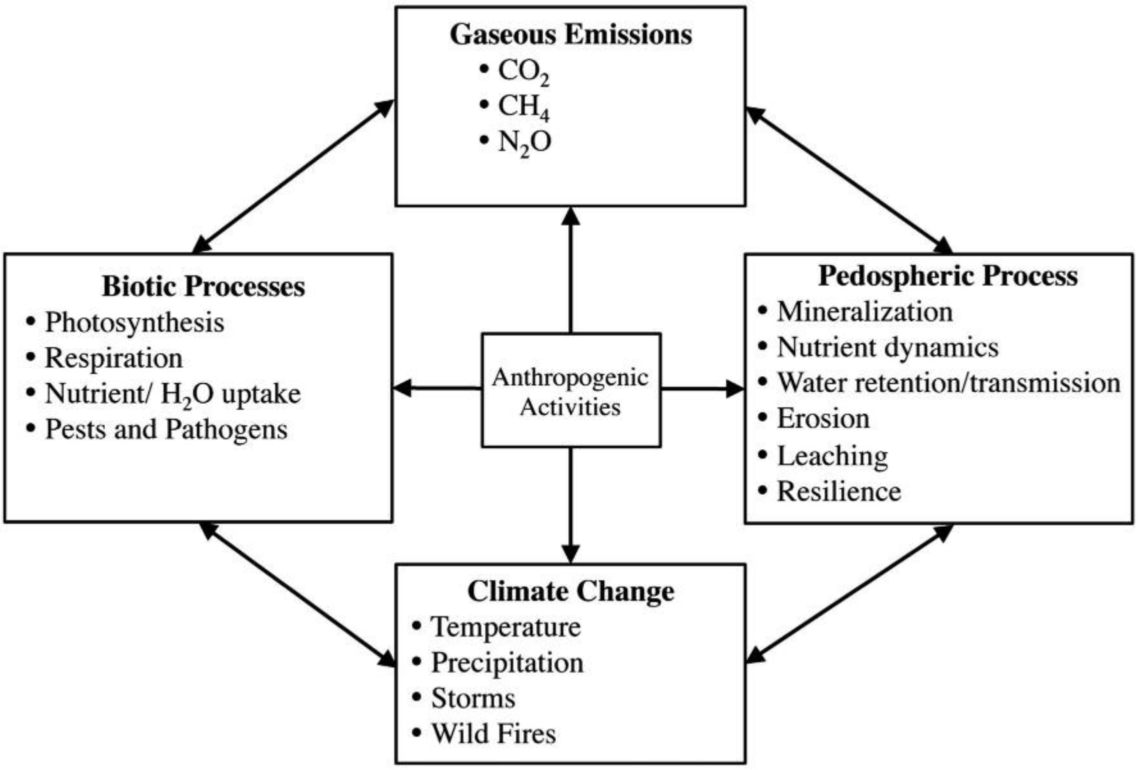


Figure 1. Climatic control on pedospheric and biotic processes

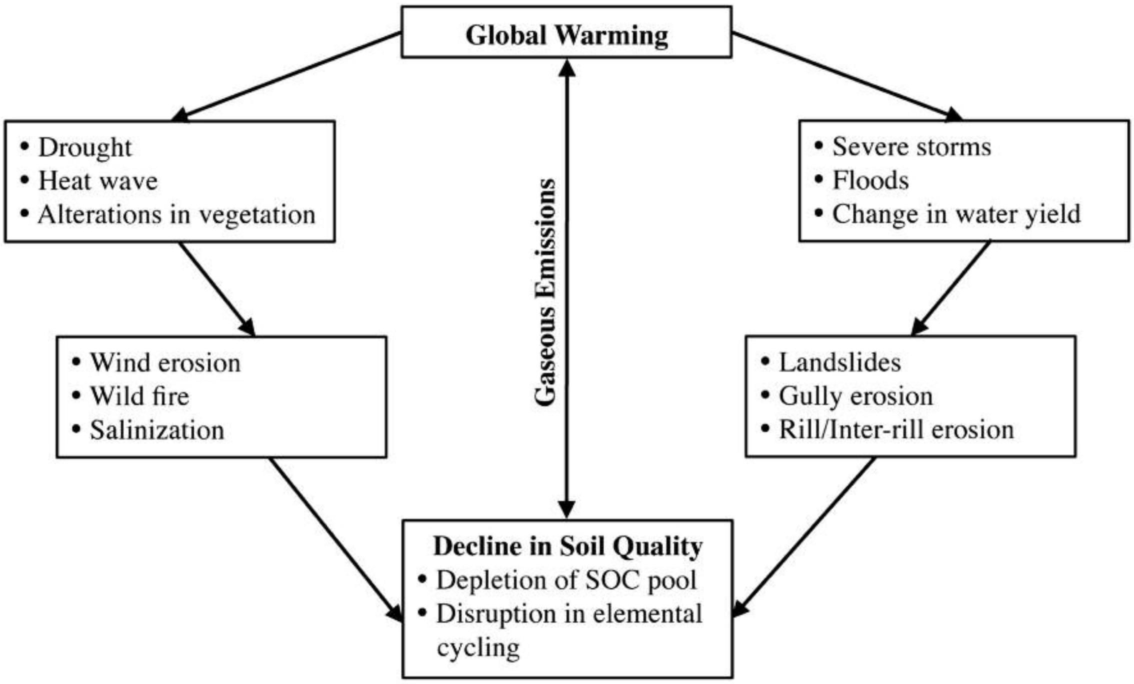


Figure 2. Global warming and soil degradation

species composition can change water yield from catchments, with adverse impacts on net primary productivity. And climate change can lead to permafrost degradation along with severe ecological changes and strong positive feedback (Jorgenson *et al*, 2001). With increasing soil degradation, still more of the food demands from densely populated areas will have to be met from elsewhere.

The global C budget shows a terrestrial C sink with a possible capacity of 2.4±0.4 Pg C/yr (Pacala *et al*, 2001; Pan *et al*, 2011). Allowing for 1.3±0.7 Pg C/yr emissions from tropical deforestation, the net land-based sink capacity has been estimated 1.1±0.8 Pg C/yr. There are some computational and methodological problems, but the importance of C sequestration in soils cannot be ignored and it brings many benefits for human wellbeing and nature conservation.

Protecting climate with soil C sequestration: can soil C management enhance ecosystem services and increase soil resilience?

The importance of soil organic matter (SOM) to productivity and fertility has long been recognised; two thousand years ago,

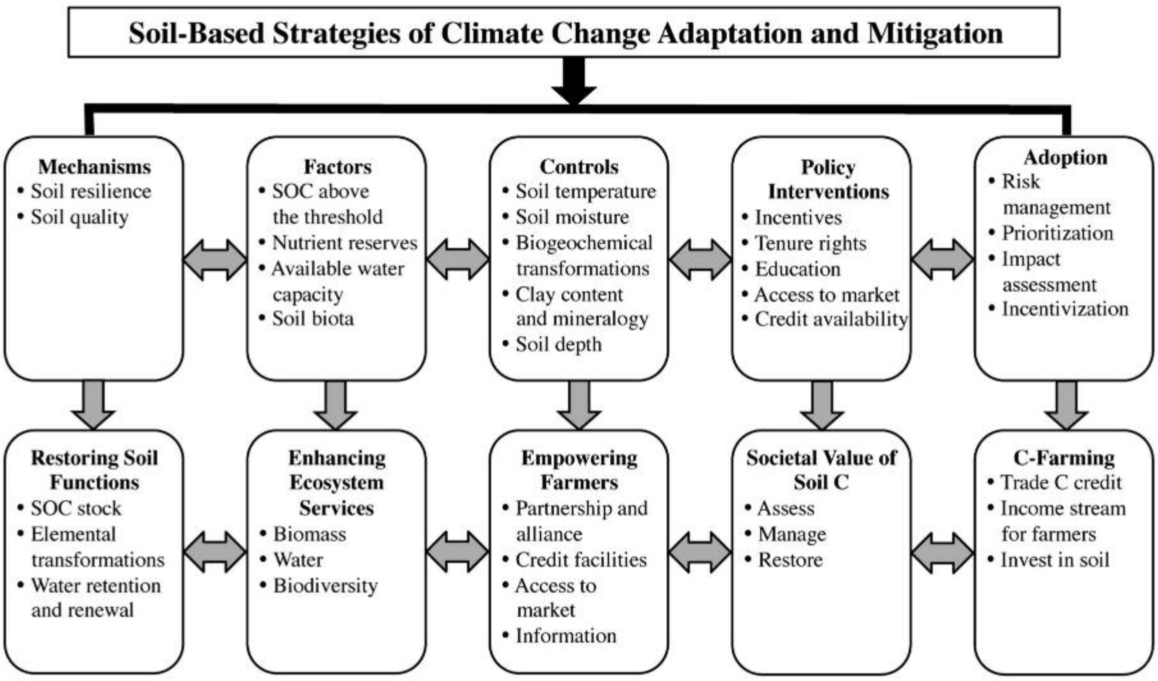


Figure 3. Restoring soil functions and ecosystem services by enhancing SOC stock to above the threshold level

the Tamil poet Thiruvalluvar wrote *'manuring profiteth more than the ploughing and, when the land is weeded, guarding it profiteth more than irrigation'*. Recognition of the role of soil in sequestering C to combat climate change has come late in the day. Carbon sequestration is a transfer of atmospheric CO_2 into SOM and carbonates through the addition of plant biomass; not all soil C being created equal, the sequestered C may remain in the soil from a few days to millennia, depending on the characteristics of SOC fractions and the protective mechanisms involved.

Croplands and grazing lands cover about 5,000 M ha. Most of their soils are depleted of SOC by degradation and extractive farming; the magnitude of depletion in some agricultural soils may be 30-40 Mg C/ha. If all of the depleted SOC pool can be restored, the soil C sink capacity of agro-ecosystems may be 150-200 Pg. Assuming that this is realised over 100 years, the atmospheric drawdown of CO_2 would be 40-50 ppm by early 2100 – this is substantial considering its cost-effectiveness and many co-benefits.

Among soils of agro-ecosystems, there are several opportunities (Figure 3). Highly degraded croplands may be a high priority for restoration; appropriate SI practices that may create a positive soil C budget include conservation tillage and mulch farming, cover cropping, integrated nutrient management and new crop species. Other options include restoration of peatlands, and management of rangelands by controlled grazing, newer species and fire management (Lal *et al*, 2012). Ancillary benefits of soil C sequestration include improvement in soil resilience against degradation and a changing/uncertain climate, soil fertility, water-holding capacity, use-efficiency of inputs (fertilisers, varieties), agronomic productivity and sustainability, and numerous ecosystem services (Lal *et al*, 2013). At the same time, there are uncertainties and concerns about strategies of SOC sequestration in cropland: finite sink capacity, permanence, measurement and validation, trade-offs with additional N and P needs, and sequestration at one site but depletion at another.

Soil-carbon sequestration mechanisms

The strategy is to protect the existing SOC pool and increase the overall C pool (Figure 4); the goal is to control the rate of decomposition and manage the input of biomass-C to exceed the losses. Input of C through plant biomass is transformed into soil organic compounds and a small amount as carbonates. Carbon enters the soil through roots and root exudates as well as through above-ground biomass. Mycorrhizae associated with plant roots play an important role in transfer of the above-ground C into the soil; *eg* ectomycorrhizal fungi can transfer much of the C allocated to them by the host tree to the roots, and the death of fungal colonies can contribute a lot of biomass and affect the soil's biogeochemistry. Clemmensen *et al* (2013) have proposed that in boreal forests, comprising only 11 percent of the land surface but 16 percent of the soil C pool, the organic layers grow from below through the continuous addition of recently-fixed C as remains of roots and associated fungal mycelia. Other environmental factors (*eg* N deposition or fixation; elevated atmospheric CO_2) may influence the rate of C sequestration through their effects on rhizospheric processes (Figure 3). Fernandez *et al* (2013) described the importance of *Cenococcum geophilum* ectomycorrhiza in forming recalcitrant litter with strong effects on biogeochemical cycles in forest soils. Fungal mycelia also affect the stability of soil C through the formation of stable micro-aggregates.

The rate of SOC sequestration depends on soil type and climate. Land use also plays an important role through the establishment of crops that produce large biomass of a wide C:N ratio, *eg* conversion of marginal/degraded lands to bio-fuel plantations of switchgrass (*Panicum virgatum*) and miscanthus (*Miscanthus giganteus*). There is a threshold C:N ratio where the microbial biomass can be impaired with significant impact on decomposition and mineralisation. Woo *et al* (2014) observed that the foliar C:N ratio in bio-energy crops at harvest is significantly higher than that in grain crops. Further, there is a critical C:N ratio in SOM at which the microbial biomass

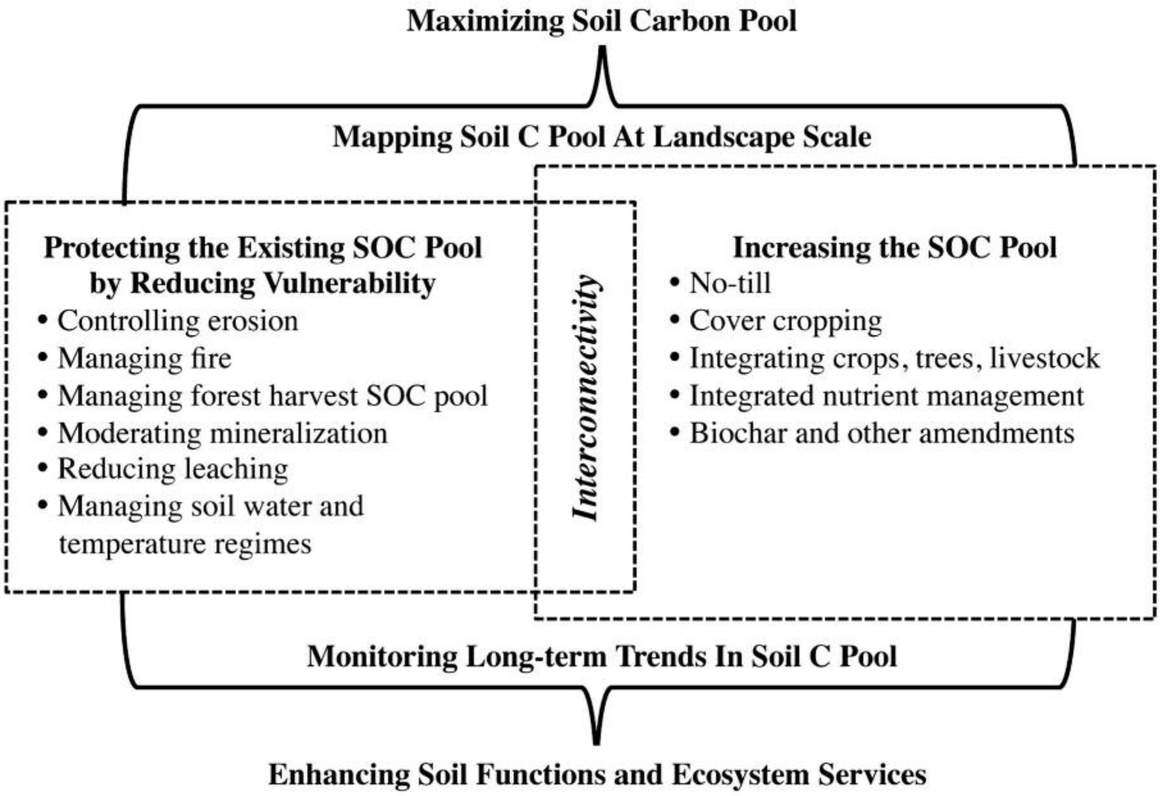


Figure 4. Managing soil C pool and enhancing ecosystem functions and services

is impaired and the microbes are dependent on the net immobilisation. Thus, values above these thresholds could result in significantly enhanced sequestration of atmospheric CO_2 in topsoil and, also reduce inorganic N losses through reduction of decomposition and mineralisation.

According to Mackey *et al* (2013), about 40 percent of the world's agricultural soils are degraded; in some severely eroded soils, as much as 70 percent of topsoil has been eroded. Given the significant loss of the antecedent SOC pool, high priority should be given to the management of C flow in degraded and drastically disturbed or mined soils (Brown & Subler, 2007; Tain *et al*, 2009). Even so, the soil C sink is finite, it can be filled within 25-100 years, and it is not enough to off-set all anthropogenic emissions from fossil fuel, cement production and other activities.

How much impact can soil C sequestration have on reducing the concentration of atmospheric CO_2? To 1m depth, SOC amounts to ~1,500 Pg (Lal, 2004). If this pool can be increased by 1 percent over a decade (0.1%/yr), that would reduce the atmospheric CO_2 pool by about 1.5 Pg C/yr, which would amount to a decline of about 0.2 percent in the atmospheric pool of 800 Pg ($1.5 \div 800 \times 100 = 0.2\%$/yr). Compared with total annual anthropogenic emissions of ~11 PgC, the technical sequestration potential of 1.5 Pg C/yr in soil is a modest 14 percent of total emissions, so the long-term strategy has to be development of no-C or low-C fuel sources. However, soil C sequestration is a no-regrets option because of its many co-benefits and cost-effectiveness (compared with $600-800/Mg of CO_2 for geological sequestration).

Recarbonising soils of agro-ecosystems: risks and responsibilities

When SOC concentration is <1 percent in the root zone, soil functions and processes may be impaired (Kay & Angers, 1999). The SOC content of most agricultural soils managed by smallholders and resource-poor farmers in South Asia and sub-Saharan Africa may be 0.1 percent or lower, resulting in meagre yields and little response to fertilisers. As much as 45 percent of soils of Europe have low or very low SOC content (Matthews, 2014); even the best soils in the world, the chernozems, have lost 30-40 percent of their organic carbon (c40 t/ha) (Krupenikov *et al*, 2011). SOC levels must be restored to increase productivity and resilience, improve the environment and mitigate climate change. Everyone is a perpetrator and a victim; everyone has a responsibility towards re-carbonisation of soil and the terrestrial biosphere.

The potential (technical) SOC storage capacity depends on clay content and mineralogy, solum depth and horizonation, and bulk density: the attainable capacity is governed by climatic parameters. Controls on SOC capacity include land use and management, but management practices are site-specific and have trade-offs – there is no one universal practice. In determining systems that may create a positive soil C budget, the challenge lies in identifying site-specific practices that create a positive soil and ecosystem C budget while improving food production, restoring degraded soils and improving the environment.

When a natural ecosystem is converted to an agro-ecosystem, the SOC pool can be rapidly depleted, especially in soils prone to accelerated erosion. Re-carbonisation is a stern task, especially in the tropics with resource-poor farmers; it is a long-term investment that needs inputs of crop and animal residues and nutrients, and resources to establish cover crops, trees, and soil amendments. Therefore, strategies of SI must be adopted which optimise inherent and applied resources (nutrients, water), reducing losses (erosion, mineralisation, leaching) and strengthening recycling mechanisms (crop and animal residues, biological N fixation, mycorrhizal association, disease-suppressive soils, microbial biomass C, earthworm activity, *etc*). SI practices that also create a positive soil C budget include conservation agriculture, cover cropping, complex rotations, integrated nutrient management and agroforestry (Lal, 2004). Social, economic and political factors also govern SI; important among these are farm size, land tenure, access to markets, credit, gender and other factors affecting social equity. These human dimensions are even more challenging than the biophysical constraints. The strategy is to empower farmers by creating a supplementary income stream.

Farming carbon and payments for ecosystem services

Carbon trading requires credible estimates of the rate (kgC/ha/yr) at which the plant-derived draw-down of atmospheric CO_2 is sequestered in soil. Techniques to monitor soil C concentration have been known since ~1850 and there are accepted ways to convert the laboratory data (g/kg) into tradable units (kgC/ha/yr). However, soil C concentration is highly variable; estimates need detailed soil survey (maps) and a baseline with reference to a specific period (*eg* 1990); and there is a high degree of uncertainty in assessing changes in soil C pool over a short period of 1-2 years because of the small changes relative to a large antecedent pool. Thus, measuring changes over a longer period of 5 to 10 years and determining the annual average change is an appropriate option. Once the spatial variability is known and baseline established, change in the soil C pool over time can also be assessed by proven methods. A more cost-effective option is a surrogate based on the land use and management practice with proven results for the same land use/soil type within the same agro-ecoregion; there are also several models available to understand soil C dynamics and estimate the magnitude of gain or losses over the specific period.

Incentivising SOC sequestration through payments for ecosystem services (green payments) should be critically and objectively considered. We should account for all GHGs (N_2O, CH_4 and CO_2) emitted by agro-ecosystems, and changes in soil C pool over a specific period. Where farmers follow recommended practices (proven to produce environmental benefits) for a specific period, they would be entitled to a green payment on the basis of area under recommended practice and the time ($/ha/yr) through assessment of societal value (Lal, 2014). The societal value must also include any additional cost incurred by farmers in adopting the recommended practices.

Conclusions

- Soils and climate are intricately linked. Soils affect climate and *vice versa*.
- C concentration and pool in degraded soils of agro-ecosystems can be enhanced by restorative land use and adoption of recommended soil/crop/water/animal management practices.
- Sequestering C in soils is a win-win option. It must be integral to any agenda of mitigating climate change: it is also essential to advancing food and nutritional security and provisioning of numerous functions and services.
- The magnitude of SOC sequestration in soils of agro-ecosystems (5 billion ha) may be as much as 1.5 Pg C/yr, causing an atmospheric drawdown of 0.2%/yr for about 100 years. However, the finite magnitude of the soil C sink necessitates a switch to no-C or low-C fuel sources.
- Priority must be given to strategies that focus on management of C flow through soils; increasing input and decreasing losses of soil C pool. Site-specific practices for soil C sequestration are those which create a positive C budget and decrease losses by erosion, mineralisation and leaching. There is no silver bullet – most practices have well-defined trade-offs.
- Assessment of soil C sequestration is a challenge in terms of logistics and of SOC pool measurements because of large spatial variability and the need to convert laboratory-based analysis into tradable units. Rather than trading C, incentivising farmers by payments for ecosystems services through green payments may be a better option. It is important to assess the societal value of soil which also considers any additional costs incurred in adopting a specific practice.

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News from the Field

Conserving soils on the island of Gozo, Malta

Introduction

In April 2014, I visited the Maltese island of Gozo to look at some of the farming practices and to respond to an invitation to talk to farmers, university scientists and students about the potential that conservation agriculture (CA) could have for the island's agriculture and environment.

The Maltese archipelago lies to the south of Sicily and comprises the islands of Malta, Comino and the most northerly member, Gozo. Gozo is predominantly made of limestone (Figure 1) with some remaining patches of green sand and blue clay. It has been cultivated for thousands of years and, consequently, the soils have become degraded or have disappeared altogether.

Figure 1. Limestone dominates the Gozitan landscape. In this valley (near San Blas) crops are protected by reed barriers from the persistent winds which are another feature of the island

The land area is just 67 km^2 with a resident population of about 30,000 giving a density of 450 people/km^2. The main source of rain is thunderstorms from September to December; the total annual precipitation is 550 mm, peaking in December with 112 mm (Zammit & Dandria, 2011).

Agriculture in Gozo

Agriculture in Gozo occupies approximately fifty percent of the land area and is dominated by part-time farmers. Crop and animal production are inter-connected, with about half of the cropped area being used to produce fodder crops (mainly wheat) for the livestock sector. Livestock production on the island is mainly dairy cattle and pig raising. Sheep and goats, whilst still playing an important role, are not as important as they once were.

After fodder production, vegetables are the second most important cropping activity. The main crop is tomatoes for processing, which are grown in open fields during the warm summer months. Greenhouse-grown tomatoes are produced between October and May and are for the fresh market.

Several thousand tonnes of tomatoes are produced in Gozo and a large part of the total Maltese annual production of 11,000 tonnes is processed there. Other crops grown in greenhouses include: sweet peppers, cucumbers, aubergines and courgettes. Low plastic tunnels (cloches) are used in open fields for protecting sensitive crops such as strawberries and early crops such as watermelon, melon, courgette, sweet pepper and aubergine.

Potatoes (Figure 2) are grown in open fields, as are fruit crops such as melons and water melons, grapes and citrus. Pulses (broad beans, peas and string beans) are grown for local markets. Other crops widely grown in the autumn/winter/spring season include cauliflower, cabbage, carrot and onion.

Figure 2. Potatoes are grown outside, often on small-scale plots by part-time farmers

Mechanisation and soil quality

The main focus of this overview of farming in Gozo is to look at the treatment of agricultural soils, and to explore ways to improve soil health and quality. Gozo's soils are over-mechanised: deep ploughing with mouldboard ploughs is common, as is subsequent pulverisation with rotary cultivators. Soil cultivation of this type is very damaging to the soil structure and to soil life (Figure 3).

Figure 3. Manually operated rotary hoes and tractor-mounted rotary cultivators are commonly used in Gozo for seed bed preparation and weed incorporation

Cultivation with ploughs and rotary hoes can form a plough pan at the depth of cultivation which effectively cuts off water and root penetration into lower soil strata. In a climate like Gozo's, with hot dry summers, this means that crops will suffer a water deficit at an early stage when compared with deep rooted crops growing in a well-structured soil with stored water.

Damaging the structure of a soil means that infiltration in intense rainfall events (such as the winter thunderstorms which can have intensities of 100 mm/h) is limited and the capacity to absorb water is quickly reached. The energy of high intensity storm raindrops rapidly caps pulverised soils, and subsequent precipitation will run off the soil surface carrying with it the nutrient-rich topsoil (Figure 4).

Figure 4. Hillside terraces (some abandoned) indicate historically high rates of soil erosion and fertility depletion. Abandonment is an indication of poor financial viability due to soil exhaustion

This sediment-laden runoff will erode soil from agricultural areas and will deposit it in dams and stream beds on its way to the sea. Rotary cultivation of dry soils will provoke wind erosion which will carry away clouds of topsoil. This wind-blown soil is composed of the nutrient rich smaller soil particles and their loss will mean that nutrients will have to be replenished through the costly application of additional fertilisers.

The need for Conservation Agriculture (CA)

The brief description of some of the negative aspects of soil cultivation points to the urgent need to consider measures to protect Gozo's fragile and diminishing soils. CA (comprising minimum soil disturbance, maintenance of a permanent organic soil cover and practising healthy rotations and associations of crops and cover crops) is one such measure which could help to rehabilitate the degraded soils.

The CA principles are universally applicable, although there will always have to be site-specific adaptations to different localities. In the case of Gozo, the value of soil cover is already appreciated as plastic sheeting is used to control weeds and to retain soil moisture. The employment of organic cover has a similar effect, but it also has the potential to act as a feed source for the soil biota which would flourish beneath it in a no-till scenario.

EcoGozo

The Ministry for Gozo is promoting a refreshingly revolutionary programme which visualises that Gozo will be an eco-island by 2020 (www.ecogozo.com). The EcoGozo project encompasses a complete range of proposals for transforming all aspects of the island economy to produce a healthy, sustainable, environmentally nurturing ecosystem (Ministry for Gozo, 2013). A key component of the project is the improvement of agricultural practices which covers the following:

- More rational use of fertilisers to reduce leaching and groundwater contamination. N use in Gozo is estimated at 117 kg/ha (compared to the European average of 44.2 kg/ha). Fertiliser use with CA can be reduced by as much as 30–50 percent once the system has stabilised after the switch from conventional tillage.

- A reduction in the use of pesticides and non-degradable plastics. There is an increasing awareness of the value of integrated pest management (IPM) which comes with the realisation that nature will often arrive at an acceptable equilibrium if pest predators are not destroyed but rather allowed to build up and control the pests. The ideas of sterilisation and blanket eradication are short-term fixes that are no longer sustainable. Pesticide applications under a CA regime where IPM is practised are typically reduced by up to 20 percent.
- Soil quality. The EcoGozo vision focuses on reducing soil erosion through better maintenance of retaining walls, especially on hillside terraces. There is also emphasis on afforestation where this is possible. CA is entirely compatible with these aims as it would be an essential component of soil stabilisation and protection, reducing run-off and erosion and keeping soils in place. A broader vision of CA includes forest establishment and agroforestry as important components of holistic sustainable catchment management.
- Water use. Water is one of the scarcest resources in Gozitan agriculture. Special measures have been adopted to harvest more rainwater and to slow or halt its passage to the sea. These include de-silting and damming existing water catchments both at valley and road-side ditch levels (Figure 5).

CA takes the process one step further by increasing water infiltration, enhancing soil storage capacity and reducing soil moisture losses to the atmosphere by not ploughing and maintaining soil cover. Water requirements for CA crops are typically 30 percent lower than those for conventionally tilled crops.

Figure 5. Roadside run-off is stored behind check dams for subsequent crop irrigation

Conclusions

Current agricultural practices in Gozo are damaging to the soil which is a precious, non-renewable and essential resource of the agricultural industry. Soils are fragile living entities which need to be treated correctly and conserved. Treating the soil well has a major positive impact on environmental improvement and should be encouraged to ensure that there is still an agricultural industry in Gozo for future generations. Agriculturally-induced soil erosion has caused most past civilisations to crumble (Montgomery, 2012) but we have it in our hands to ensure that that does not happen in Gozo.

EcoGozo is a remarkable and positive initiative of the Ministry for Gozo which looks at a broad range of environmentally enhancing actions that urgently need to be undertaken to secure Gozo's future. These include many related to achieving a sustainable agriculture and this is precisely where Conservation Agriculture can play a huge role. Basic R&D, preferably using side-by-side demonstration plots comparing CA with conventional practice, should be undertaken without delay at Xewija experimental farm and would greatly benefit from research input from the Institute of Life Studies of the University of Malta.

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Brian Sims

Soil erosion and conservation

Francis Shaxson and Amir Kassam

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Summary

Soil degradation is generally understood as loss of soil function and productivity as a result of human activities, and manifest as displacement of soil material through water and wind erosion, and chemical and physical damage such as depletion of nutrients and organic matter, salinity, acidity, compaction and surface sealing – often with severe off-site effects. Such a description treats soil mainly as a physical entity: actually, a productive soil is a living system in which the activities of soil organisms create and enhance soil health and productive capacity. In the same vein, soil conservation activities used to focus on physical actions to control erosive runoff. The erosive force of rain splash and the protective effect of ground cover were recognised in the 1930s but the implications were not widely acted-upon for half a century. Conservation Agriculture is a different paradigm embracing no-till; maintaining ground cover with a mulch of crop residues; and diversification of crops grown in rotation or association. In concert, these practices build resilience by protecting the soil surface from driving rain, wind and baking sun; put back organic matter into the soil that feeds soil organisms that build and stabilise soil structure, increase infiltration and cut destructive runoff; control weeds and pests; and increase crop yields – while substantially cutting the use of fossil fuels. From its beginnings in the 1970s, its spread to 11 percent of the global arable cropland has been farmer-led, but success requires participation of all stakeholders. Much more could be done with real government, institutional, research and educational support.

Geological and ecological processes

Climatic factors (temperature changes, wind and water) and geological processes (weathering, dislodgement, transport and deposition) have created varied landscapes. If, when and where the land is colonised by bacteria, fungi and vegetation, these shape-degrading and transporting processes become muted. This appears to fly in the face of the Second Law of Thermodynamics which decrees that, once energy has been dissipated into the environment, it may not be reversed. Living organisms, however, have the astonishing capacity to build complex molecules from simple ones, whose *'regular and lawful unfolding is guided by a mechanism entirely different from the probability mechanism of physics* (Schrödinger, 1944; Al-Khalili & McFadden, 2014). The presence of plants and of a sufficiency of their leaves, shoots, roots and components of their rhizosphere, modifies the effects of sun, wind, rain and gravity.

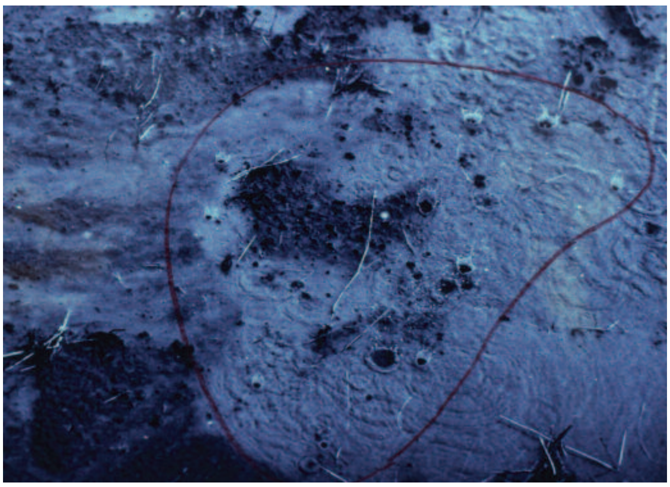

Figure 1. Storm rainfall on saturated soil. Impacts of raindrops on a surface produces forces for both splash and compaction (Photo: T F Shaxson)

Plants, if of sufficient density across a landscape, both protect and enrich their living-spaces, and those of other organisms that associate with them, tending towards a dynamically stable *ecological climax* which may include effects of grazing animals. Climax conditions include a dense cover of living and dead leaves that minimises the erosive force of raindrops (Figures 1 and 2); re-cycles organic matter and the nutrients therein; and creates a porous soil within the layers explored by the plants and within which soil-inhabiting organisms live. As long as its porosity is not diminished by induced, relatively-impermeable layers (be they only a few millimetres thick), such a soil enables the diffusion of root-respiration gases between the soil and the above-ground atmosphere. It also permits the infiltration and storage of water available to plants, and drainage of the remainder to aquifers and streams. The dynamics of these ongoing processes give soils the capacity for self-repair and self-renewal. In short, the system is sustainable.

Figure 2. Vegetative cover dissipates energy of single raindrops among a multitude of smaller splash-droplets (Photo: T F Shaxson)

Soil erosion and land degradation

However, humanity's capacity for thought and action has proven capable of severe damage to ecosystems. One manifestation is accelerated soil erosion, from which soils may only slowly be able to reassemble themselves. Activities such as clearing vegetation, burning the residues, compacting the surface and sub-surface layers, and tillage that hastens the loss of soil carbon to the atmosphere, all contribute to soil degradation that often results not only in loss of soil-productivity potential but, also, redistribution of runoff and eroded soil across the broader landscape (Figure 3).

Figure 3. Runoff and erosion from an overgrazed and seriously compacted pasture (Photo: T F Shaxson)

The various processes that degrade the soil can take merely hours to occur: the counteracting, life-based transformation of subsequently applied raw organic matter into soil organic matter, and restoration of the soil to optimum porosity and other features favourable to the soil-inhabiting life-forms, may take weeks or, even, months. Biological soil restoration may also be prejudiced if land-use has not earlier been planned with due respect to those features of the particular landscape on which it has been imposed (Shaxson *et al*, 2014a, b). In particular, shallow soil depth above impermeable subsoil and even moderate gradients exacerbate the down-slope removal of soil materials dislodged from their earlier resting-place by tillage and/or by intense rainfall; and exposure of infertile subsoil slows down the potential rate of recovery of the soil and vegetation from prior damage.

Agricultural soil degradation is generally understood as loss in the functional quality or productivity of soil as a result of human activities, leading to decreased biological productivity and environmental services or its abandonment for agricultural use. Two main categories of degradation are distinguished: (1) displacement of soil material through water and wind erosion; and (2) chemical and physical deterioration such as depletion of soil nutrients and organic matter, salinisation, acidification and pollution, but also compaction, sealing and crusting, truncation of the soil profile, or waterlogging. There is a strong relationship between the two categories because the occurrence and degree of soil displacement is a consequence of chemical and physical deterioration of the soil. In addition, both kinds of soil degradation may have severe off-site effects such as sedimentation of reservoirs, harbours or lakes; flooding; riverbed filling and riverbank erosion; and eutrophication of water bodies.

In these definitions and descriptions of agricultural soil degradation, soil is treated mainly as a physical entity (Kassam *et al*, 2013). In reality, a productive agricultural soil is a living system in which biological processes carried out by soil microorganisms and meso-fauna are key elements in the creation, maintenance, and enhancement of soil health and productive capacity. This includes the superior phenotypic performance of genotypes through symbiotic relationships between the plant root systems and the soil microbiomes that have co-evolved over time. Deterioration of soil biological health, and consequent loss in soil productive capacity and ecosystem services, is not given the attention that it deserves in agricultural soil management and degradation research or in farming system management (Uphoff *et al*, 2006; Kassam *et al*, 2013).

Soil conservation and improvement

In the past, soil conservation activities were chiefly predicated on physical actions to control erosive runoff. Although the power of large raindrops to dislodge soil particles, and the physical buffering-effect of ground cover was recognised in the 1930s (*eg* Duley, 1939), the implications of these findings and demonstrations were not widely acted upon, nor recognised in government policy, until some 40 years later.

In southern Brazil in the 1970s, farmers experienced disastrous runoff and soil erosion, much of it related to the exposure of

Table 1: Area of arable cropland under CA by continent in 2013 (FAO AquaStat: www.fao/ag/ca/6c.html)

Continent	Area (M ha)	Percent of global total	Percent of arable land
South America	66.2	42.2	60.0
North America	54.0	34.4	24.0
Australia & NZ	17.9	11.4	35.9
Asia	10.3	6.6	3.0
Russia &Ukraine	5.2	3.3	3.3
Europe	2.1	1.3	2.8
Africa	1.2	0.8	0.9
Global total	**157**	**100**	**11.0**

bare soil to compaction (by intense rain falling onto bare de-structured topsoil and by year-after-year of tillage with heavy disc-equipment). Dedicated research in Brazil resulted in recommendations for (a) initial breaking-up of the compacted zone to appropriate depth, to enable improved acceptance and storage of incoming rainwater – followed by no subsequent soil-disturbance by any further tillage; (b) retention of crop-residues (as opposed to burning them) as a perpetual protective mulch to provide both a permeable buffer against rain splash as well as a source of slow-release carbon-rich materials to provide energy and nutrients for soil organisms – contributing to the maintenance of soil-structure and soil health; and (c) direct-seeding through the mulch-cover with appropriate equipment to ensure the least disturbance, both of the cover and of the well-structured soil beneath. Within as little as one year, as soil-protective cover increased and soil structural conditions improved, less of the rainfall became runoff and soil became less liable to dislodgement and dislocation as sediment. These changes, in regions where the recommendations were being adopted, significantly improved the economics of a range of different farming systems, as well as providing increased income and improved water-supply and quality to local communities.

From the above, it may be seen that whereas soil erosion used to be considered as a prime cause of degradation of soil, present understanding of the processes leads to the understanding that its converse, soil conservation, can be a consequence of better soil management and improvements in land husbandry.

Conservation Agriculture

These various improvements in care and management of soils have become increasingly widespread with adoption of appropriate forms of what have now become no-till farming systems, known worldwide as *Conservation Agriculture* (CA). Three, key, interlinked attributes of CA appear to be able to minimise or eliminate the degrading effects of inappropriate agricultural practices on the soil:

- Minimal or no mechanical soil disturbance, by seeding directly into untilled soil so as to maintain soil porosity and minimise loss of soil organic matter.
- Permanent, permeable ground cover with, *eg*, crop residues which not only protect the surface from extremes of rain-impact and temperature but are, also, a nutrient and energy source for soil-inhabiting organisms.
- Diversification of the cropping system through rotations, sequences or associations of crops, which minimises the effects and spread of disease organisms, both above and below the soil surface.

Adoption of these fundamental premises creates optimum conditions for other interventions aimed at improving plant growth and realising the potentials of chosen soil/plant systems. Once CA has effectively been adopted, the soils on which it is practised tend ever closer to being self-sustaining.

Spread of CA

In 1973/74, CA was practised across some 2.8M ha worldwide; in 1999, the area had increased to 45M ha; and by 2003 to 72M ha. Over the past decade, the area under CA has increased at an average rate of 8.3M ha/year, reflecting the growing interest of farmers small and large, mainly in the Americas and Australia and, more recently, with large farms in Kazakhstan and small farms in India and China. The updated figures for 2013 (Table 1) show the global spread of arable CA across all continents is some 157M ha (11 percent of the global arable cropland).

This farmer-led transformation of agriculture from tillage-based to CA is a new paradigm for sustainable, climate-smart production intensification. About 50 percent of the global CA area is in developing regions (Friedrich *et al*, 2012; Kassam *et al*, 2014a; Jat *et al*, 2014). Europe and Africa are the developing continents in terms of CA adoption. Good, long-term research in these continents has shown positive results for CA systems, which are now making progress there as more attention is paid to its promotion by governments and the development community. The arable crop area under CA has more than doubled in Europe since 2010; indications are that there has been a substantial increase in CA area in Africa, although more recent data are needed to confirm this.

The reasons for the spread of CA may be varied and complex. The original attraction was the lessening of runoff and erosion. The concomitant improvements in both crop performance and the environment, and the cutting of costs of production – labour, fuel, equipment, disease and pest control – have also been motives for adoption. Only in a few countries (USA, Canada, Australia, Brazil, Argentina, Paraguay and Uruguay) is CA mainstreamed in agricultural development programmes; in fewer still (*eg* Canada, Kazakhstan, China, and Zambia) is it backed by government policies and some public institutional support.

Support for CA

The ecological processes going on in the soils of agricultural systems are potentially self-sustaining: their best management is not. Political, legislative, economic and educational support to those who would practise CA are not yet identified, agreed, applied, or delivered by means available and appropriate to aspiring practitioners. Given the array of agro-ecologies and socio-economic situations across the world, any such support must involve the farmers themselves and appropriate mechanisms to test and locally formulate practices to suit local conditions. However, for scaling-up beyond local level, it is necessary for governments to arrange policy and institutional support that may encourage the local private-sector to provide CA-related services and inputs, including equipment and machinery; it may also include incentives to farmers for delivering environmental services (Kassam *et al,* 2014b). And for such policy and institutional support to be feasible and affordable, farmers need to work and learn together in organisations such as cooperative or Farmer Field School arrangements or in associations that take advantage of savings that are possible with joint purchase and delivery of inputs and that attract the best market prices for bulk delivery.

Challenges to sustainable soil management

CA represents a fundamental change in production-system thinking that has been compared with the paradigm-change from flat earth to round earth (Kassam *et al*, 2014b). Its roots lie largely in farming communities and its adoption to-date has been mainly farmer-driven. However, experience across many countries is that the adoption and rapid spread of CA requires a change in commitment and behaviour of all stakeholders. For the farmers, a mechanism to experiment, learn and adapt is a prerequisite; and this can be provided through innovation networks or farmer associations or farmer learning groups such as Farmer Field Schools. For the policy-makers and institutional leaders, transformation of tillage systems to CA requires that they fully understand the big but longer-term productivity, economic, social and environmental benefits offered by CA to producers and the society at large. Furthermore, the transformation calls for sustained policy and institutional support that can provide incentives and required services to farmers to adopt CA practices and improve them over time.

Challenges to designing and adapting CA to the circumstances of the smallholder in Asia and Africa vary across agro-ecologies (including the level of land degradation) and prevailing farming systems along with the associated socio-economic environment. However, smallholders across Asia and Africa are adopting CA – especially where there is a support programme with know-how, input support and market access (Jat *et al*, 2014; ACT, 2014). Thus, challenges are being addressed selectively. To accelerate the adoption of CA needs champions across the spectrum of public, private and community institutions and programmes. This is now happening, but even more is needed so that smallholders in Asia and Africa can benefit from stronger support – including locally formulated, adaptive research on the availability and use of equipment and machinery, management of soil cover and competition for crop residues, effective weed management, and economically viable cropping systems. Some challenges, such as positive integration of livestock into CA systems and minimising competition from livestock for crop residues, require both farm-level and community-level solutions.

In monsoon Asia, farming systems are dominated by rice grown in paddies with puddled soils. Transforming such high-soil-disturbance systems into CA systems is a complex challenge, but we have learned from the System of Rice Intensification (SRI) that wetland rice does not have to grow under water; where water control is possible, it can achieve a much better agronomic performance in moist aerobic soils that are not flooded (Uphoff & Kassam, 2011; Stoop, 2013). So, in some rice agro-ecologies, it is possible to produce rice by disturbing the soil as little as possible and keeping it covered with mulch to maintain and enhance soil health and functions. In Bangladesh and elsewhere in Asia, several approaches to implementing CA rice-based systems are showing promise – direct-seeded rice production on permanent no-till broad beds, direct-seeded rice production in no-till levelled paddies, or direct-seeded rice in no-till soils with sub-surface micro-irrigation.

The future

If farming and agricultural landscapes are to become multi-functional, ecologically sustainable and integrated into the greater ecosystem alongside other land uses, then enhanced agricultural production must go hand-in-hand with enhancement and delivery of ecosystem services. Production systems must be efficient, with high input factor productivities, and resilient in on-farm performance and socio-economic development. And soil erosion must be arrested – not accepted as being unavoidable.

There are many local, national and international challenges to be addressed, including food, water and energy insecurity, climate change, pervasive rural poverty and degradation of natural resources. More advantage of the benefits offered by CA can be realised if all stakeholders become involved in the transformation process as is happening in Brazil, Argentina, Paraguay, USA, Canada and Australia. This is beginning to happen in Europe (*eg* Finland and Spain), Africa (*eg* Zambia and Zimbabwe) and Asia (*eg* Kazakhstan and China). However, a more structural response to the opportunities presented by CA calls for a realignment of agricultural institutions, including research, extension and education, as well as agriculture development policies, to enable CA to become the preferred agriculture paradigm. The World Conservation Agriculture Congress process has evolved as a global, multi-stakeholder, community of practice that is facilitating the uptake and spread of CA as a basis for commercialisation as well as rural economic and civil society development. During the past decade, efforts to promote CA have become better organised. Donor agencies, governments, national research and extension systems, private sector firms, NGOs, and farmers themselves are engaged in finding ways and means to introduce and spread CA as a basis for sustainable land management as well as for adaptation to climate change.

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News from the Field

Progress at the World Soil Survey Archive and Catalogue (WOSSAC): developments in the dissemination of legacy soils materials

The World Soil Survey Archive and Catalogue (WOSSAC, www.wossac.com) at Cranfield University is a repository of both historic and contemporary soil survey reports and maps produced mainly by British surveyors, departments and companies in overseas territories. Many of the older documents date from the early 20th century and, of these, a good number are the only existing copies. Today, WOSSAC holds more than 24,000 catalogued maps, books, reports, photographs, imagery and field notes; with a further substantial number of items ready for cataloguing. These legacy materials are important sources of information and real data in contemporary studies contributing to land resources assessments worldwide, including climate change, food security, deforestation, and commercial farming involving disruptive land-use change. Potentially, many other initiatives will benefit from an awareness of historic survey information.

Since our last report in *Agriculture for Development* in 2011 and the visit by TAA members in 2012, WOSSAC has made significant progress – notably, the recognition and support of a grant of over £200,000 from the Natural Environment Research Council in 2013. This enabled WOSSAC to acquire its own document and microfilm scanners, other image- and data-processing equipment; and an innovative 3D *virtual reality* data visualisation suite to help draw digital representations of legacy data together with other contemporary data arising from, *eg* climate change scenarios, satellite imagery and land capability modelling. The award also includes a component for dedicated staff time for cataloguing, scanning and data-processing.

WOSSAC has continued with the physical collection, preservation, and sorting of soil- and land-related materials, particularly the *grey literature* that is at particular risk of being lost forever. Retired soil surveyors and the executors of their estates appreciate WOSSAC as a safe home for their archives and, in the last few years, we have received valuable material from: Ian Baillie, Fred Collier, David Dent, Brian Kerr, Neil Munro, Ian Thornton, and Dick Webster; from the estates of Gordon Anderson, Don Chambers, Richard Dunham, Bruce King, Ted Wilmot, and Reen Ysselmuiden; as well as from institutions that are rationalising storage, such as the former National Institute of Agricultural Engineering and Royal Holloway College. Another significant development has been the formal transfer to WOSSAC by HTSPE (formerly Hunting Technical Services) of their substantive worldwide report and map collection, which was already at Cranfield and is now fully integrated into the archive. To ensure that new arrivals are correctly assessed and made available for researchers and stakeholders, all incoming materials are triaged with respect to their priority for cataloguing and scanning. Inevitably, some of the donations include general soils and related textbooks and similar items. With the permission of the donors, we pass on those items that do not belong in WOSSAC to the British

Society for Soil Science, which also has its headquarters at Cranfield; the Society has a scheme for sending academic texts to institutions in the developing world, mostly in Commonwealth Africa.

We continue our efforts to integrate WOSSAC with similar archives elsewhere. Presentations to the European Commission's Joint Research Council at Ispra, and to the Food and Agriculture Organisation of the United Nations in Rome, have struck a chord; these institutions are keen to see WOSSAC develop procedures whereby soils archives in the EU and further afield are mutually accessible. Appreciating that this is a substantial task, they suggested that we start at a realistic scale by forging bilateral coordination with the ex-colonial soil archives in Portugal. We have established contact with willing partners in Lisbon but the woes of the Eurozone and constraints on Portugal's public finances mean that resources for this kind of project are hard to come by. For the present, we can do little more than mount cross-links to each other's web portals. This may also be a way forward for appropriate archives in Britain and the rest of the world, such as the archive for Zambia that is being developed at Royal Holloway College.

The principal challenges to date have been to process and catalogue the backlog of items not in the on-line catalogue; to begin scanning in a systematic way the most important documents; and to respond effectively to the increasing flow of requests and queries. In addition, there is a demand from within Cranfield University for legacy materials that can be utilised in on-going teaching and research projects, all of which have an international dimension; for instance, recent projects on monitoring land use change in Côte d'Ivoire and land suitability assessment for sugar cane plantations in Nigeria. In such cases, it is the fusion of legacy data with contemporary sources of information that reveals the full answer.

We would like to reiterate our appreciation for the continued support of TAA and its individual members. We always welcome donations of any soil survey-related materials that are no longer in regular use and now held in studies, lofts and garages. Some TAA members have delivered donations in person. We particularly appreciate this, as it enables individual donors to see the archive and the cataloguing and scanning processes.

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The scientific basis for ecological restructuring of agriculture on the steppes

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Summary

Moldova, like most countries throughout the world including the republics of the former Soviet Union, followed the industrial model of agricultural intensification with a dependence on mineral fertilisers, pesticides for weed, pest and disease control, dominance of row crops and neglect of animal husbandry. It has paid a high economic, environmental and social price. Seeking a practical alternative farming system, this article draws on data from a long-term poly-factorial field experiment with different crop rotations, systems of soil tillage and fertilisation. The effect of crop rotation was determined for different crops under different systems of tillage and fertilisation. Crop rotation with perennial legumes and grasses, integrated with animal husbandry, provides self-sufficiency in nutrients and facilitates no-till farming.

Unsustainable farming systems

The industrial approach to agricultural intensification, depending on mechanised power, ever-increasing application of mineral fertilisers and agrochemicals, irrigation, and new crop varieties including GMOs, is unsustainable. Increased yields have been pursued without considering the maintenance of soil fertility, biodiversity, or the health of the whole food chain (Foresight, 2011). Across the steppes from Moldova, through Ukraine, Russia and into Central Asia, lack of an holistic approach to the action and interaction between the factors of intensification has been an obstacle to sustainability (Boincean, 1999); recent satellite data presented elsewhere in this issue of *Ag4Dev* (Bai *et al*, 2015) indicate a system in trouble.

In Moldova, privatisation of agriculture following the collapse

Table 1. Change in the sown area in Moldova, 1990-2012 (Annual statistical data)

Indices	1990 thousands, ha	1990 %	2012 thousands, ha	2012 %
Total arable	**1,674.5**	**100**	**1,460.0**	**100**
Compact-drilled crops	687.9	41	488.8	34
Cereals	407.1	24	453.9	31
Perennial legumes	192.1	12	5.0	0.3
Row crops	986.6	60	971.5	67
Corn for grain	258.0	15	415.9	29
Sunflower	134.1	8	252.4	17
Forage crops	538.2	32	75.3	5
Use of fertiliser				
	Total, thousand tonne	per ha	Total, thousand tonne	per ha
Farmyard manure	9,700	5.8t	15	0.01t
Mineral fertilisers	217	130kg	20	14kg

of the USSR brought sweeping changes in the structure of the sown area and use of manure and fertilisers (Table 1). The proportion of row crops increased; the area under cereals also increased, but opportunities for farmers to drill winter cereals after early-harvested predecessors, crucial under the severe climate of the steppes, have been restricted. Early sowing of winter cereals enables the crop to develop a robust rooting system before the winter sets in and, thereby, ride out drought in the next growing season. Lack of early-harvested predecessors for winter cereals and the preponderance of row crops does not respect scientifically-based crop rotations. There has been a sharp increase in the area under cash crops like sunflower and maize-for-grain, whereas the area under forage crops has fallen dramatically (perennial legumes decreased from 12 percent of the sown area down to 0.3 percent) and stockbreeding has almost disappeared. The application of farmyard manure and mineral fertilisers has greatly decreased which means reduced soil fertility and increased vulnerability to soil erosion and drought.

A basis for an alternative system

Seeking a practical alternative, a long-term poly-factorial experiment was established in 1995 at the Selectia Institute for Field Crops on the Balti steppe in the north of Moldova. The soil is a typical chernozem: a heavy clay with 4.5-5.0 percent humus (Tiurin), pH(water) 7.3, pH($CaCl_2$) 6.2, and total NPK of 0.20-0.25, 0.09-0.11 and 1.22-1.28 percent, respectively. The mean annual precipitation (1996-2009) was 544 mm. The experiment tested the comparative advantages of a whole landscape approach respecting crop rotation, integration of animal and crop husbandry, minimum soil disturbance, and a higher diversity of genetic resources. It examined the action and interaction between three main components of farming systems: crop rotation with and without perennial legumes and grasses, two systems of tillage and three of fertilisation. Each plot was 264 m^2 with three replicates, a total experimental area of 8.7 ha. No chemicals were used for control of pests, diseases and weeds. The sequence of crops in the two rotations was:

I. 1. Lucerne + ryegrass, third year after first cut
2. Winter wheat
3. Sugar beet
4. Maize for grain
5. Winter barley
6. Maize for green bio-mass under-sown with lucerne and ryegrass
7. Lucerne + ryegrass for green bio-mass

II. 1. Maize silage
2. Winter wheat
3. Sugar beet
4. Maize for grain
5. Peas
6. Winter wheat
7. Sunflower

The systems of tillage were: 1) alternation of inversion of the topsoil with the mouldboard plough (3-5 fields) and disc or tine cultivation that does not invert the topsoil; 2) only ploughless tillage with discs or tines . The systems of fertilisation were: 1) Control (without fertiliser); 2) Composted farmyard manure; 3) Farmyard manure + mineral fertilisers. The same amount of manure was used in both crop rotations (10 t/ha) but the amount of mineral fertilisers was different ($N_{12.8}P_{21.8}K_{24.2}$ kg/ha in the first crop rotation, $N_{38.6}P_{24.2}K_{24.2}$ kg/ha in the second). Simultaneously, trials were conducted with continuous wheat, barley, sugar beet, maize-for-grain and sunflower under the two systems of soil tillage and three systems of fertilisation, but without replication.

Experimental results and discussion

We have determined the effect of crop rotation for different crops in the rotations with and without the mixture of perennial legumes and grasses, on unfertilised plots and with farmyard manure and with manure supplemented by mineral fertilisers, under both systems of soil tillage. The effect of crop rotation may be taken as the difference in yields between crops in rotation and monocropping. Tables 2-5 present means for three crops over two full rotations.

On the unfertilised control, the benefit of crop rotation with perennial legumes and grasses (Table 2) is higher for winter wheat and sugar beet (104 and 101 percent) compared with maize-for-grain (37 percent). Use of farmyard manure in the

Table 2. Effect of crop rotation including perennial legumes and grasses with different systems of fertilisation under a combination of ploughing and ploughless tillage, average for two full rotations (1996-2009)

Crops	System of fertilisation							
	Control (without fertiliser)		Farmyard manure		Farmyard manure + NPK			
							Relative to farmyard manure	
	± t/ha	%	± t/ha	%	± t/ha	%	± t/ha	%
Winter wheat	+2.15	104	+1.84	77	+1.84	74	-	-
Sugar beet	+17.7	101	+17.0	77	+17.8	79	+0.80	3.6
Maize for grain	+1.38	37	+1.10	27	+1.07	28	-	-

Table 3. Effect of crop rotation without perennial legumes and grasses with different systems of fertilisation under a combination of ploughing and ploughless tillage, average for two full rotations (1996-2009)

Crops	System of fertilisation							
	Control (without fertiliser)		Farmyard manure		Farmyard manure + NPK			
							Relative to farmyard manure	
	± t/ha	%	± t/ha	%	± t/ha	%	± t/ha	%
Winter wheat	+0.97	47	+0.94	40	+1.30	52	+0.36	15
Sugar beet	+11.4	65	+13.6	62	+17.6	78	+4.00	18
Maize for grain	+1.03	27	+0.93	23	+0.83	19	+0.10	2

Table 4. Effect of crop rotation for different crops in rotation with a mixture of perennial legumes and grasses with different systems of fertilisation under ploughless tillage, average for 1996-2009

Crops	System of fertilisation							
	Control (without fertiliser)		Farmyard manure		Farmyard manure + NPK			
							Relative to farmyard manure	
	± t/ha	%	± t/ha	%	± t/ha	%	± t/ha	%
Winter wheat	+2.36	127	+2.06	97	+2.11	93	+0.05	2
Sugar beet	+17.0	113	+11.2	44	+17.7	86	+6.5	25
Maize for grain	+1.25	33	+1.05	26	+1.00	24	-	-

Table 5. Effect of crop rotation for different crops in rotation without mixture of perennial legumes and grasses with different systems of fertilisation under ploughless tillage, average for 1996-2009

Crops	System of fertilisation							
	Control (without fertiliser)		Farmyard manure		Farmyard manure + NPK			
							Relative to farmyard manure	
	± t/ha	%	± t/ha	%	± t/ha	%	± t/ha	%
Winter wheat	+1.15	62	+1.10	52	+1.61	71	+0.51	24
Sugar beet	+12.3	82	+7.6	30	+15.8	77	+8.2	32
Maize for grain	+0.99	26	+0.79	20	+0.77	18	-	-

same rotation under the same system of tillage diminishes the effect of crop rotation but the benefits remain highest for winter wheat and sugar beet (77 percent) and the lowest for maize (27 percent). Supplementary addition of mineral fertilisers hardly changes crop yields. The effect of crop rotation is significantly lower in the rotation without the legume-grass mixture (Table 3) but the ranking is the same: highest for winter wheat and sugar beet (without fertiliser 47 and 65 percent, respectively) and the lowest for maize-for-grain (27 percent). Application of farmyard manure decreases the effect of crop rotation for all crops but to a lesser degree than in the rotation with perennial legumes and grasses (40, 62 and 23 percent respectively). Supplementary addition of NPK increases the effect of crop rotation for winter wheat and sugar beet up to 52 and 78 percent, respectively, but it remains the same for maize (19 percent) which hardly responds to crop rotation. It is evident that the benefit of fertiliser, especially the combination of manure and mineral fertiliser, is greater in the crop rotation that does not include perennial legumes and grasses.

The system of tillage hardly changes the results (Tables 4 and 5) although the benefit of rotation is somewhat increased for winter wheat and sugar beet under ploughless tillage.

Reviewing all the data, we may conclude that it is possible to save the expense of applying fertilisers in a crop rotation with a mixture of perennial legumes and grasses. And where an adequate dressing of farmyard manure is applied, the cost of supplementary mineral fertilisers is hardly justified in either crop rotation (Table 6).

Table 6. Yields of crops (t/ha) in crop rotations with and without a mixture of perennial legumes and grasses under different systems of fertilisation, average for two full rotations (1996-2009)

Soil tillage	Control (without fertiliser)			Farmyard manure			Farmyard manure + NPK			Farmyard manure + NPK: ± relative to farmyard manure		Farmyard manure + NPK: ± relative to control	
	1	2	± / %	1	2	± / %	1	2	± / %	1	2	1	2
a) Winter wheat													
Mouldboard plough	3.04	4.22	+1.18 /39	3.32	4.22	+0.9 /27	3.78	4.32	+0.54 /14	+0.46 /14	+0.10 /2	+0.74 /24	+0.10 /2
Ploughless	3.01	4.22	+1.21 /40	3.22	4.18	+0.96 /30	3.89	4.39	+0.50 /13	+0.67 /21	+0.21 /5	+0.88 /29	+0.17 /4.
Difference	-0.03 /1	0		-0.10 /3	-0.04 /1		+0.11 /3	+0.07 /2					
b) Sugar beet													
Mouldboard plough	28.9	35.2	+6.3 /22	35.6	39.0	+3.4 /10	40.2	40.4	+0.2 /0.5	+4.6 /13	+1.4 /4	+11.3 /39	+5.2 /15
Ploughless	27.4	32.1	+4.7 /17	33.3	36.9	+3.6 /11	36.4	38.3	+1.9 /9	+3.1 /9	+1.4 /4	+9.0 /33	+6.2 /19
Difference	-1.5 /5	-3.1 /9		-2.3 /7	-2.1 /5		-3.8 /9	-2.1 /9					
c) Maize for grain													
Mouldboard plough	4.81	5.16	+0.35 /7	5.07	5.24	+0.17 /3	5.13	5.37	+0.24 /5	+0.04 /1	+0.13 /3	+0.32 /7	+0.21 /4
Ploughless	4.75	5.01	+0.26 /6	4.85	5.11	+0.26 /5	4.96	5.19	+0.23 /5	+0.11 /2	+0.08 /2	+0.21 /4	+0.18 /4
Difference	-0.06 /1	-0.15 /3		-0.22 /4	-0.13 /3		-0.17 /3	-0.18 /3					

1 Rotation without perennial legumes and grasses
2 Rotation with perennial legumes and grasses

Table 7. Production of forage units and digestible protein in the poly-factorial experiment, average for two full crop rotations (1996-2009)

Indices	Crop rotation without mixture of perennial legumes and grasses		Crop rotation with mixture of perennial legumes and grasses	
	Farmyard manure	Manure + NPK	Farmyard manure	Manure + NPK
Forage units, tonnes (without straw)	19.4	21.1	28.2	29.3
Digestible protein, kg (without straw)	1,882.9	2,054.0	3,600.8	3,713.1
Digestible protein, g/ forage unit	96.9	97.4	127.7	128.7

Under the crop rotation with the mixture of perennial legume and grasses on *unfertilised plots*, the yield increase of winter wheat is 38-40 percent; the yield increase of winter wheat under the influence of farmyard manure is 27-30 percent; supplementary application of NPK increased winter wheat yields by 13-14 percent. But the effect of fertilisation depends on the rotation. The least increase in wheat yield from application of manure and fertiliser was in the rotation that included the perennial legume-grass mixture (2-5 percent). The highest increase was in the rotation without the perennial legume-grass mixture (14-29 percent) and, in this rotation, the effect of manure plus mineral fertiliser is greater than for manure alone (24 and 14 percent respectively). The efficiency of both systems of fertilisation is greater under ploughless tillage compared with the combination of ploughing and ploughless tillage (29 and 21 percent respectively).

The impact on yields of the predecessors of winter wheat is significantly more than the system of fertilisation. The predecessors of winter wheat in crop rotations even influence the yields of the following sugar beet and maize crops; the yield increase of sugar beet on unfertilised plots after winter wheat sown into the perennial legume-grass mixture is 17-22 percent higher than the yield of sugar beet sown after winter wheat following maize silage. Fertilisation with manure and manure-plus-mineral fertiliser attenuates the influence of predecessors.

In the rotation with the perennial legume-grass mixture, supplementary mineral fertilisers hardly change the yield of sugar beet – just as with winter wheat. This indicates a real cost saving to be made by cutting the rates of mineral fertilisers when farmyard manure is applied – the problem is the lack of farmyard manure. Both animal husbandry and crop rotation were neglected during the industrialisation of agriculture and, in Moldova, the situation worsened after privatisation – yet integration of animals in crop rotations that include perennial legumes and grasses eliminates the need for mineral fertilisers. The yield data for different crops in both rotations have been used to calculate the equivalent forage units and digestible protein (Table 7). The superiority of the crop rotation with the

Table 8. Milk and pork production on 1 ha of crop rotation, average for two full rotations (1996-2009)

Animal products	Crop rotation without mixture of perennial leguminous crops and grasses				Crop rotation with mixture of perennial leguminous crops and grasses			
	Farmyard manure		Farmyard manure + NPK		Farmyard manure		Farmyard manure + NPK	
	on forage units	on digestible protein	on forage units	on digestible protein	on forage units	on digestible protein	on forage units	on digestible protein
Milk, litres	16,192	15,090	17,575	16,450	23,500	28,858	24,417	30,204
Pork, kg	3,238	2,853	3,515	3,111	4,700	5,457	4,883	5,713

Table 9. Total amount of NPK in the solid and liquid fractions of the farmyard manure from cows and pigs produced from the experimental crop rotations, kg and kg/ha of crop rotation

Farmyard manure	Crop rotation without mixture of perennial crops						Crop rotation with mixture of perennial crops					
	Farmyard manure			Farmyard manure + NPK			Farmyard manure			Farmyard manure + NPK		
	N	P	K	N	P	K	N	P	K	N	P	K
						Cows						
Solid fraction	228	105	228	246	113	246	432	199	432	456	210	456
Liquid fraction	163	83	205	176	90	221	309	158	388	326	166	409
Total	**391**	**188**	**433**	**422**	**203**	**467**	**741**	**357**	**820**	**782**	**376**	**865**
Total/ ha of rotation	56	27	62	60	29	67	106	51	117	112	54	124
						Pigs						
Solid fraction	282	359	286	308	392	288	549	688	492	565	720	515
Liquid fraction	420	363	232	458	397	253	804	696	444	841	728	464
Total	**702**	**722**	**518**	**766**	**789**	**541**	**1 353**	**1 384**	**936**	**1 406**	**1 448**	**979**
Total/ha of rotation	100	103	74	109	113	77	193	198	134	201	207	140

Table 10. NPK taken up by crops and returned to the soil in farmyard manure in the experimental crop rotations, average for two full rotations (1996-2009), kg NPK/ha of crop rotation

Crop rotation with mixture of perennial leguminous crops and grasses						Crop rotation without mixture of perennial leguminous crops and grasses					
Farmyard manure						**Farmyard manure**					
Nutrients taken up			**Returned nutrients**			**Nutrients taken up**			**Returned nutrients**		
N	P	K	N	P	K	N	P	K	N	P	K
					Cows						
145	45	135	106	51	117	111	40	119	56	27	62
					Pigs						
145	45	135	193	198	133	111	40	119	100	103	70
Farmyard manure + NPK						**Farmyard manure + NPK**					
Nutrients taken up			**Returned nutrients**			**Nutrients taken up**			**Returned nutrients**		
N	P	K	N	P	K	N	P	K	N	P	K
					Cows						
151	46	139	112	54	124	124	45	132	60	29	67
					Pigs						
151	46	139	201	207	140	124	45	132	109	113	77

mixture of perennial legumes and grasses in these terms is clear, and this translates to milk and pig-meat production (Table 8). The calculation assumes that production of 1 litre of milk needs 1.2 forage units and 104 g digestible protein per forage unit; and production of 1 kg of pork needs 6 forage units and 110 g digestible protein per forage unit. We have taken an average annual production per milk cow as 4,000 l and the average marketable weight per pig on feed lots as 100 kg.

Knowing the numbers of cows and pigs to be fed, it is possible to calculate the amount of manure/ha and its NPK content (Table 9). Table 10 compares the amount of NPK taken up by crops and returned to the soil through the solid and liquid fractions of farmyard manure.

Integration of milk cows with the crop rotation including perennial legumes and grasses does not compensate for the crop's uptake of nitrogen with the nitrogen applied by farmyard manure; there is a deficit of 39 kg/ha but this deficit is compensated for by the lucerne through symbiotic nitrogen fixation. The balance of phosphorus is positive; a small deficit of potassium is not a problem on chernozem soils, which are very rich in potassium. Integration of pigs in the rotation including the perennial legumes and grasses gives a positive balance of nitrogen and phosphorus. There is no need for supplementary application of NPK to this crop rotation. In the case of the crop rotation without the perennial legumes and grasses, integration of cows compensates for only half of the NPK taken by the crops; integration of pigs compensates only for the phosphorus deficit and additional sources of nitrogen, including nitrogen from mineral fertilisers, has to be found. We should also note that the quality and the capacity of cow and pig manure to restore soil fertility are different – cow manure is preferable but a combination of different animals creates the best conditions for complete restoration of soil fertility on the farm.

Conclusions

Structural changes in the agriculture of Moldova since 1990 have contributed to soil degradation, water pollution, reduction of crop productivity and increasing the vulnerability to climate change. Putting things right requires ecological rather than technological restructuring; respect for crop rotation will increase the resilience of the farming system through crop diversity and lesser dependence on external, industrial inputs. What is true of Moldova probably applies in large measure to arable land across the steppes as far as Central Asia:

1. The benefits of crop rotation are greatest on unfertilised plots, especially with a rotation including perennial legumes and grasses, and the rates of mineral fertilisers can be reduced in crop rotation with the mixture of perennial legumes and grasses. This is significant in view of the high cost of mineral fertiliser and lack of farmyard manure.
2. Supplementary use of mineral fertilisers does not influence the yields and effect of crop rotation for different crops relative to farmyard manure.
3. The effectiveness of fertiliser is increased by ploughless tillage, especially in crop rotation without perennial legumes and grasses.
4. The idea of integrating crops with livestock comes from the original Norfolk four-course rotation. This was more than crop rotation: it produced forage for livestock so as to restore soil fertility. This approach was abandoned during the era of agricultural industrialisation, but integration of animals in crop rotations with a mixture of perennial legumes and grasses renders industrial inputs, like mineral fertilisers and agrochemicals for pests, disease and weed control, unnecessary.

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Newsflash

UN Climate Change Talks: the Lima Conference

We have now started the countdown to the UN Conference of the Parties (COP) 21st climate change talks in December 2015 in Paris when greenhouse gas (GHG) emissions reduction agreements for post-2020 will be forged. The Lima talks (COP20) in December 2014 were the last opportunity for countries to agree on the elements of the deal to be debated and finalised in Paris. The Lima Call for Climate Action[1] is a five-page text which pledges all 190 countries to actions cutting emissions and offers help for those least able to fend for themselves.

The US and China are between them responsible for over one third of global GHG emissions, so it was good news to hear, in November 2014, that both Presidents (Barack Obama and Xi Jinping) had reached agreement on curbing the atmospheric

[1] https://unfccc.int/files/meetings/lima_dec_2014/application/pdf/auv_cop20_lima_call_for_climate_action.pdf

pollution emanating from the two countries. The US is now committed to cut emissions to 26-28 percent below the 2005 level by 2025; while China has agreed to cap its output by 2030, or earlier if possible. In China, the world's most prodigious polluter, there is now a target to expand energy from zero-emission sources to 20 percent by 2030. This will mean around 1000 gigawatts of nuclear, wind and solar generation capacity by that date and that is more than all the coal-fired plants that exist in China today and is roughly equal to total US generation capacity. Together with the EU, which has pledged, in October 2014, to reduce GHG emissions by 40 percent below the 1990 level by 2030, the US and China hope that their collaborative effort will be a beacon for other major polluting economies.

Countries are now required to produce national plans for GHG reduction targets by March 2015, and whilst this is a positive stride forward, much detail remains unclear. For example, the Paris talks will need to define the legal aspects of enforcing the achievement of targets. Another vital discussion point, is the size of the UN Green Climate Fund (GCF) which is aimed at assisting developing countries to fund green energy production. At US$9.7 billion, developing countries complain that the GCF is currently too miserly and needs to be dramatically increased (by countries with developed economies). If this can be agreed in Paris, then the hope is that developing countries can make good progress towards achieving C-neutral economies. If not, and future development is fuelled by burning fossil fuels, then the prospects for emission reduction, and therefore control of global warming, are bleak indeed.

Much depends on the outcome of the UN COP21 summit in Paris. If it proves impossible to reach agreement on reducing GHG emissions, then the probability of not constraining global temperature rise to under 4^{o}C is very high. The prospects of keeping temperature rises to below the 'safe' threshold of 2^{o}C are even now painfully slim.

Brian Sims

The state of soil fertility in sub-Saharan Africa

Wim Andriesse and Ken E Giller

Wim Andriesse is a consultant in project evaluation, advisory services and process facilitation in agricultural research, education and institutional development; and he has advised the European Commission and the Netherlands' Ministries of Agriculture and Foreign Affairs on the role of agriculture for economic development. Wim has worked in natural resources management and inventory in Indonesia and the Philippines, land use planning in Jamaica, and agro-ecological characterisation in West Africa. From 2000 to 2012 he was responsible for the institutional liaison between Wageningen University and Research Centre and its partner organisations in sub-Saharan Africa.

Ken Giller is Professor of Plant Production Systems at Wageningen University. Formerly, he was Professor of Soil Science at the University of Zimbabwe (1998-2001) and, before that, held a personal chair at Wye College. He has worked extensively in tropical Asia, Latin America and Africa but, for the past 25 years, has focused on smallholder farming systems in sub-Saharan Africa. From 2004-2008, he led the project 'Exploring trade-offs around farming livelihoods and the environment: the AfricaNUANCES framework'. Currently he is scientific leader of the N2Africa programme: 'Putting nitrogen fixation to work for smallholder farmers in sub-Saharan Africa.

Summary

An overview of the state of soil fertility in sub-Saharan Africa and how stakeholders are dealing with it: farmers, of course, but also traders, scientists, development workers, planners/policy makers and society at large. In addition, we discuss soil fertility management in the wider context of agricultural development in sub-Saharan Africa.

Background

The recent *Soil Atlas of Africa* (Jones *et al*, 2013) highlights soil degradation as a threat to about one quarter of the productive land of the continent. This degradation includes desertification and erosion, but most prominent is the decline of soil fertility through loss of nutrients and organic matter under continuous cropping. Nye & Greenland (1960) recognised that the fertility of virgin land declines to a new equilibrium dependent on the intensity of cropping. Soil mining had been encroaching in Africa as land was used more intensively and fallow periods shortened and disappeared; but, although the importance of soil fertility management was recognised, farmers, agricultural scientists and governmental agencies were preoccupied with erosion control and soil conservation. It can be argued that the crisis of soil fertility was triggered by donor enforcement of pan-African structural adjustment programmes in the 1980s; the increase in fertiliser prices brought about by removal of subsidies, together with the breakdown of national extension services and infrastructure, put fertiliser and other inputs beyond the reach of smallholder farmers – in contrast to Asia where the *Green Revolution* was fuelled by consistent government support.

In 1990, Stoorvogel & Smaling, uncovered alarming trends of nutrient losses in prevailing crop production systems in sub-Saharan Africa (SSA). They calculated that, every year on average, African crop production systems fell short of replenishing nutrient uptake by the crops by approximately 20 kg/ha N, 10kg P_2O5 and 20kg K_2O, up to a maximum of 40kg N, 20kg P_2O5 and 40kg K_2O, even when manure and fertiliser were applied. At around this time, Sanchez (1994) called for a *Second Paradigm* of soil fertility management to move away from back-breaking reliance on the recycling of nutrients in traditional smallholder farming, where additional nutrients in the form of chemical fertiliser were needed to replenish soil nutrient stocks and make farming systems sustainable while feeding an ever-growing population. Scrutiny of the case for replenishment of soil nitrogen (including the use of nitrogen fixing legumes: Giller & Cadisch, 1995) and soil phosphorus (Buresh *et al*, 1997) demonstrated that a one-time investment in nutrient replenishment is not efficient in either agronomic or economic terms. There was an avalanche of studies and high-level conferences on nutrient mining and the need for interventions to restore soil fertility in Africa. For instance, the *Africa Fertiliser Summit* in 2006, in Abuja, where Heads of State pledged to increase fertiliser use from 8kg to 50kg of nutrients/ha through national and regional strategies, subsidies and investments, quality control systems, distribution networks, extension services, *etc* (AU & NEPAD/NPCA, 2006). But this ended up being just another high-level initiative dealing with politics and institutions: it had little or no impact in the farmers' fields. Whereas in Kenya and Zambia, average fertiliser consumption increased from 21 to 33kg/ha and from 11 to 50kg/ha between 1990 and 2008, respectively; the average for SSA is still less than 10kg/ha.

While there was a basic understanding of the utility of organic resources to supply crop nutrients and build up soil organic matter (Palm *et al*, 2001), it was clear that the nutrients available in crop residues or cattle manure were insufficient to sustain productivity. During the late 1990s, and until around 2005, legume green manures and improved fallows of fast-growing legume shrubs were actively promoted, but there is little evidence of their continued use. Participatory research has shown repeatedly that smallholders reject such technologies in favour of grain legumes or fertiliser application that give immediate benefits of food and/or cash (Ojiem *et al*, 2006).

Current initiatives on soil fertility in Africa

Research at farm and farming system level

Testing soil-fertility-improvement technologies on smallholdings led to a realisation that success was patchy, even in technical terms. In many cases, soils were so depleted of nutrients and organic matter that green manures and other soil fertility improving technologies resulted in little response in crop yield. Recognition of repeating gradients of soil fertility decline with increasing distance from the homestead led to a focus on whole-farm analysis of soil fertility constraints. These soil fertility gradients are caused by the shortage of manure, which is applied preferentially to home-fields for food self-sufficiency; and the differences in soil fertility have implications for the efficiency with which added nutrients are used by crops. This work under the *AfricaNUANCES Framework* recognised and characterised the diversity among farmers in any given locality, which had strong influences on their resource availability and use. Rather than promoting *best-bet* technologies, it was necessary to seek *best-fit* technologies that recognised the inherent diversity among farming systems, farmers, their farms and fields (Giller *et al*, 2011).

The need for integrated soil fertility management

A large body of research has coalesced around the need to use efficiently all of the nutrient resources available to farmers. This is defined as *Integrated Soil Fertility Management (ISFM): A set of soil fertility management practices that necessarily include the use of fertilisers, organic inputs and improved germplasm, combined with the knowledge of how to adapt these practices to local conditions, aimed at maximising agronomic use efficiency of the applied nutrients and improving crop productivity. All inputs need to be managed following sound agronomic principles* (Vanlauwe *et al*, 2010).

The goal is optimised crop productivity through maximising interactions that occur when fertilisers, organic inputs and improved germplasm, along with the required associated knowledge, are integrated by farmers. The proven assumption underlying ISFM is that increased production of plant and root mass, and returning this into the soil, increases soil organic matter with a beneficial effect on the soil's capacity to store water and nutrients, better aeration and infiltration of rainwater. This may be considered as a fourth principle needed to define Conservation Agriculture (Box1).

Box 1. Conservation Agriculture

In recent years, conservation agriculture (CA) has won the attention of an alliance of FAO, many largely church-based NGOs, and African governments. CA is based on three principles of zero-till or reduced tillage, mulch retention, and crop rotation (see Shaxson & Kassam, pages 21-25 in this issue).

The zero-till or CA movement in the Americas may be characterised as big farms with intensive use of herbicides and fertilisers, reliant on 'Round-up Ready' GM soyabeans and maize. By contrast, CA in Africa has been portrayed as low-input agriculture – for instance under the FAO's Save and Grow paradigm. Whether CA is an appropriate technology for smallholder farmers is moot (Giller *et al*, 2009) because of the increased labour demand for weeding when soils are not ploughed: few smallholders have access to herbicides; and because crop residues are highly-valued for feeding to livestock. And no-till without mulch is disastrous! It leads to soil capping, extreme runoff within minutes of the start of a heavy shower, and precipitates rather than controls soil erosion.

In view of the high rates of dis-adoption of CA by farmers within a few years (Andersson & D'Souza, 2014; Arslan *et al*, 2014), a fourth principle may be needed to define CA highlighting the equal need for fertiliser to increase productivity (Vanlauwe *et al*, 2014).

Increasing scale and scope of developments
Recently, projects on soil fertility in Africa have become much larger. The *Soil Health* programme of AGRA (www.agra-alliance.org) started with initial funding of US$160M from the Gates Foundation; Dutch funding to the *2Scale* and *Catalist* programme under IFDC (http://www.ifdc.org) amounts to US$60M; and, in Ethiopia, the Dutch-Ethiopian *Cascape* program (www.cascape.org) receives €12M from the Netherlands. The *N2Africa programme: Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa* (Giller *et al*, 2013, www.N2Africa.org) emphasises the inclusion of legumes in the cropping sequence to enhance biological nitrogen fixation in the crop-soil system that eventually benefits crop growth and yields, as opposed to investments in crop genetic improvement and markets; and has just started a second phase with Bill & Melinda Gates Foundation funding of US$30M. These initiatives, which often work together, apply comprehensive integrated approaches beyond ISFM *sensu stricto*, mostly in the perspective of value-chain development. Intervention areas include adaptive technology, access to finance, input market development, capacity building in extension organisation, agro-dealers and research, output markets and market information systems, and policy support. Moreover, the programmes are being implemented with a view to adapted replication in other environments.

Farmers' assets and environmental contexts
With respect to assets and environmental context, Berdegué & Escobar (2002) distinguish endowment categories as visualised in Figure 1. On the horizontal axis, environmental quality has been set out from unfavourable to favourable; on the vertical axis, access to labour, skills and capital assets ranges from low to high.

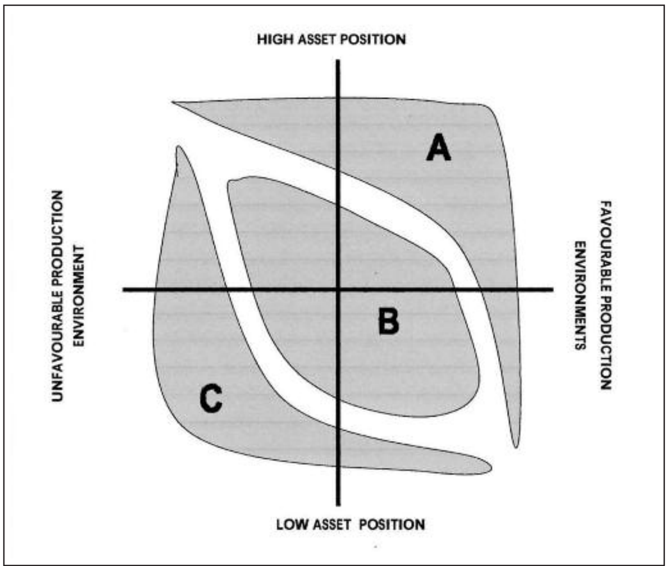

Figure 1. Differential strategies for the development of agricultural knowledge and information systems (Berdegué & Escobar, 2002)

Farmers in category A are mostly fully integrated in market economies and make substantial contributions to food production for national and international markets. Productivity is high as a result of important asset endowment paired with high investments in relatively favourable production environments; the prevailing soils are Luvisols, Lixisols, Nitisols, Cambisols, Acrisols, Vertisols and, in floodplains, Fluvisols (Jones *et al*, 2013). This category includes few smallholder enterprises, except for specialised production systems like vegetables and flowers (though the latter are mainly grown on substrates). In sub-Saharan Africa, category A environments include the former colonial lands that were, and still are, growing cash crops, with cattle reared on pastures. Over the past 10-15 years, much of this land in SSA has been captured by external investors for large-scale production for bio-fuel and food crops.

Many of the farmers in category B have skills and land but lack critical elements that enable entry into market-driven systems: access to credit to invest in quality seeds, fertiliser, implements and irrigation; access to output markets (poor infrastructure, poor market information, volatile prices); or access to post-harvest value-adding facilities (storage, processing, packaging). Nowadays, many donors and governments target farmers in this category, aiming to pull 'family farms' into market-oriented production – a panacea for public-private sector investment and local agri-sector entrepreneurship.

Category C comprises asset-poor smallholders in environmental contexts that are not conducive to economic growth and social development. For these marginalised farmers on marginal lands, conditions are gloomy. Conditions are adverse even for other economic activities: their land is remote from economic centres such as ports and industrial zones. Marginal lands in SSA include the shallow Plinthosols and Regosols of West and Central Africa, Ferralsols in Central and Eastern Africa, and shallow Leptosols in large parts of southern Africa. Average land holdings of these farmers are mostly less than 2 ha; labour is supplied by family members themselves and the food produced is largely for home consumption. Sustainable development options for farmers in category C are unlikely to be provided by the agricultural sector: mostly, family members derive extra income from working outside their own farms.

Each category requires specific strategies and policies to allow farmers in these different categories to make optimum use of assets. Therefore, the categorisation into high, medium and low resource endowment of farms has been adopted for fertiliser recommendations at the local level, for instance by Vanlauwe *et al* (2014), who used agronomic efficiency values in terms of unit weight of extra yield produced per unit weight of fertiliser applied, as recommendation domains for soil and crop management.

Input subsidy programmes and other fertiliser policies
In SSA, input subsidy programmes (ISPs) are re-emerging as a policy tool of many governments, in some cases with the support of international development partners (Jayne & Rashid, 2013) although, even in Malawi, Kenya and Zambia (countries with above-average fertiliser consumption rates) the benefits of ISPs during the post-2008 high-food-price years rarely exceeded costs. (Editor's note: *Agricultural input subsidies: the recent Malawi experience*, by Ephraim Chirwa and Andrew Dorward was reviewed in *Ag4Dev23*, 23-24.) Obstacles to higher economic returns on fertiliser include crowding out of commercial fertiliser demand, late delivery, poor management practices, lack of complementary inputs and unresponsive soils. Jayne & Rashid (2013) acknowledge the short-term political gain, but also observe that, once implemented, they have proven difficult to take away again.

Comprehensive data sets and analyses on the effects of various fertiliser policies on smallholder consumption in SSA are few and not up-to-date. However, there is a measure of agreement on the need to improve agronomic response to manure and fertiliser, better communication to extension agents and farmers, the need for less-volatile and higher output prices, and lower fertiliser costs (Kelly, 2005; Meertens, 2006; Ariga & Jayne, 2006). The latter authors point out that, although the amounts of fertiliser used are often still small, some 70 percent of smallholders in Kenya were using fertiliser in 2003-4.

Conclusions and recommendations

- Western hegemony of prescribing what is good, is not good for Africa. Stories of failing donor-driven interventions abound (Box 2).

> ***Box 2. Farmers' uptake***
>
> When one of us (KEG) started working in Tanzania in the mid-1980s, he sought out soil scientists who had been involved in earlier soil fertility research. Alan Scaife, who conducted hundreds of on-farm fertiliser-response experiments with maize in the early 1960s, recalled that when he asked a farmer in northern Tanzania what he thought of the spectacular increases in maize growth and yield, the farmer replied with a shrug of his shoulders: *'White man came here before the war and showed the same thing!'* We have to remain modest in our claims, but hope that the current investments to assist farmers in gaining access to inputs and knowledge to use them efficiently will have some lasting impacts.

- What research can offer to farmers is choice and, in participatory approaches, facilitation of access to fertiliser and to post-harvest technologies and markets once the farmer's investments result in higher yields. Such research is relevant, especially if it is implemented in close partnership between local and international research and development organisations and universities.
- There is need for a much stronger engagement from African Governments in the design and implementation of agricultural strategies beyond the level of declarations, as well as for a much more critical and more transparent monitoring system of the implementation of national, regional and pan-African strategies. Most of the big agricultural development programmes, including those focusing on IFSM, are donor-driven, with limited financial support from national governments beyond the basic salaries of governmental employees (and these salaries are mostly being topped-up in order to retain staff capacity, at least for the lifetime of the programmes).
- The international fertiliser industry has an active role to play, together with national governments and development partners like IFDC and AGRA, in developing a range of products that matches smallholders' needs for tailored fertilisers, both in terms of composition, form, distribution and bag sizes at retail level. Market-led competition among distributors will keep the prices down but quality control mechanisms need to be enforced by national governments.
- A strong knowledge base has been built across SSA on the need, the utility and the appropriateness of soil-fertility-improving technologies. We remain optimistic that the current impetus for improving the fertility of Africa's soils will lead to lasting impact and share this optimism with Pedro Sanchez in his recent note to *Nature: 'En route to plentiful food production in Africa'* (Sanchez, 2015).

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International Agricultural Research News

Improving soils

Soil science in the CGIAR has a chequered history. The application of the International Board for Soil Research and Management (IBSRAM) to join CGIAR was rejected in 1990 on the grounds that *'involvement in adaptive research and development activities of national programs ...is not a desirable evolution'*. IBSRAM was wound up a decade later, although it was formally incorporated into the International Water Management Institute (IWMI) in 2001, its soils research programme was phased out. The Tropical Soils Biology and Fertility programme (TSBF) fared somewhat better. Following its merger with the Centro Internacional de Agricultura Tropical (CIAT), also in 2001, it continued its programme on integrated soil fertility management (ISFM) and sustainable land management, focussing on generating soil information, mapping soil properties and ecosystem health. Although TSBF no longer exists as an independent programme, soils research remains one of CIAT's three principal research areas.

In recent years soil science has seen something of a renaissance within the CGIAR with several Centres, especially IITA, seeking to strengthen their soils programmes. A major boost occurred in 2012 with the creation of the CGIAR Research Programme (CRP) on Land, Water and Ecosystems. Research on soils is an integral component of the new programme's effort to sustainably intensify agricultural production and improve resilience while maintaining vital ecosystem functions. Outside the CGIAR, the International Fertilizer Development Centre (IFDC), a member of the Association of International Research and Development Centres for Agriculture (AIRCA), is the only independent international entity with a primary focus on soils, working especially in the areas of environmentally sound crop nutrient technology and agribusiness.

Following are three recent examples of international soil science in action:

Soil organic matter

The upper 1m of soil is estimated to hold about 2,000-2,500 Gt of carbon worldwide, with 60 percent being in the form of soil organic carbon (SOC). This is about three times the amount of carbon bound in the above-ground biomass. It is often assumed that the introduction of measures to sequester more carbon in agricultural soils, such as through Conservation Agriculture, would make a significant contribution to reducing atmospheric CO_2 far into the future. However, a recent study by CIAT soil scientists (Sommer & Bossio, 2014) found that increasing carbon sequestration by agricultural soils has a finite potential to contribute to the mitigation of climate change (CC) and the global effects of SOC-sequestration measures will only be felt over some decades.

The study calculated the global SOC sequestration potential of agricultural land for the period up to 2100, based on both an optimistic and a pessimistic scenario regarding the rates of carbon sequestration that could be achieved. Over the period, approximately 31 Gt of carbon would be sequestered under the pessimistic scenario and 64 Gt under the optimistic scenario. These extremes are equal to only 1.9 percent and 3.9 percent respectively of the mean projected total anthropogenic emissions of carbon according to the SRES-A2[1] scenario of the Intergovernmental Panel on Climate Change (IPCC). Carbon sequestration would peak in 2032–33, at that time reaching 4.4 and 8.9 percent respectively of the projected annual emission. Thirty years later the sequestration rate would have reduced by half as a new equilibrium is reached.

In conclusion, the study reported that improving the carbon sequestration potential of current agricultural soils is likely to contribute relatively little to solving the climate problem of the coming decades. However, the authors also pointed out that additional measures such as the large-scale restoration of degraded lands (see below), and adoption of agroforestry systems, could significantly increase the amount of carbon sequestered beyond the levels reported in their study, up to 5-15 percent of total global C emissions (Smith *et al*, 2008). Furthermore, they stressed that soil organic carbon is vital for sustaining soil health, agro-ecosystem functioning and increasing productivity; all issues of global significance that deserve attention, irrespective of any potential impact on climate change.

Putting biological nitrogen fixation to work for smallholder farmers

Nitrogen is severely depleted in many African soils, making it difficult for smallholder farmers to produce the

[1] The Special Report on Emissions Scenarios (SRES) is a report by the Intergovernmental Panel on Climate Change (IPCC). The A2 family of scenarios is characterised by a world of independently operating, self-reliant nations, continuously increasing population and regionally oriented economic development.

yields needed to feed growing populations. According to Bernard Vanlauwe, Research Director of IITA, *'smallholder farmers often cannot access or afford the inputs needed to put nitrogen back into the ground. Biological nitrogen fixation can help them do this – and earn them additional income at the same time.'*

Legumes are renowned for their ability to fix nitrogen in association with species of the symbiotic bacteria *Rhizobia*. Nitrogen is taken from the air to produce various nitrogen-containing compounds needed by the plant. When the plant dies, the nitrogen becomes available to other plants and helps fertilise the soil. Rhizobia are widely found in soil around the world, but many legumes need specific rhizobium strains to fix well. By adding the correct inoculum to legume seed before planting, farmers are able, in many cases, to significantly increase yields.

A pan-African project, *N2Africa*, that aims to improve legume technologies to counter the debilitating impact of low-nitrogen soils, is generating higher yields and new income streams for smallholder farmers. The project, funded by the Bill and Melinda Gates Foundation, is led by Wageningen University together with the International Institute of Tropical Agriculture (IITA) and the Centro Internacional de Agircultura Tropical (CIAT).

Since it began in 2009, *N2Africa* set out to increase the adoption of improved nitrogen-fixing legume technologies – specifically for soybean, cowpea, groundnut and common bean – and support the creation of new markets for the resulting crops, enabling farmers to continue to improve the quality of their soil, as well as increase household income and nutrition. Key participating countries include DR Congo, Ethiopia, Ghana, Kenya, Mozambique, Malawi, Nigeria, Rwanda, Tanzania, Uganda, and Zimbabwe.

To date, the project has reached more than 250,000 smallholder farmers with better genotypes of legumes and rhizobia inoculants. These, in addition to phosphorus fertiliser and improved crop management practices have, in many cases, more than doubled yields. They can also improve performance of successive crops by as much as 50 per-cent as a result of improved residual soil nitrogen levels. Net household income rose by an estimated average of $355 per year.

Professor Ken Giller, *N2Africa* Director, said: *'There have been very few projects that have been able to test technologies at the scale that we've been able to. We have measurements and observations on thousands of farmers' fields across Africa. With these we can understand what the reasons are for better or poor crop performance, and what particular technology fits each type of farmer. Legumes are very flexible crops, and suitable for both the wealthier or poorest farmers ... We've got proof of massive improvements in yield at field level, due to the right combination of better genotypes of legumes and rhizobia, adapted fertiliser and improved crop management.'*

Initiative 20x20: Restoring 20 million hectares of degraded land in Latin America

In early December last year, a number of Latin American and Caribbean countries launched *Initiative 20x20*, a country-led effort that aims to make substantial progress by 2020 in restoring 20 million hectares of degraded land. The planned restoration will result in improved soils, greater carbon storage, reduced soil erosion, more productive agricultural systems and increased livelihoods over a total area larger than that of Uruguay. The initiative is expected to make a major contribution to meeting the 'Bonn Challenge', a global commitment to bring 150 million hectares of land worldwide under restoration schemes by 2020.

Scientific and technical backstopping of the initiative will be provided by the World Resources Institute (WRI), Centro Internacional de Agircultura Tropical (CIAT), Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), and the International Union for the Conservation of Nature (IUCN).

At the launch, *Initiative 20x20* announced that commitments had already been made for the restoration of some 16 million hectares including 8.5m ha in Mexico, 3.2m ha in Peru, 1.2m ha in Guatemala and 1m ha in Colombia. Five private institutions pledged to invest up to US$365 million of new financing to support the initiative, and additional investments are expected from bilateral and multilateral funders. Other financial instruments are also being designed, including a partial risk guarantee for restoration.

In pledging support at the launch, Ruben Echeverria, CIAT's Director General, stated: *'We are committed to support Initiative 20x20 as a cost effective approach to reduce GHG emissions while promoting improved soil quality, nutrient retention and agricultural yields.'*

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Geoff Hawtin

Healthy soil: the foundation for healthy people and landscapes

Dyno Keatinge, Trevor Nicholls and Amit Roy

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Summary

A healthy human population starts from the ground up. Soil is an essential element of food and nutritional security, and healthy people and ecosystems. This article examines three issues: *Creating healthy soil* considers how approaches such as Integrated Soil Fertility Management (ISFM) and improved fertiliser use can increase crop health and yield for human benefit; *Supporting healthy people* looks at the relationship between healthy soil and human health and nutrition; and *Managing healthy landscapes* puts soil in the wider framework of managing land and how farmers can be supported in making land use decisions.

Introduction

The International Year of Soils is a time to celebrate the importance of soil as a critical component of the natural and agricultural system in which we live, and a foundation for human wellbeing; and to raise awareness of the soil as an essential element of healthy people and ecosystems, and of food and nutritional security. A growing world population projected to reach 9.6 billion by 2050 from the present level of 7.2 billion, combined with economic and social development, along with climate change, will continue to increase the demands on agriculture for food, fodder, fuel and fibre. This means we need to think carefully about the way that we use our resources. In the context of food security, simply increasing the amount of land dedicated to agriculture to meet future consumption is neither desirable nor feasible. Instead, we need to think about how we can establish and sustain healthy soil, healthy people and healthy landscapes as effectively and efficiently as possible – from the ground up.

Creating healthy soil

Increasing the amount of land dedicated to agriculture cannot be accomplished easily, and would have significant impacts on biodiversity and ecosystems. It is far better to produce more food using the same, or less, land in a way that minimises negative impacts on resources such as soil and water. In the near future, the greatest growth in food demand will come from developing countries. It will be important to share scientific knowledge of sustainable agricultural intensification, and the most practical and relevant innovations for smallholders, with other countries that can benefit or, alternatively, further disseminate local best practices that are already being used effectively in the developing world. Conducive policies are extremely important in adoption of best practices.

Integrated Soil Fertility Management (ISFM) is an obvious example. ISFM strategies centre on the combined use of improved germplasm, mineral fertilisers and locally available organic amendments such as crop residues, compost and green manure, to replenish soil nutrients. This is an important aspect of the work of the International Fertiliser Development Centre (IFDC). It has proven to be a viable method of increasing agricultural productivity while protecting the environment and maintaining and improving soil health (Nicholls *et al*, 2013).

Farmers using ISFM replenish soil nutrients by combining mineral fertilisers with organic matter and soil amendments. The practice substantially increases crop health and yield (Wopereis *et al*, 2008; Vanlauwe *et al*, 2010). More than 250,000 farmers in the Great Lakes Region of Central Africa have used ISFM to boost soil health and increase incomes by 20 to 50 percent. Combining ISFM with farm-to-market linkages assists producers to greater economic returns (IFDC & CTA, 2011).

Figure 1. A farmer tests rice growth with and without fertiliser as part of an ASHC project, Uganda (Copyright: CABI)

While there is a wealth of ISFM information, the goal now is to place it in the hands of farmers who can benefit (Figure 1). Partnerships such as the [Africa Soil Health Consortium] (ASHC) accomplish this objective. ASHC works with knowledge and delivery partners, including IFDC, to support the development and production of high-quality communication materials to get ISFM research into use by capacity building along the information supply chain from research to practitioners and policy makers. ASHC's on-line library of practical ISFM materials includes books, cartoons (Figure 2) and posters. Answering the question of how new farming approaches or produce varieties can be adopted by farmers is essential. A big part of the answer lies in improving communication channels and methods. Although the relative importance of, and demand for, different types of information varies in different situations, there is a consistent demand for information on new varieties, pests and diseases, use of pesticides and fertiliser, as well as weather, credit and markets.

Knowledge transfer must play an increasing role in food security. The explosion in modern technologies in developing countries brings an opportunity to reach more smallholder farmers than ever before, helping them to grow more and lose less. No or low-literacy and language barriers can be overcome with the help of mobile agro-advisory services using, for example, voice messages (Figure 3). Although there are not enough extensionists to support the world's farmers, mobile technology can help fill the gap. The information given via mobile services can include ISFM information and, also, information about nutrition. The Mobile for Development Foundation of the GSM Association (GSMA) recently appointed a CABI-led consortium to support the *mNutrition* initiative, which helps beneficiaries to access nutrition-based agricultural and health information using mobile technology.

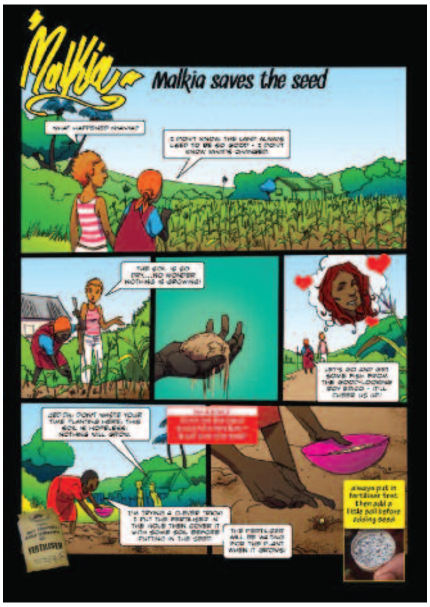

Figure 2. *Malkia saves the seed* was commissioned by ASHC and published in Shujaaz, a youth media magazine, developed by Well Told Story (the double Emmy Award winning, Kenyan-based, social communications consultancy) in partnership with Farm Inputs Promotions Africa (case study), and Peter Okoth, CIAT (agronomic impact)

Figure 3. Mobile technology can deliver a greater range of agro-advisory information to farmers, India (Copyright: CABI)

There is a clear link between good soil health and human health. Small changes, such as altering the way in which fertilisers are introduced to the soil, can have a substantial impact on crop health which, in turn, benefits people. Research shows the beneficial role micronutrients, such as iron and zinc, play in the health chain. Using micronutrient-enriched fertilisers can help transmit nutrients from soil to plants and from plants to animals and humans, benefitting the health of all (Bruulsema *et al*, 2012) and increasing farmers' profits. Recent field trials in sub-Saharan Africa illustrate productivity increases of 40 percent when fertiliser nutrients appropriately match soil characteristic needs. In Mozambique, for instance, maize farmers did not profit from using only primary-nutrient (NPK) fertiliser; the soil needed additional nutrients. After using a site-specific fertiliser formulation containing secondary and micronutrients, farmers increased yields and lowered investment costs (IFDC, 2014).

The *Optimising Fertiliser Recommendations in Africa* (OFRA) project aims to contribute to improved efficiency and profitability of fertiliser use within the context of ISFM. This project, jointly led by CABI and the University of Nebraska, Lincoln, works closely with ASHC and helps collect and analyse data to develop practical decision-making tools, including fertiliser optimisation tools. These tools provide advice on how much fertiliser farmers should use to maximise their profits, tailored to their individual situation. Projects like OFRA bring research from the laboratory to the field, and help find practical applications for scientific information.

In drylands and seasonal wet-and-dry lands, healthy agricultural soil needs irrigation. As global water demand escalates, water management systems must become more efficient. Alongside simple water-saving techniques such as polythene sheeting, practices and technologies that yield 'more crop per drop' must be researched and implemented. Innovations include the use of non-conventional water sources, biosaline agriculture, precision agriculture and cultivation of plants requiring less water. In Bangladesh, for instance, groundwater exploitation for agriculture has increased by 63 percent since 1971, depleting natural supplies. In a society where lowland rice farming comprises nearly all agricultural endeavours, farmers require a lot of water, but farmers who utilise alternate wetting and drying (a paddy field is alternately flooded and then not flooded) generate more paddy rice and conserve water. This irrigation method also strengthens nutrient efficiency and decreases insect infestation. In other places, drip irrigation is being used to increase water efficiency and curb dependence on rain for nourishing crops.

Supporting healthy people

Healthy soil leads to healthy crops, but we can maximise health benefits and sustainable intensification by carefully choosing the types of crops grown. The research of new crop varieties that are resilient to drought and submersion, for example, will be essential for producing more food. Developing better crops for the future may also mean re-evaluating neglected or underutilised local varieties. These varieties may not only be more robust in a sustainable intensification framework but, also, offer potential new sources of improved food, nutritional, culinary and medicinal value.

This is important because, until recently, food security has been focused on investment in the research of traditional staples – maize, rice, wheat – to tackle hunger. But it is now widely accepted that we should go beyond calories and look at the nutritional balance of the crops grown and consumed. We need more focus on horticultural crops like fruit, legumes and vegetables (Figure 4). Malnutrition – that is to say lack of nutrition or imbalanced nutrition – is fast becoming the main threat to peoples' health in developed and developing countries alike. Helping people achieve a well-balanced diet will address the 'hidden hunger' of malnutrition; sufficient consumption of fruit and vegetables is key to alleviating this serious health problem. In Bangladesh, where most food calories come from rice, horticulture is the exclusive domain of women. Empowering women farmers to grow more fruits and vegetables can provide their families with more diverse food and higher incomes (Schreinemachers *et al*, 2014).

Figure 4. A farmer harvests leafy green vegetables – Amaranth – from her farm, ready for sale at market, Tanzania (Copyright: CABI)

Mungbean is a valuable addition to a crop rotation, both from its nutritional benefits as a grain and as a vegetable, and its compatibility with other crops. It can fix up to 110 kg/ha of nitrogen to benefit following crops after meeting its own requirements (Shah *et al*, 2003), so it is a valuable addition to the crop rotation in locations like the Indo-Gangetic Plains where continuous cereal production removes 500-700 kg of nutrients/ha annually (Ali & Kumar, 2004). Mungbean and vegetable soybean are warm-season legumes; in a warming world there will be expanded opportunities to fit these crops into a range of multiple and intercropping systems. Mungbean, in particular, is well suited to the semi-arid zone; short-duration and disease-resistant mungbean varieties that fit into the 65-75 day fallow period between rice and wheat crops have allowed farmers in the Indo-Gangetic Plains to earn an extra Indian Rs 25,000-30,000/ha (US$540-650), to save Rs 2,000/ha (US$43) on tillage, 30 percent of annual irrigation water, and 25 percent of annual nitrogen fertiliser.

Mungbean also benefits the environment. Mungbean fits into rice-wheat rotations where it improves soil health by changing the soil microflora and bacterial composition and adds nitrogen into the soil, helping to make impoverished soils more productive. With low water requirements for good growth, it puts less strain on water resources than intensive cereal production. As more farmers add mungbean to their rotations, a more sustainable balance between cereals and legumes is emerging across Asia. The same can be said for vegetable soyabean.

Learning how to manage soil for health benefits is a basic gardening skill. AVRDC, the World Vegetable Centre, works in tropical developing countries, promoting home or kitchen gardens. Training for farmers combines information about the nutritional value of growing and eating vegetables with practical demonstrations of home gardening methods, and has succeeded in diversifying family diets and increasing supplies of local produce (Nicholls *et al*, 2013). For many rural communities, growing and selling resilient and relatively high-value fruit, nuts, vegetables and medical herbs offer indirect health benefits, since the income gives farmers the choice to buy the nutritionally valuable produce they cannot grow. With increasing migration to cities, there are opportunities to supply urban populations that no longer have the desire, knowledge, space or time to grow their own food. Strengthening market linkages between producers and processors or buyers can increase farm profits and supply more food resources to urban areas. IFDC is fostering public-private partnership in several African countries for smallholder farmers to have an assured market for their produce. Private companies engaged in this initiative are both local and multinational companies.

We must also look at the way we utilise land and water resources for animals, fish and poultry, which are valuable sources of protein, fatty acids and essential vitamins. Increased demands from expanding population present challenges in terms of fodder provision, water use, greenhouse-gas emissions and the potential transmission of diseases in animals.

Managing healthy landscapes

When considering land use, it is important to keep an eye on the bigger picture, understanding that agricultural production systems interact in many ways and at many scales, from plot to farm, and from farm to landscape, and that there are trade-offs between different land use objectives. Finding a solution to the landscape trade-off is not always obvious. Should farmers preserve their land for the sake of food production or should they focus on generating income from eco-tourism, for example? Furthermore, what implications will this have for food security? Agriculture is a huge part of making landscapes profitable, but so too is tourism. How can people in developing countries achieve an appropriate balance?

The members of the Association of International Research and Development Centres for Agriculture (AIRCA) are committed to tackling these problems at the landscape level. The *landscape* approach to sustainable agriculture seeks solutions that take into account the diversity of interactions among people and the environment, agricultural and non-agricultural systems, and other factors that represent the entire context of agriculture. This approach also takes into account the trans-national aspects of landscapes where they cross national boundaries, making concerted efforts to find solutions to sustainable agriculture more pressing.

It is worth highlighting an essential gender and youth angle to creating healthy land, produce and landscapes. Young people may believe there is no future in farming, but the opposite is true (Figure 5). By 2050, global food demand is predicted to grow by 60 percent from 2005 levels. Education about the career opportunities that lie ahead, as well as skills training, can help create the next generation of eco- and nutrition-savvy farmers. Women play a central role in feeding families and communities, and if women farmers have the same access to resources that male farmers do, the number of hungry people in the world may be reduced by up to 150 million (World Food Programme, 2014). We need to overcome the challenge of how we best reach women, create an environment that lets them put new agricultural and nutritional information into practice, and help them build healthy and empowered future through horticulture.

Figure 5. Teenager Felix Kamiri Muchiri from Kenya in his kitchen garden; winner of a joint CABI-Young African Express 'smart farming' ISFM poster competition. His poster showed how ISFM can make farming more productive. *'In future, I plan to earn enough to assist my mother in our dream of owning a greenhouse'* says Felix (Copyright: CABI-Young African Express)

How we sustain human health, food security and natural ecosystems are some of the most important development questions we need to ask and answer. We must be careful not to overlook the very ground we stand on as one of the most essential components to meeting some of the world's most important challenges. Healthy soil is, literally, one of the most important foundations upon which we can start to do this.

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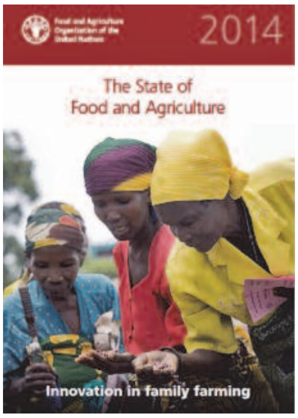

The State of Food and Agriculture: Innovation in Family Farming.
Food and Agriculture Organization of the United Nations (FAO), 2014.
139 pages.

Available at: http://www.fao.org/3/a-i4040e.pdf

The State of Food and Agriculture (SOFA) is FAO's flagship annual publication which focuses on a particular topic relevant to the issue and analyses it in depth. For 2014, the issue is family farming and the vital role of innovation in ensuring global food security.The following is a summary of the main points.

Characteristics of family farming and the need for innovation systems

More than 500 million family farms manage the majority of the world's agricultural land and produce most of the world's food; these farms are not only essential for food security, but their good management is crucial for global natural resource preservation and environmental sustainability. Smaller farms tend to produce higher yields per hectare than larger farms, but produce less per worker. Labour productivity is also much lower in low-income countries than high-income countries, so that raising labour productivity is a vital requirement for improved farm incomes. Also, yields per hectare are much lower in poorer countries than in richer ones. The potential to improve labour productivity and yields can only be realised if family farmers are able to innovate, and the pathways to increased productivity include the development, adaptation and application of new technologies, plus the application of existing successful technologies. An agricultural innovation system will include an enabling economic and institutional environment; other key components are research and advisory services and farmers' organisations. Farmers with access to markets have a strong incentive to innovate so long as they have the technologies to produce marketable surpluses. However, investments in physical and institutional market infrastructure are an essential prerequisite.

Sustainable intensification

Many family farmers supplement both income and nutrition from other parts of the landscape; risk-spreading through diversity of livelihood strategies is a necessity. Demand for food is growing while land and water resources are becoming ever more scarce and degraded. Climate change will make these challenges yet more difficult. The large gaps between actual and potential yields show the scope for increased production through productivity growth. Overcoming poverty also means boosting labour productivity and providing other opportunities for employment. Increased production must be sustainable production: the Green Revolution paradigm of input-intensive production cannot meet the challenge. This means conserving, protecting and enhancing natural resources and ecosystems, and bolstering their resilience. The world must rely on family farms to grow the food it needs and to do so sustainably. For this to happen, farmers must have knowledge and economic and policy incentives to provide key environmental services.

Overcoming barriers to investment

Smaller family farms tend to rely on tried and trusted methods because one wrong decision can jeopardise an entire growing season. Several obstacles stand in the way of farmers adopting innovative practices. Key impediments include the absence of physical and marketing infrastructure, financial and risk management instruments, and secure property rights. Farmers often face high initial costs and long pay-back periods when investing, and this can prove to be a prohibitive disincentive. Farmers are also unlikely to undertake costly work to generate public goods (such as natural resource protection) without compensation. Local institutions such as producers' organisations have a key role to play in overcoming some of these barriers.

Research and Development

Investment in agricultural R&D is vital and provides high returns to public investment. Agricultural research is a public good and is unlikely to attract the private sector. Returns to investment may take a long time to materialise and research is cumulative with results building up over time. Stable institutional funding is necessary, and all countries need a certain level of R&D capacity to ensure adaptation to local agro-ecological conditions. Local adaptation of international research results may be the wisest investment and there is scope for South-South cooperation. Family farmers should be involved in defining research agendas and should engage in participatory research efforts to improve the relevance of the results to their situations.

Effective extension services

Sharing knowledge about innovative practices is perhaps more important for closing existing yield gaps. Far too many farmers do not have regular access to effective extension services. There is no standard model for delivery of extension services, but governments, private businesses, universities, NGOs and producer organisations can all play a role. Benefits accruing to quality extension services include increased productivity, improved sustainability, lower food prices, poverty reduction, *etc* and constitute public goods. One important area is to provide advisory services relating to more sustainable agricultural practices, or for climate change adaptation or mitigation through reduced greenhouse gas emissions or increased carbon sequestration. The public sector is responsible for ensuring that advice provided is technically sound and socially and economically appropriate.

Education and training

Innovation presupposes a capacity to innovate. Skills may need to be upgraded through education and training at all levels. Special attention needs to be given to women, girls and youth in general, who tend to have a greater inclination to innovate than older generations and represent the future of agriculture. Collective innovative capacity depends on effective networks and partnerships; producers' organisations and cooperatives are of particular importance. They can serve as a vehicle for closer cooperation with national research institutes, provide advice to their members, act as intermediaries, and provide a voice for small-holder farmers in policy making.

As FAO's DG, José Graziano da Silva, points out in his foreword to the report, nothing comes closer to the sustainable food production paradigm than family farming, which is why 2014 was declared the International Year of Family Farming. The report offers an unprecedented wide-ranging analysis of family farming globally and the crucial role of the sector in promoting development in rural communities. Fostering innovation in the family farm sector does, indeed, contain the essence required for improving food security and nutrition while conserving natural resources and limiting the extent and impacts of climate change.

Brian Sims

Economics of salt-induced land degradation and restoration.

Qadir M, Quillérou E, Nangia V, Murtaza G, Singh M, Thomas RJ, Drechsel P, Noble AD, 2014.

Natural Resources Forum 11/2014. DOI: 10.1111/1477-8947.12054 Pre-publ. PDF: https://macsphere.mcmaster.ca/handle/11375/15397 (accessed 8-11-2014)

The authors suggest a possible US$27.3 billion annual 'cost of salt-induced land degradation' in irrigated lands: clearly an order-of-magnitude estimate. This figure was produced by multiplying the estimated global irrigated area in 2013 (FAO-AQUASTAT) by 20 percent salt-affected irrigated land and the difference in crop yield value/ha between salt-affected and non-saline lands (both from estimates by Ghassemi *et al*, 1995) and by the $ inflation rate 1990-2013. The amount is placed in context by a critical discussion and a list of some further costs from salinity and sodicity, not captured in the crop yield estimates.

In brief summaries of published case studies, the authors show the diversity of saline, sodic and Mg-toxic conditions in salt-affected lands and a range of physical, chemical and biological approaches to their reclamation or improvement. Three case studies describe productivity losses at farm level in India, Pakistan and Kazakhstan; and five (condensed below) illustrate diverse methods to reclaim or enhance productivity of salt-affected land, also touching on economic aspects.

The authors conclude with a brief section on modelling and a wide-ranging discussion on hydrological, economic, infrastructure, health and employment conditions, actions and policies at local to national scales that could hinder or contribute to development and sustainable land management in salt-affected areas.

Case Study 1. Magnesium-affected soils, relatively rare globally, cover around one third of the irrigated area in southern Kazakhstan. In a farmers' participatory study, they were treated once with 4.5 and 8 t/ha phosphogypsum (a by-product of superphosphate production, Ca sulphate with around 2% phosphate). The calcium displaced much magnesium from the soil; subsequent 4-year average cotton yields were around 2.4 and 2.6 t/ha after treatment compared with 1.4 t/ha without treatment. Net income from the treatments was $522 and $554/ha, more than double the $241/ha from the control.

Case Study 2. On highly saline abandoned land in an irrigated area in the Hungry Steppe in Uzbekistan, 13 ha were planted with liquorice (*Glycyrrhiza glabra*), a perennial legume used as fodder; its large root system is in demand for extraction of its strong sweetening and flavouring substances. Fodder yields increased from 3.6 to 5.1 t dry matter/ha from the first to the third year, and the root yield after 3 years was 8.5 t/ha. The water table was somewhat lowered, hydraulic conductivity and organic matter content increased, and salt leaching enhanced.

Wheat after the liquorice yielded 2.42 t/ha against 0.87 t/ha from control plots and an average of 1.75 t/ha in the area. Cotton yield was 1.89 t/ha against 0.31 t/ha in the control and the area average of 1.5 t/ha. The reclamation thus appeared successful. The authors put this in perspective by noting that it can help but not substitute for a functional drainage system for improved, sustainable, salinity management. Data for a benefit-cost analysis over the reclamation period were not available.

Case Study 3. In abandoned salt-affected lands in the Amu Darya plain in Uzbekistan, four years of biomass data were collected for oleaster, Siberian elm and Euphrates poplar trees, and compared with data on mature, 15-20-year-old trees growing in the area. These were used to estimate the potential for investment in woodlots producing annual fuelwood, fodder and fruit, plus the standing timber (stumpage) value after 20 years. The calculations showed net present values at 16 percent discount rate between $1,3924/ha for oleaster and $1,717/ha for Euphrates poplar woodlots.

In later papers on the same area and subject, the reviewer saw positive results also with a 7-year woodlot cycle on salt-affected land in farms (shorter because of tenure insecurity), and noted the benefit of water savings by the low demand of the woodlots (3 to 30 percent of the demand of annual crops).

Case Study 4. The authors summarised a recent (2013) unpublished synthesis by G Murtaza of amelioration experiments using gypsum, farm manure, sulphuric acid and rice husk applications on saline-sodic soils under a rice-wheat rotation from eight salt-affected areas in the Indus basin, Pakistan. Average net income from treated fields was $1,940/ha per year, against $1,198 from the untreated controls. Both soil salinity and sodicity declined to around half their untreated values.

An earlier 2-year study by Murtaza *et al*, (2009) in the same area showed that amelioration of the medium-textured saline-sodic soils was most effective by applying 100 percent of the soil gypsum requirement followed by one irrigation with saline-sodic water and one with fresh water on a salt-tolerant rice crop, followed by a salt-tolerant wheat crop. Murtaza *et al* cautioned that use of saline-sodic water for reclamation would not work without adequate drainage.

Case Study 5. Four practices – deep ploughing, crop rotation, mixing residues, and digging drains – were compared with their respective control treatments in a farmers' participatory study in the Euphrates-Tigris plain on medium textured, poorly drained, moderately saline soils. The results showed significant reduction in salinity and higher net returns by these best-bet practices compared with their controls.

The economic results of this case are not relevant to the specific practices mentioned in the text of the summary, however, because they were due to more differences in management. For example, the accompanying table indicates that the deep ploughing was accompanied by a fertiliser application more than double the control ($330 against $150/ha) and that herbicide was used, but not in the control. The same was the case for the crop rotation treatment in which also the value of the wheat plus mung bean yields was compared with the value of the wheat-only yield of the control. None-the-less, this case does show that several combinations of good practices improve net returns and reduce salinity and sodicity in these soils.

In these five cases, the authors present analyses of the local economics of improving or reclaiming salt-affected lands by comparing costs and returns from the land without such improvement or reclamation with the higher costs, including for improvement or reclamation, and the resulting returns from the land. Irrigation costs (of water and of its delivery or pumping) are included. Additional benefits from ecosystem services are mentioned in the paper but not quantified because, to date, functional markets for them hardly exist.

While the authors take into account the local cost of irrigation water, they ignore its marginal social cost: the opportunity cost of not using it so as to generate the highest net returns achievable elsewhere. In many arid or semiarid areas, water rather than land is the scarcest commodity, so its marginal social value rather than local cost should be weighed in economic and policy decisions. This can lead to different outcomes with higher benefits. In several canal command areas in the Pakistan Punjab, for example, insufficient water is available to fully satisfy irrigation demand. In the past, water has been allocated to attempt reclamation even of unused areas of dense, saline-sodic soils, resulting in a small net return from low wetland rice yields, while allocating it to enable full irrigation of cotton, rice or other crops grown on the productive, non-saline land would have brought significantly higher net returns. In a similar situation at a much wider scale, as in the Aral Sea watershed, such economic optimisation of irrigation water use would face larger obstacles than in an area like the Punjab with a single irrigation authority because, without negotiation among its several governments, a near-optimal economic outcome for use of the water from the two rivers will remain out of reach.

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Robert Brinkman

Global Nutrition Report 2014: actions and accountability to accelerate the world's progress on nutrition.
IFPRI (International Food Policy Research Institute), 2014

ISBN: 978-0-89629-564-3
Paperback, 118pp.
Washington, DC.
Downloadable on http://global nutritionreport.org/

On 2 December 2014 the All Party Parliamentary Group (APPG) hosted the UK launch of the inaugural Global Nutrition Report. The Global Nutrition Report, one outcome of the Nutrition for Growth Summit in London 2013, is the first-ever comprehensive narrative on global and country level progress in all forms of malnutrition and its drivers.

Introducing the event Lord Chidgey, Vice-Chair of the APPG, said that: *'One of the most pressing challenges facing us in our planet today is malnutrition... The benefits of improved nutrition cascade through the life cycle and across generations and the cost of failing to act are tragically high for all countries: premature death, stressed health systems and severe drag in current and future economic progress.'*

This report was produced by an Independent Expert Group (IEG) empowered by the Global Nutrition Report Stakeholder Group. The writing was a collective effort by the IEG members, supplemented by additional analysts and writers.

This is a comprehensive, multi-authored audit of the status of national and donor reporting of the health and nutrition status of 193 countries. It comprises an Executive Summary, 10 chapters, six appendixes and 24 reports by panels of experts on specific subjects. The focus is on health and nutrition; there are only two passing references to the need to increase agricultural production as a means to reduce malnutrition.

Essentially, the report concludes that countries 'could do better' – in fact, must do much better if global health targets are to be achieved. Key points that it makes are that more nutrition indicators are needed within the Sustainable Development Goal accountability framework; commitments to improve nutrition faster need to be built into targets for 2030; more high-quality case studies are needed aiming to understand why the world is currently failing to meet global nutrition targets; resources and expertise need to be better aligned towards dealing with different and overlapping forms of malnutrition (including obesity as well as underweight); more attention needs to be paid to data covering nutrition-specific programmes; and a greater share of public and donor investments needs to be allocated to the design, implementation, effectiveness and reach of nutrition approaches.

It concludes that the current tracking of expenditure on nutrition makes it difficult to hold responsible parties responsible, and that information gaps which constrain priority action and accountability need to be filled.

Hugh Brammer

No ordinary matter: conserving, restoring and enhancing Africa's soils
The Montpellier Panel, December 2014,

Agriculture for Impact
35 pp, Paperback
Available online at http://bit.ly/1BaH9V1

The latest report from the Montpellier Panel[1] *'No ordinary matter: conserving, restoring and enhancing Africa's soils'*, released on 4 December 2014, is a comprehensive analysis of land management in Africa today. It argues that, if left unattended, the cycle of poor land management will result in higher barriers to food security, agricultural development for smallholder farmers, and economic growth for Africa.

Despite soil's vital role in Africa, it is often overlooked or neglected, to the great detriment of smallholder farmers in particular. In sub-Saharan Africa, an estimated 65 percent of soils are degraded and unable to nourish the crops that this chronically food-insecure continent needs. In some areas, agricultural productivity declined by half between 1981 and 2003 as the result of soil erosion and desertification. Poverty, climate change, population pressures and inadequate farming techniques are driving a continuous decline in the health of African soils. The resulting economic loss is estimated at US$68 billion per year. Conversely, better land management could deliver up to US$1.4 trillion globally in increased crop production.

The Montpellier Panel report answers a series of critical questions:

Are donors and governments neglecting soil health in Africa?
Soil health should be a global priority. However, current donor and government strategies do not pay enough attention to land management or land restoration. The Comprehensive African Agriculture Development Programme (CAADP) investment plans do not prioritise soil health; those investment plans and financial commitments that are in place are either unclear or lack appropriate monitoring and evaluation criteria.

What are the key approaches to restoring Africa's soils?
Africa's soils are diverse and varied. Also, African farmers have differing kinds of knowledge, resources and endowments – which must be recognised, enhanced and addressed when developing soil management strategies. With that in mind, the Montpellier Panel advocates wide adoption of Integrated Soil Management (ISM) techniques that combine organic approaches with a prudent use of necessary technical inputs. For example, traditional approaches such as water harvesting, erosion control and intercropping should be combined with precision-farming techniques that may involve micro-dosing of fertiliser, pesticides and water. Additionally, more use could be made of leguminous crops such as beans and groundnuts that naturally fix nitrogen in the soil and improve nitrogen uptake, planted amid leguminous *Faidherbia* trees that provide nutritious and protective mulch with their shed leaves.

ISM offers the ability to sustainably intensify agricultural production and maximise the social, economic and environmental benefits. African farmers need to strike the right balance between adequate nutrient management to achieve higher yields, whilst minimising costs and environmental impacts. Yet the uptake of ISM practices in Africa remains low. More often than not, the choice is made to forgo better land management practices in lieu of more affordable, less labour-intensive or alternative uses of resources. Reversing these choices will require better information and stronger incentives; governments need to support this by establishing appropriate structures for sustainable land use such as long-term lease regulations, protection of tenancy rights, and payments for ecosystems services.

How can improved land management tackle climate change in Africa?
Soil plays a significant role in sequestering carbon from the atmosphere. This carbon is lost when soil is degraded. Restoring this lost carbon to the soil through sustainable land management practices not only makes soils more resilient and fertile, but it can also remove a significant amount of excess carbon from the atmosphere, thus lowering greenhouse gas levels. Practices like no-till farming and agroforestry have substantial effects for sequestering carbon. Mitigation techniques that reduce greenhouse gas emissions include targeted use of inputs, such as deep placement of urea briquettes, the main fertiliser for rice. Further, adaption techniques that enhance soil moisture, such as no-till, terracing or ridge and furrow systems, can reduce the stress that African soils will face from higher temperatures.

The report concludes that restoring and sustaining Africa's soil health is possible, but it requires more and better support. Donors and governments can take action to conserve, restore and enhance Africa's soils by:

1. **Strengthening political support for sustainable land management** as a focus area within the post-2015 global development agenda, and committing and building upon the Rio+20 target of 'Zero Net Land Degradation' (ZNLD).
2. **Increasing financial support** for investment in land and soil management practices and research that will combat land degradation.
3. **Improving transparency for land and soil management**, clearly identifying contributions in national investment plans and food security strategies, coupled with ongoing monitoring of the effectiveness of these investments.
4. **Quantifying the costs of land degradation** and of benefits generated by sustainable land management practices to reinforce attention to treat land degradation as a serious global challenge.
5. **Bridging gaps in data available on African soils** through the use of advanced remote-sensing systems, dense networks of local weather information and citizen science.
6. **Creating incentives**, particularly secure land rights, to encourage the care and adequate management of farm land.
7. **Building on existing knowledge and expertise** on soil science and land degradation in Africa.
8. **Strengthening soil research centres in Africa** and by collaborating with European and other international scientists and research centres.
9. **Promoting integrated soil management (ISM)** as a cornerstone of sustainable land management, combining organic

[1] The Montpellier Panel is a group of eminent European and African experts led by Professor Sir Gordon Conway, Director of Agriculture for Impact and Professor of International Development at Imperial College London.

farming methods, conservation agriculture, ecological approaches, and selective and targeted use of inputs.

10. **Providing knowledge, resources and incentives** to help farmers adopt climate-smart practices for soil management – through more secure land tenure rights that encourage the care and adequate management of farmland, and better access to markets, extension services and training.

Stephanie Brittain
Agriculture for Impact
Imperial College, London
www.ag4impact.org

New ways of looking at the soil profile

Alfred E. Hartemink

Alfred Hartemink is professor of soil science at the University of Wisconsin-Madison. He has worked in Congo, Kenya, Tanzania, Indonesia, Papua New Guinea, Australia, and at ISRIC in the Netherlands. He co-initiated and coordinated the GlobalSoilMap project, served as Secretary-General of the International Union of Soil Sciences, and is editor-in-chief of Geoderma Regional. He likes soils. (hartemink@wisc.edu)

Summary

There is a need for rapid and accurate collection of soil information with depth. However, the methods of soil profile description and quantification have not changed much in past decades. Commonly, a soil profile is divided into genetic horizons, described and sampled, and its properties analysed in the laboratory. The information is used to classify soils and for interpretations of soil functions. Interpolative procedures using the analytical data from soil horizons have been developed to estimate soil property values at any depth or depth class. Proximal soil sensors and other tools are now able to measure *in situ* a range of soil properties. These sensors may accumulate high-spatial-resolution data very rapidly compared with traditional methods of analysis. Some ideas and novel practices for soil profile analysis are discussed, including tools and techniques for soil profile observations, continuous depth functions of soil properties, and the mapping of the soil profile. These three aspects, termed *digital soil morphometrics*, offer potential for enhancing our understanding of soils, their distribution across the landscape, and their genesis and classification; and they have the potential for resurrection of pedology programmes across the world.

The changing place of soil science

Soil science has rapidly changed from the days of large scientific discoveries in the first half of the 20th century; expansion in the decades following the Second World War; and through decades of declining funding, students, research institutes and university departments (Dent & Dalal-Clayton, 2014): trends have happened at a different pace and level of impact in different parts of the world. The tide has turned. For several years now there has been an increase in the number of projects and publications and an overall increase in the demand for soil science expertise (Hartemink & McBratney, 2008). Where soil science departments have survived, student numbers have risen and new tools and techniques are being tested to enhance scientific understanding of the soil. A recent study in the UK lists soil science amongst the top ten most-wanted skills in a nationwide skill gap analysis, and indicates that there is a specific need for soil scientists that have expertise in soil carbon monitoring and modeling, soil system functions, or impact of land use on soils (NERC, 2012).

The link between soil science and agriculture has weakened over several decades (Hartemink & Bouma, 2012), but soil scientists now play a role in thematic issues around food production, water quality, biodiversity loss, bio-energy generation, climate change and human health. Whilst much of our advanced teaching is disciplinary, a considerable part of our research is multidisciplinary. The overall upsurge in soil science is led by advances in soil mapping, analytical techniques and theoretical development.

Particularly, digital soil mapping is revitalising many soil survey centres across the world. Soil profile or pedon descriptions are important in digital soil mapping, but the methods of soil profile description have hardly changed in half a century. Here I will describe some ideas and novel practices for soil profile analysis, including tools and techniques for soil profile observations, continuous depth functions of soil properties, and the mapping of the soil profile. These three aspects, termed *digital soil morphometrics*, offer potential for enhancing our understanding of soils, their distribution across landscapes, and their genesis and classification (Hartemink & Minasny, 2014).

Soil description as it has been

For detailed soil observation, a soil pit may be dug (some bigger than others: see Figure 1). Observations are also made using augers, samplers, push probes, slice shovels, trenches, road cuts, and in quarries. The traditional field toolbox for soil profile descriptions includes the auger, pickaxe, spade, knife, spatula, rock hammer, Munsell soil charts, map, note book, water bottle, acid bottle, sample bags, tape measure, clinometer, compass, altimeter or GPS, and camera. The soil profile is divided into genetic horizons, their attributes are described, and samples are collected for analysis in the laboratory. The information is used to classify soils and for interpretations of

Figure 2. A Mollisol (Phaeozem), hand-held XRF, and a map of the Fe content of the same profile (1 by 1 m, values increase from red, through yellow and green to blue)

Figure 1. Cross section (250 m trench) through a hill near Luki in DR Congo as part of the field excursion of the 5th World Congress of Soil Science in 1954. According to Dr Charles Kellogg *'…a pedological extravaganza'* (quote and picture by Dr Peter Le Mare)

soil functions. Interpolative procedures using the analytical data from soil horizons have been developed to estimate soil property values at any depth or depth interval.

Some new developments – digital soil morphometrics

Currently, a range of sensors is being used in agricultural and environmental soil studies. Compound attributes (horizons, structure) are harder to measure than single properties like soil texture and soil moisture. Soil attributes most commonly assessed in the field by digital morphometrics are soil horizons, soil texture, soil colour, and soil moisture. Several studies have focused on soil horizons using ground penetrating radar (GPR), electrical resistivity (ER) or the cone penetrometer. GPR and ER are non-invasive techniques, the penetrometer is an invasive technique, but none of these requires a soil pit. Of all newer sensors, near infra-red spectroscopy (NIR) has, possibly, the largest potential. The spotty and uneven nature of redoximorphic features makes them highly suitable for visible-NIR analysis. There are limitations to using IR sensors in a soil pit: there can be interference from signals not related to the soil; the vis-NIR sensor is also sensitive to soil moisture; and the variation and unevenness of the soil surface itself, as well as sample preparation. But, recognising the limitations, such sensors open up a new world, and digital morphometric techniques have been used for all soil properties both in a soil pit and on monoliths in the laboratory (Hartemink & Minasny, 2014).

The sensor may accumulate high spatial resolution data more rapidly compared with traditional methods of analysis. Importantly, measurements can be made in a soil pit at very small depth intervals. In other cases, the measurement is conducted in the laboratory at intervals in the micron range or few centimetres, and the increment is much smaller than the depth of soil horizons. In this way, we can create continuous depth functions of soil properties based on measurements rather than interpolations, map the soil profile and more precisely investigate horizon boundaries (Figure 2). Conventionally-described genetic horizons may or may not coincide with all the attributes of interest. In the example in Figure 2, we see the not-uncommon situation of a property of interest (in this case total iron content) that is masked in the soil profile (in this case by organic matter).

The future

There is an increased demand for soil information by a range of users that drives many of the new soil projects. Considerable progress has been made in digital soil mapping and the potential for timely collection of new soil data and information (Arrouays *et al,* 2013). The wide array and use of proximal soil sensors contributes to increased data availability and soil information, and there is a potential using digital morphometrics for *in situ* soil characterisation and the production of continuous soil depth functions. The new techniques to describe and analyse soil profiles have the potential to frame our understanding of soils and be a spur to the resurrection of pedology programmes across the world.

We suffer from an inadequate number of well-trained soil scientists to tackle an array of problems confronting humanity. These new developments are of particular importance for soil science in tropical regions where there is dearth of pedologists.

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Mailbox

Africa is a big place

Dear Sir,

As in too much current practice, in the Winter 2014 issue of *Agriculture for Development*, you describe on page 29 Hugh Brammer as having *'worked … in Africa and East Pakistan …'*. If in Africa, why not in Asia instead of East Pakistan? Or, as the article refers to his work in Bangladesh, if East Pakistan why not Gold Coast instead of Africa? Gold Coast became Ghana while Hugh was working there; I'm not sure about the Asian country name change. I am not aware that Hugh was peripatetic in Africa!

My point is that Africa is popularly referred to as though it was a country; it is a very large continent comprising umpteen countries. In general I think reporters should be more specific and refer to the individual country in Africa unless the continent is the subject matter. Perhaps this is especially desirable for a journal dealing with development in a wide variety of environments. What is your editorial policy in this matter?

Kind regards,

Peter Le Mare (22y 6m in Africa! Tanganyika 6; Uganda 11; Tanzania 5; Nigeria 6 months)

Editor's response: Our policy is to use our common sense. We refer to individual countries when appropriate, but rather than listing several individual countries we may sometimes refer to the relevant continent. In bionotes we aim to be as brief as possible.

The *System of Rice Intensification* (SRI): a continuing debate

Dear Sir,

Since writing the article on the *System of Rice Intensification* (SRI), for *Ag4Dev23* (Winter 2014), some additional aspects have become even more prominent. Though strongly resisted by the mainstream (international) agricultural research establishment, the SRI phenomenon (particularly its profuse root development, abundantly-tillering plants, and many large and productive panicles) has raised a number of fundamental (agronomic) research questions. In particular: 'what are optimum seeding rates?' and associated with that 'what is the optimum number of plants per unit area?' One would have assumed that these questions had been resolved long ago. In today's research culture such simple and basic questions are unlikely to invite extensive research funding. Yet the SRI case illustrates how important such questions might be, because the findings/outcomes crucially affect the validity of on-going, very costly and ambitious research projects. This applies directly to the development and testing of new crop cultivars (*eg* varieties, hybrids, GMOs, *etc*), all kinds of modelling efforts and decision-support tools (based on assumptions derived from the conventional intensification practices), as well as new technologies aimed at ensuring sustainable intensification. The results of that research will probably be strongly biased.

What has the SRI research illustrated? Notably, that crop varieties will develop into entirely different plant types (phenotypes) depending on local agro-ecological conditions (in general: the location-specific *context*) along with the use of properly *adapted* agronomic management practices. As a result, the efficiency of the plants' physiological functioning is profoundly affected. This applies to both the below-ground roots as well as above-ground canopy development that ultimately will determine the quantity of harvested grain. SRI requires greatly reduced seed rates and a plant population of 15-30 plants per m^2; conventional recommendations advise about 150 plants per m^2; while most (smallholder) farmers traditionally use densities even way above that (200-300 plants). Under SRI practices, 16 rice plants/m^2 produced a total root mass that was equal to that produced by 150 plants/m^2 in the conventional system, while the SRI grain yield was greater by 50 percent or more. The conclusion must be that, because the root systems of the conventional planting are seriously stunted, they must be inefficient in their basic functions, including uptake of water and nutrients, symbiotic linkages with soil biota, and production of growth hormones and exudates. Similar features could be observed for other cereal crops such as wheat, millets, sorghum, maize, teff *etc*.

Such pronounced effects of plant density on phenotypes have important agronomic ramifications. It means that, for instance, to establish the superiority of one crop cultivar over another (*eg* a newly introduced cultivar) is much more complex than is generally assumed. Simply by changing the plant density factor, the outcome of a comparison can be changed significantly. On that basis, many (excellent) local or traditional varieties tend to be eliminated not for being inferior in terms of grain yield, but rather for responding negatively to high plant densities (or in other words high seed rates). But still more importantly, seriously-stunted root systems will be restricted in developing beneficial associations with the living and active part of the soil, the soil biota. Here it should be recognised that soil (micro-) biology has been a neglected research domain for many years.

In all these respects, the SRI phenomenon is posing fundamental challenges to current mainstream research that still views solutions for global and local food security mainly in terms of new crop varieties (and high seed rates), mineral fertilisers and crop protection chemicals, water and precision technologies. These techniques will not achieve a sustainable intensification: not on large industrial farms, nor on the multitude of smallholder farms. Instead, these efforts might be viewed as attempts to compensate for the large inefficiencies associated with *modern* agriculture. These are obviously priorities of a powerful global agro-industrial complex that, however, does not meet the more basic and longer term needs of smallholder farmers.

As concluded in the *Ag4Dev23* article, we are presently seeing in India a form of *creeping* adoption of various SRI components. The popular evaluation concepts of adoption, dis-adoption or non-adoption/rejection thereby become inappropriate, if not misleading. One can hardly be surprised that farmers, smallholders in particular, are responding positively to the SRI features of increased yields at reduced costs as they become aware that seeds and chemicals have been formally recommended at excessive rates, while exaggerated benefits were claimed.

Moreover, the general public has increasing reasons to become concerned as the conventional intensification paradigm continues to be widely taught at universities to future generations of agriculturists. It also constitutes a major pillar of national agricultural policies as well as of overseas agricultural development programmes.

Willem A Stoop

TAA Forum

TAA 2014 Annual General Meeting

The TAA 2014 Annual General Meeting was held on Wednesday 10 December 2014 at the Royal Overseas League, London, attended by approximately 40 members.

Following a welcome from TAA President Andrew Bennett, and approval of the minutes of the 2013 AGM, reports were presented by the TAA Chairman Keith Virgo; Treasurer Jim Ellis-Jones; and TAAF Chairman Antony Ellman. Their reports are provided below.

The Treasurer's report was followed by:

- Adoption of the Audited Accounts for the 2013-2014 Financial Year.
  Proposer: Gary Robertson; Seconder: George Taylor-Hunt
- Reappointment of the Examiners for the Association, Montpellier Professional of Dashwood Square, Newton Stewart, Wigtownshire, for the next financial year.
  Proposer: Gary Robertson; Seconder: George Taylor-Hunt

The 2014 Annual TAA Honours Awards were presented by the President to: Professor John Witcombe (Development Agriculturalist of the Year), Antony Ellman on behalf of Richard Bliault (Young Development Agriculturalist of the Year), and John Russell and Antony Ellman (Awards of Merit). Further details are provided below.

The President nominated Fiona Johnson as a member of the Executive Committee, and this was endorsed by proposer: Phil Hollington, and seconder: Taff Davies.

Jim Watson gave a short presentation on the early history of the TAA (an extended and updated version will be included in *Ag4Dev25*); and Ben Evans gave a presentation on his research supported by his TAAF Award entitled *Responding to Change: Bushmeat Hunting in Congo-Brazzaville* (see *Ag4Dev23*, TAAF News).

The 32nd Ralph Melville Memorial Lecture, entitled *Improving smallholder agriculture: how technology and other factors have contributed to improvements*, was presented by Professor Mike Bushell, Principal Scientific Advisor for Syngenta. It will be reproduced in full in *Ag4Dev25*. It generated a lively debate, which had to be curtailed in order for members to enjoy the annual reunion buffet.

Chairman/General Secretary's 2014 Annual Report

It has been an exciting year for TAA. New overseas branches have been established and UK groups have flourished. We have enhanced our charitable status by joining LendwithCARE and generous contributions have strengthened TAAF. Membership is on the increase, with more younger people joining. ExCo has met quarterly to strengthen and encourage a wider influence and effectivness of TAA. We have even been rediscovering our history, as we shall hear shortly from Jim Watson.

Regional Groups and Overseas Branches: UK Regional groups have offered an exciting programme of meetings: the Southwest (Bill Reed and Tim Roberts) continues to prosper with meetings, seminars with partner organisations, and an annual tour; East Anglia (Keith Virgo and Bill Thorpe) has promoted several successful events in association with Cambridge institutions; Scotland and Northeast (John Gowing) has re-awakened to hold a seminar; London and South East (Terry Wiles) has blossomed with their bimonthly 'Curry Lunch Talks' and re-invigorated links with APPG. At the same time, the Agribusiness (Roger Cozens) and Land Husbandry (Amir Kassam) groups have arranged events. We are still seeking a member to open a Northwestern branch. Overseas, the Caribbean (Bruce Lauckner) and India (Sanjeev Vasudev) branches continue to provide a regional focus and we now have a branch in SE Asia (Wyn Ellis). Moreover, we have proposals from members to set up branches in Ireland (Paul Wagstaff) and in the Pacific (Ravi Joshi). Discussions are continuing with contacts in Kenya and in Zambia about possible branches. However, as we need to be sure that we provide the support and services required by these branches, we have appointed a Branches Coordinator (Fiona Johnson) to ExCo to handle this increase in activity.

Agriculture for Development: The four-monthly journal has been developed into a world-class publication, with themed editions containing quality articles from renowned experts in the field (Paul Harding and team). Other sections have been rationalised to enable inclusion of news from the field, news of corporate members, TAAF, events and fascinating reflections by members. Each edition has been over-suscribed, and it is now running to almost 70 pages. We have instituted a questionnaire survey to assess the views and suggestions of the readership.

TAA Website (www.taa.org.uk): Our Web Manager (Keith Virgo) has made many improvements to the website to make it more user-friendly and appropriate to the needs of members (and others). These include pages for reflections and opinions, a discussion forum, new pages for regional groups and overseas branches, corporate members' pages and a slot for members to enter their career summaries. The Directory of CVs has now been consolidated into the main website under a wider 'Expertise' section and members can enter their own CVs on-line at no charge. The 'alert' system brings latest news and information on events direct to registered members and has created a good deal of interactive responses.

Annual Memorial Lectures: The traditional Ralph Melville Memorial Lecture (RMML) and the mid-year Hugh Bunting Memorial Lecture (HBML) at the University of Reading have continued to be promoted as high profile international public events. The lectures are being recorded for wider dissemination via the *Ag4Dev* journal and on the website. The 2013 RMML was delivered by Sir John Beddington on the challenges of the 21st Century. The 2014 HBML was delivered by Dr Wyn Ellis on voluntary sustainability standards for incentivising smallholder adoption, especially rice farmers.

TAA Award Fund: The TAAF programme continues to be very popular, mainly with MSc students, giving them opportunities to conduct their dissertation studies overseas. There is less demand for the longer duration assignments. The TAAF committee performs a valuable service of mentoring awardees. We are also linking with the Cambridge University Hub to tap suitable new candidates. Generous donations have strengthened TAAF funds and we are now looking at setting up a formal Trust to accumulate funds and income more efficiently. We shall hear a report from the Chairman of the TAAF committee, Antony Ellman, and a recent awardee.

All Party Parliamentary Group (APPG) on Agriculture and Food for Development: This was established in 2008 by UK-FARD and corporate TAA members. TAA is now an official 'supporter' of the APPG and our convenor for L&SE group (Terry Wiles) has been actively discussing with the APPG Coordinator future programmes and possible contributions by TAA members.

Honours: The Honours Panel, under Paul Harding, has been reconstituted to seek wider canvassing for nominations, especially from our corporate members. The three categories are 'Development Agriculturalist of the Year', 'Young Development Agriculturalist of the Year' and 'Award(s) of Merit' (restricted to TAA individual members and employees of corporate members). This year the awards go to John Witcombe (Development Agriculturalist of the Year), Richard Bliault (Young Development Agriculturalist of the Year), and to John Russell and Antony Ellman (Awards of Merit).

Membership. The membership secretary (Lin Blunt) has transformed our ability to communicate with members and she has successfully maintained a constant flow of new members. But she relies on suggestions from the membership! Most of the 'sleeping' members have now been deleted from the database. The current active membership is 613 individual members and 22 corporate members.

Charitable Status. We became a registered charity in 1989, 25 years ago this year. We need to abide by our charitable status. To strengthen this, we have joined *LendwithCARE*, a peer-to-peer lending relationship between people in the UK and people in developing countries, operated by CARE International. It is an innovative way of raising micro-finance to help entrepreneurs in developing countries to lift themselves out of poverty. We have also formed links with *GrassrootsAfrica*, set up by a member, to provide a pool of advice to farmers in sub-Saharan Africa.

General Administration and Executive Responsibilities: We will soon hear reports from other ExCo members, particularly the Treasurer (Jim Ellis-Jones), and the Chair of the TAAF Committee. However, we ask the membership to join in expressing our grateful thanks for the hard work that they, other members of ExCo, the members of the Regional and Specialist Groups, and overseas branch organisers have done during the year. We also thank the many members who have contributed ideas and participated in the Associaton's activities. We always welcome suggestions on how to improve further.

Keith Virgo (Chairman) and Elizabeth Warham (General Secretary)

Treasurer's 2014 Annual Report and TAA 2014 Accounts

TAA's 2014 annual accounts (1 July 2013 to 30 June 2014), finalised by our external accountants, Montpelier Professional Limited, were presented at, and approved by, the AGM on 10 December 2014. The accounts are submitted each year to the Charities' Commission and can be viewed on www.taa.org.uk under the page on Finance and Accounts. Key points include:

Income

Total income was £31,537, some £2,500 more than in 2013. This included:

- Subscription income of £18,110 from some 550 members, 15 of whom were corporate.
- Six donations for the Award Fund amounting to £9,442, five totalling £4,442 from TAA members and one of £5,000 from the Leonards Stock Foundation. All are greatly appreciated.
- A tax rebate of £2,620 received from the Inland Revenue for 'Gift Aided' subscriptions and donations. Although there continues to be an increase in members providing 'Gift Aid' forms, we continue to lose potential income from members who do not do so.
- Other income included £1,010 from events, £292 for directories, £32 interest and £31 miscellaneous.

Expenditure

Total expenditure in 2014 was £27,776, marginally morer than in 2013. £25,683 was charitable expenditure and £2,093 was for governance.

- *Agriculture for Development* journal costs were £11,691 for the three publications produced during the year. This compares with £10,871 during the 2012-13 financial year.
- TAAF approved eight new awards amounting to £9,575, compared with nine awards made in 2013 amounting to £9,106.
- Other charitable expenditure included £1,770 for events, £693 for ongoing development and maintenance of the website, £276 for membership of the Biology Society, and £250 for the All Party Parliamentary Group (APPG) on Agriculture and Food for Development.
- No subventions were made to regional groups.
- A donation was made to CARE international for their Lend withCARE micro-finance scheme funding small entrepreneurs across nine developing countries. As repayments are made, these are used for funding further micro-loans.
- Governance costs amounted to £2,903, compared with £3,909 in 2013, the decrease being largely due to the improvements made to the membership data-base during 2013.

Funds available

A surplus of £3,761 was achieved, compared with a surplus of £1,572 in 2013. The total funds available at the end of June were £58,771 of which £20,771 is restricted for TAAF and £1,070 for the UK Forum.

Looking forwards

A deficit of around £8,000 is expected in 2015, largely due to TAAF awards being made from TAAF donations received in earlier years.

Jim Ellis-Jones (Treasurer)

ACCOUNTS July 2013 to June 2014

	2014	2013	Change
Receipts			
Subscription	£18,110	£18,210	-£100
Award Fund donations	£9,442	£7,792	£1,650
CV Directory	£292	£120	£172
Functions	£1,010	£864	£146
Inland Revenue	£2,620	£1,963	£657
Bank Interest	£32	£29	£3
Miscellaneous	£31	£50	-£19
Total receipts	**£31,537**	**£29,028**	**£2,509**
Expenditure			
Charitable			
Journal	£11,691	£10,871	£820
CV Directory	£205	£295	-£90
Shows and functions	£1,770	£2,378	-£608
Regional Subventions	£0	£306	-£306
Biology Society	£276	£0	£276
LendwithCARE	£2,000	£0	£2,000
UK forum for APPG	£250	£0	£250
Award fund and expenses	£8,798	£9,106	-£308
Internet/web costs	£693	£591	£102
sub total	***£25,683***	***£23,547***	**£2,136**
Governance			
Insurance	£441	£435	£6
Accounting services	£360	£360	£0
Executive Committee	£1,136	£1,143	-£7
Admin	£156	£1,971	-£1,815
sub total	***£2,093***	***£3,909***	**-£1,816**
Total expenditure	*£27,776*	*£27,456*	**£320**
Excess of receipts over payments	£3,761	£1,572	£2,189
Bank balance brought forward	£44,977	£53,438	£8,461
Funds available	**£53,438**	**£55,010**	**£1,572**

TAAF 2014 Annual Report

2013/14 awards

In April 2014, we gave eight TAAF awards to MSc students from six UK universities (Imperial, Newcastle, Reading, Sheffield, Southampton and UCL) to a total value of £8,800. This was from a budget of £10,000 for the year. The students undertook valuable studies on subjects including:

- Responses to environmental and management changes in Congo;
- Impact of soil and water conservation on crop yields in Burkina Faso;
- Communal management of water resources in Uganda;
- Cocoa agro-forestry and reforestation in the Peruvian Amazon.

Recent activities

In the second half of 2014, TAAF Committee members continued to offer mentoring advice to these students, six of whom have completed their MScs and submitted interesting reports. We have given one more top-up award of £450 to a civil engineering graduate from Newcastle who is currently training rural water engineering students in Cameroon.

From award to employment
We are encouraged by the fact that four of this year's MSc awardees have already found paid employment in development jobs:

- two are working for the Wildlife Conservation Society of Congo;
- one is employed in the London office of WaterAid;
- one is constructing and distributing fuel-efficient stoves in Malawi.

Two others are running their own businesses importing and distributing tropical wholefoods and horticultural seeds respectively.

Earlier awardee experiences
Many of our awardees from earlier years have also continued to work in development:

- Alastair Stewart, who received an MSc award in 2011 for an assessment of conservation agriculture in Tanzania, is now responsible for monitoring and evaluation of the Aga Khan Foundation's rural development programme in Mozambique. Alastair also serves on the Publications Committee of TAA.
- Richard Bliault, who studied smallholder fruit tree planting in Kenya for his MSc in 2011, is now Smallholder Coffee Manager for an international coffee processing and marketing company in Tanzania. Richard was nominated as ***Young Development Agriculturalist of the Year 2014*** in recognition of this work. He made a presentation at a London and South-East Regional Group Meeting on 7 November, where he was presented with his certificate since he was due to be back in Tanzania at the time of the TAA AGM.
- Case studies of several other TAAF awardees' experiences in moving into employment in development are on the TAA website (TAAF/Case Studies).

Future Expansion of TAAF
Our success in helping awardees to move into employment encourages us to consider expanding the TAAF scheme in future. We are constrained by two considerations.

- We are reluctant to grow too big since this would make it difficult to provide individual professional mentoring to awardees, which is clearly appreciated by them and plays a big part in the successful outcome of the scheme.
- Our funds are largely limited to contributions from TAA itself and donations from individual members since, despite intensive efforts, we have not been successful in identifying new sources of finance.

Advertising campaign
Despite our reluctance to grow too big, we have nonetheless decided to embark on a more courageous publicity campaign, if only to ensure that we get more applications particularly for our long term awards. We are advertising our awards through Cambridge Student Hubs, both through their on-line newsletters and at their International Development Conference which reaches some 25,000 students at all UK universities.

We are also trying to link awardees to each other and to TAA members through an on-line bulletin board, and through a webex link which will allow wider participation in conferences and meetings.

At the same time, we need to adopt a more energetic fund-raising campaign to ensure that we are better able to fund the larger flow of applications expected to result from our advertising campaign.

Fund-raising campaign
TAAF receives an annual subvention of £3,000 from TAA core funds, which has been supplemented in recent years by generous donations from individual TAA members:

- £7,271 from 6 donors in 2011/12,
- £7,792 from 4 donors in 2012/13 (including £5,000 from a family trust)
- £9,442 from 5 donors in 2013/14 (including a further £5,000 from the trust).

We greatly appreciate the contributions made by individual TAA members. We are confident that we put them to very good use: they have enabled TAAF to keep its head above water in a difficult financial climate.

These donations, together with funds carried forward from earlier years, when we still had institutional forms of finance, have enabled us to offer 8-10 TAAF awards per year at an average cost of around £10,000. We would like to be able to raise our annual expenditure to £15,000 and to increase the number of awards made to 12-15.

We therefore earnestly request loyal TAA members to take action of two sorts:

- **Member donations.** Any member who is in a position to do so is urged to donate any amount from £1,000 to £5,000 (or more or less) for TAAF awards. If just five members contribute a mean annual sum of this dimension, we would reach our short term objective.
- **Legacies to TAAF.** In the longer term, we would like to build up a capital fund of £100,000-£200,000 which would secure the long term future of TAAF. A practical way of achieving this would be if members can consider leaving a legacy to TAAF in their wills, in a Trust set up for this purpose.

The procedure for leaving a legacy to TAAF is explained in the Winter 2014 Issue of *Agriculture for Development (Ag4Dev23)*. There are advantages to donors: any money left to charity is exempt from Inheritance Tax, thus reducing the tax burden on family beneficiaries. Also under recent legislation, if 10 percent of an estate is left to charity, the tax due on the balance may be reduced — currently to 36 percent instead of the normal 40 percent — with obvious benefits to heirs. So please give this option serious thought!

Acknowledgements
I conclude by acknowledging the contributions of many people to the recent advances made by TAAF:

- The financial contributions of many TAA members to TAAF's budget (hopefully many more of these will now come in).
- The sterling efforts made by TAAF committee members in vetting applicants for awards, mentoring successful candidates, publicising our scheme at universities and at International Development Conferences, and maintaining a database of past and present TAAF awardees.
- The contributions of returned TAAF awardees to managing TAA and TAAF affairs, *eg* through membership of the

Finance, Communications and TAAF Committees, setting up bulletin board, web links, *etc*.
- And finally, many congratulations to Richard Bliault on his recognition as Young Development Agriculturalist of the Year.

Antony Ellman (TAAF Chairman)

2014 TAA Honours

Each year, the TAA recognises the contributions to agriculture for development of a few outstanding individuals. The most prestigious awards, Development Agriculturalist of the Year, and Young Development Agriculturalist of the Year, are open to anyone involved with agriculture for development. Awards of Merit are restricted to TAA Members. The TAA wishes to congratulate this year's worthy awardees.

Professor John Witcombe – Development Agriculturalist of the Year

Proposer: Dr Philip Hollington

Seconder: Dr Katherine Steele

Citation: During a lifetime of work, John Witcombe has developed novel strategies for breeding crop varieties. He advocated client-oriented breeding, developed from participatory varietal selection and participatory plant breeding, with farmers and end users consulted throughout the programme. He applied theory to propose a low risk, cost effective 'smart cross' method that he tested in rice, in which breeders need to make fewer, carefully-chosen, crosses to obtain the required traits; in maize and in pearl millet they only require a single base population. John's two Ashoka rice varieties have better drought tolerance, higher grain quality (hence market price) and yield 30-50% more than landraces (an extremely difficult combination). By 2012 they were grown by more than 270,000 farmers in eight States of Eastern India. Farmers like the superior grain quality of his GM-6 maize, which out-yields landraces by 29%. It has improved the livelihoods of 300,000 of the poorest farm households in Gujarat, and is grown on over 2 million ha.

Figure 1. TAA President Andrew Bennett presents Professor John Witcombe with the 2014 Development Agriculturalist of the Year award (Photo: Marie-Claude Quieffin-Witcombe)

Professor Witcombe responded as follows:

Thank you very much for this award that I feel honoured to receive. I have been asked to make a short speech. However, as I need to explain why I have been given the award it threatens to be a long one.

I am grateful to colleagues in Bangor University for nominating me for this award. They did so on the basis of two particular achievements that have brought me much personal satisfaction - new maize and rice varieties for farmers in India. My interest has been in promoting participatory plant breeding where instead of breeding for research station trials we breed to meet what farmers actually want.

In maize in Gujarat, India, we breed for very early varieties, as this is what we knew farmers wanted. Very early maize is not going to do as well on research station fields as later varieties and so it is a hard job to get them released. We did manage to release GM-6 maize - a very early variety - in Gujarat. In recent years it has accounted for nearly 100% of all the certified maize seed production in Gujarat and has been grown on a cumulative area of more than 2 million hectares.

In upland rice in eastern India breeders have always targeted coarse-grained rice as they believed it was what farmers wanted. From our participatory research we found that farmers actually loved fine-grained rice. They preferred the taste and if forced to sell grain they could get a higher price for it. Our new rice varieties, Ashoka 200F and Ashoka 228, have been the most successful upland rice varieties in eastern India and they quickly replace any modern varieties that were previously grown. The UK's Department for International Development (DFID) recognised this success, and provided funding from the Research into Use Programme that has enabled 250,000 farmers in eastern India to receive seed. Almost 100% of farmers that have received seed continue to grow the Ashoka varieties. Not only that, but farmers give seed to other farmers in their own, and other, villages. In turn these farmers also distribute seed. It becomes impossible to say how many farmers are growing these varieties but it has to be millions.

As I said this has given me much personal satisfaction but it could not have been done alone. It is difficult to pick out a few individuals but I would like to thank particularly two of my Bangor University colleagues, Krishna Joshi from Nepal and Daljit Virk , originally from India, for their help, and two Indian scientists Arun Joshi, who worked with me to start the breeding of GM-6, and JP Yadavendra who helped evaluate its impact.

I also have to thank the funders of this work, DFID, through its KRIBHCO projects in western and eastern India and DFID, again, through its Renewable Natural Resources Research Strategy (RNRRS). It is ironic that the RNRRS has stopped because of a perceived lack of success, when I am receiving this award today on the basis of the considerable *impacts produced from this research programme. It is a tragedy that UK scientists and UK science no longer have these opportunities for the direct application of science for the alleviation of poverty through the RNRRS. Instead, DFID's money is now spent second hand through organisations such as the BBSRC and Innovate UK. Now the priorities of BBSRC are high quality science and for its scientists to publish in journals like Nature and Science, and not the alleviation of poverty. Innovate UK's priorities are the building of UK enterprises and not the alleviation of poverty in the developing world. I only hope that something will happen to change direction in DFID so that funding will again come first hand. This will allow UK scientists to more effectively alleviate poverty through agricultural science.*

Richard Bliault – Young Development Agriculturalist of the Year

Proposer: Antony Ellman

Seconder: Laurence Sewell

Citation: This award recognises Richard Bliault's extension work in Tanzania, where he has managed the certification with the Rainforest Alliance of the first coffee supply chain in Tanzania, encompassing 7,500 farmers. He has demonstrated his commitment to development and his persistence to work in rural Africa, despite health problems and a motor accident.

Richard was unable to attend the AGM because he was overseas, however, Antony Ellman presented Richard with his certificate at a Curry Club meeting in November (Figure 2).

Figure 2. TAAF Chairman Antony Ellman, himself the recipient of a TAA Award of Merit, presents Richard Bliault with the 2014 Young Development Agriculturalist of the Year award (Photo: Jim Waller)

John Russell – Award of Merit

Proposer: Bill Reed

Seconder: Tim Roberts

Citation: This award recognises John Russell's contributions to the Tropical Agriculture Association through his service as Chairman of the Tropical Agriculture Association Award Fund (TAAF) Committee, Convenor of the SW Group, and a Trustee of the Bicton Overseas Agricultural Trust (BOAT). During a successful career with the World Bank and the International Fund for Agricultural Development (IFAD), John has also provided a lifetime of service to agricultural extension and training worldwide.

Figure 3. TAA President Andrew Bennett presents John Russell with the TAA Award of Merit (Photo: Marie-Claude Quieffin-Witcombe)

Antony Ellman – Award of Merit

Proposer: Keith Virgo

Seconder: Jim Ellis-Jones

Citation: As Chairman of the Tropical Agriculture Award Fund (TAAF) Committee since 2006, Antony has developed links with UK Universities, established evaluation criteria, and ensured that awardees receive competent mentoring. As a result, the TAAF has become a major feature of the TAA. In addition, Antony has for 20 years promoted Artemisia cultivation by small farmers, for the extraction of the antimalarial drug artemisinin. Some 100,000 small farmers now grow the crop in China, Vietnam, Madagascar and East Africa, and about 400 million artemisinin treatments are dispensed annually

Paul Harding
TAA Honours Panel Convenor

Membership Secretary's update

The Membership Secretary's Annual Report records the membership details from 1 July 2013 – 30 June 2014. As of 30 June 2014 the total paid up membership was 616. This figure comprised 289 full members receiving the journal (151 under 70 years, and 138 over 70). Online members total 267 (231 under 70 years, and 36 over 70). Student membership was 26, plus 9 complimentary TAAF membership awards. Corporate members totalled 22, and there are 3 long-standing Honorary members. Some 197 members were registered for Gift Aid, allowing TAA to reclaim 25 pence from HMRC for every pound paid in subscription.

We would like to welcome the members who joined or re-joined TAA in the year 2013-2014: Dr Sandy Williams, John Crossley, Sebastien Moineau, Ben Frampton, Richard Kapff, Marije Schaafsma, Dr. Mahmood Khalid, Torsten Thiele, Richard Carpenter, Islam Abdel-Aziz, Andrew Kirkby, Ben Evans, Alex O'Connor, Samuel Holmes, Mirian Denis Le Seve, Alexander Chaudrary, Harriet Smith, Dr Wataru Yamamoto, Rachel Friedman, Dr Karim Hussein, Dr Mark Luterbacher, Peter Aagaard, Curt Bowen, Mohammad Chekene, Wim Andriesse, David Billing, W Vellacott, Dr Andrew Daymond, Valerio Rizzo, Terry Wiles, Harriet Moyo, Benny Dembitzer, Maria Coutinho, Elizabeth Wilson, Ian Robertson, Christopher Schofield, David Colozza, John Mullett, Janice Pedersen, Mike Woolford, Thomas Gegg, Theodora Forbes, Vijaya Vijayaran, Barbara Adolph, Dr. Laura Silici, Dr Henry Wainwright, Dr David Moore.

Since the end of June 2014 the membership secretary is pleased to report a sharp increase in numbers, with a further 41 new members joining the TAA. Of these new members 10 are full members under 70 years, six are online under 70 years, two are new corporate members, and there is one late TAAF allocated membership. The biggest change however is the increase in student members. Some 22 student members have joined in the last 7 months, taking advantage of the £10.00 annual membership fee for students. A strong recruitment drive at a TAA event at the Royal Agriculture University in October proved to be very successful, but new members have also joined from Reading, Newcastle and Bangor Universities. It is hoped that the provision of technical material, the news and events, and of course the job alerts, will continue to attract younger members to both enrol and continue membership after completing studies to ensure the continued success of the TAA.

The TAA is sad to announce the loss of members GD Wilkinson (Hereford), EJR Hazeldon (Surrey), A Seager (Reading), and DC Davies (Marlborough).

Linda Blunt
Membership Secretary

Publications and Communications (P&C) Committee update

Ag4Dev24 – a Special Issue on Soils
The editorial team is very grateful to Dr David Dent, the Guest Editor of this Special Issue on Soils. David has done an outstanding job of planning, commissioning and delivering seven excellent articles on soils, written by a total of sixteen experts from around the world.

Ag4Dev25 – an Open Issue
Ag4Dev25, the Summer 2015 issue, will be an open issue with no specific theme. Members are invited to contact the Coordinating Editor (paulharding@btinternet.com) with ideas, articles and *News from the Field* items. Although several articles have already been received, there is still room for a few more.

Ag4Dev26 – a Special Issue on Urban and Peri-Urban Agriculture
Ag4Dev26, the Winter 2015 issue, will be a Special Issue on Urban and Peri-Urban Agriculture, with Brian Sims as the Guest Editor. We invite contributions on the theme for consideration for inclusion. These can be full articles, *Newsflashes* or *News from the Field* items. We look forward to an enthusiastic response, especially from TAA members.

Ag4Dev27 – an Open Issue
Ag4Dev27, the Spring 2016 issue, will be another open issue with no specific theme. Articles and other items are invited from members.

Ag4Dev28 – a Special Issue on Agroforestry
Ag4Dev28, the Summer 2016 issue, will be a Special Issue on Agroforestry, with James Brockington, Robert Brook and colleagues at Bangor University as Guest Editors. Members wishing to submit articles or other items for this Special Issue should contact James (j.brockington@bangor.ac.uk) or Robert (r.m.brook@bangor.ac.uk) in the first instance.

Survey of *Ag4Dev* readers
Thank you to all members who completed the *Ag4Dev* questionnaire of December 2014. Your responses will be very helpful in guiding the P&C Committee in its efforts to continue improving your journal. A preliminary analysis of the responses has already been undertaken, and a full report will be included in *Ag4Dev25*.

New member of the Editorial Team, James Malins
We are pleased to welcome James Malins to the Editorial Team, as the coordinator of the *Upcoming Events* feature. James worked in commercial horticulture in the UK, before moving to the Windward Islands in 1990, where his wife had been offered a job. He helped small-scale growers with various vegetable crops and installing new equipment. On returning to the UK he did a post-graduate diploma in Landscape Management at Sheffield University, and then an MSc in Tropical and Semi-Tropical Horticulture and Crop Physiology at Wye College. It was then that he joined the TAA.

James worked in the UK for several companies in the food industry, before moving to the USA, where he worked freelance, primarily for UK suppliers undertaking food safety and social audits mostly in Central and South America, but also in the Caribbean and North America. He became involved in the Ethical Trade Initiative and also sat on the working party that eventually helped form the Gangmaster Licensing Authority.

He is now based in Beijing, where his wife was sent on 'a short term posting', which has already been extended three times.

Paul Harding,
Coordinating Editor, *Agriculture for Development*

Web Manager's update

Vacancies: jobs, consultancies, internships

We have long appreciated the importance of job-seeking to our members, especially the younger ones. Therefore we have re-activated the vacancies pages on the website (www.taa.org.uk) - just click on 'Vacancies' in the top navigation bar. You will need to log-in with your membership number and password. This will bring you to a list of current employment, consultancy and internship opportunities, with details of how to apply and the deadlines. If you do not yet have a password, please contact membership_secretary@taa.org.uk.

We are very grateful to TAA members Alan Stapleton, Michael Fitzpatrick and Bookie Ezeomah, who have volunteered to act as Vacancy Managers. They will keep the pages up to date. If any member, corporate member or others have suitable vacancies for jobs, consultancies or internships that they would like to be considered for posting on the TAA website, please email them to vacancies@taa.org.uk.

We hope to make this an active service for members.

Keith Virgo
Webmanager@taa.org.uk

News from the Regions

New Regional Branch for the Pacific

The TAA is pleased to announce the establishment of a new branch for the Pacific Region. The new TAA regional Coordinator for the Pacific is Dr Ravi Joshi. We provide below a note on Dr Joshi's background, and his initial thoughts on the development of the TAA Pacific region branch.

Ravi is an Indian citizen, and his current positions are Adjunct Professor, University of the South Pacific, Fiji, and Visiting Professor of Biology, University of the Philippines at Baguio, Philippines. His research interests include addressing family food and nutrition security in Asia, Africa and the Pacific through local production of a diverse range of nutritious foods using sustainable farming practices. He is particularly interested in helping communities living in small outer islands where the threats from climate change on food and nutrition security are most serious. (rcjoshi4@gmail.com)

I started my career as an entomologist with the Commonwealth Agriculture Bureaux International (CABI)'s Institute of Biological Control in India. Throughout my scientific life, I have preferred biological control, or natural methods in managing plant pests, and integrated pest management.

I worked for many years with rice, this being the staple food of more than half of the world's population. From the International Rice Research Institute (IRRI), based in the Philippines, I moved on to the International Institute of Tropical Agriculture (IITA), Nigeria, where root crops are the main staples.

A few years ago, I joined the World Vegetable Centre (AVRDC) in the Solomon Islands as the site coordinator, and later became the senior adviser (agriculture development) with the Ministry of Agriculture and Livestock. This involved considering food and nutritional security, and I soon realised that small island countries across the Pacific face more nutritional insecurity than food insecurity.

In the Solomon Islands, I developed the blueprint for the first ever national agriculture and livestock policy, and also subsidiary policy documents on organic agriculture systems, the System of Rice Intensification (SRI) and the national rice sector policy (2010-2015). These are the first such policy documents in the Pacific islands region. In addition, I teamed-up with the government's Ministry of Fisheries and Marine Resources, and the Ministry of Health and Medical Services, to draft the national food security, food safety and nutrition policy (2010-2015).

The blueprint for addressing food and nutrition security in small outer islands facing the consequences of climate change, family food and nutrition insecurity, and loss of biodiversity was based on the **Kwai Island organic farming model**, developed with help from Pastor Philip Manuao.

Kwai Island is a tiny dot off the east coastline of Malaita, one of the Solomon Islands. The people of Kwai generally live on seafood and root crops. This model is now widely known around the Pacific: see http://www.youtube.com/watch?v=4cgXnzfDcbk. It was costly for islanders to procure vegetables and fruits from the mainland, and their sandy soils hindered crop growth. We introduced *'Sup-Sup'* home organic gardening. This facilitates proper waste segregation and sanitation, as well as successful local organic production of fruits and vegetables of various colours. It is a simple approach that has allowed Kwai Islanders access to a 'rainbow-coloured', nutritious, diversity of organically grown foods. This small change has impacted greatly on the lives of the Kwai Islanders, and has become a success story for other small outer islands across the Pacific. We aim to disseminate this information and reproduce the system in other Solomon Islands, and in nearby Pacific countries.

Addressing issues of food and nutrition security is not just the concern of government. It is the responsibility of every citizen and relevant organisations to work together. For example, I was able to convince the Solomon Islands postal corporation to issue postage stamps on important vegetables such as tomato, pumpkin, string beans, eggplants and indigenous vegetables. Similarly, I persuaded local women's groups to submit local recipes for a small booklet on *Local Vegetable Food 'Kaikai' Recipes in the Solomon Islands* produced by the Ministry of Agriculture and Livestock, the Ministry of Health and Medical Services, and supported by the World Health Organisation.

To enhance and sustain food and nutrition security at family level, we have to educate everybody, including the young and disadvantaged members of the community, on the importance of proper food and healthy nutrition. We need to give them the skills and confidence to produce their own foods organically and locally. As a Kwai Island fisherman, Eratus Tom, has said, *'Without the right information, we could not help ourselves… .food is the difference between life and death'*.

From the Solomon Islands, I was employed by the Fiji National University as Visiting Professor of Entomology and, about a year thereafter, I was appointed as Consultant to the Offices of Minister and Permanent Secretary, Ministry of Agriculture, Fiji, to advise on policy and research areas. During my two years' tenure, major milestones achieved include the revival of the Fiji Agricultural Journal and the Fiji Institute of Agricultural Science; and crafting of the Fiji2020 Agriculture Sector Policy Agenda. I was recently elected as the Non-OECD Representative to the CG Fund Council (formerly CGIAR) to represent the Pacific Island Countries and Territories.

I am confident that, as the newly-appointed TAA regional coordinator for the Pacific, I will be able to network between the TAA and regional/international organisations, regional and national universities, and Government Ministries of Agriculture in Solomon Islands and Fiji.

Ravindra Chandra Joshi

SW Region 2015 AGM

Forty-six members, wives and speakers attended the AGM of the TAA SW Group at Exeter Golf and Country Club on 8 January 2015 – the same number that attended the 2014 AGM.

Following the formality of approving last year's AGM minutes, the meeting chairman, Tim Roberts, gave a brief **review of the year**, the main points of which were:-

- **Membership.** According to the list kindly provided by Linda Blunt, there are 121 members of TAA SW. Of these, only 80 are known as 'active'. Members were asked to help trace the others.
- **The 2014 Seminar programme**. These were held at our usual venues of Cannington and Bicton Colleges and at the Royal Agricultural University. The latter event was particularly gratifying because of the substantial attendance of students, a number of whom joined the TAA. These TAA SW seminars are well attended and the quality of speakers is generally excellent. As always, the summer field trip, this time to Exmoor with around 20 attending, was very popular, thoroughly enjoyed and very informative.
- **Award of Merit**. John Russell was congratulated on receiving the TAA Award of Merit for his outstanding services to TAA committees, as Convenor of the SW branch, and Trustee of BOAT (Bicton Overseas Agricultural Trust), an organisation linked to Bicton College and TAA SW which provides training to senior and middle level staff from overseas, mainly Africa.

TAA SW Treasurer Mike Pash reported that our income exceeded expenditure by £150 in 2014; accordingly this increased the bank balance of £1,094 by that amount. Our events usually more or less break even financially.

Election of Officers. John Wibberly tendered his resignation as Chairman, due to his many other commitments, and Bill Reed offered to be interim Chairman for the year. Other Officers (re)elected were: Branch Organisers, Tim Roberts and Bill Reed; Treasurer, Mike Pash; and Minutes Secretaries, Ray Bartlett and Chris Finney. Other members of the committee are George Taylor-Hunt, David Wendover, John Wibberley, Geoff Hawtin, Fiona Johnson and two new members, Nathan Kiyaga and Rebecca Smith.

The programme for 2015 was discussed and agreed. Since 2015 has been designated as the UN FAO 'International Year of Soils', the programme will include:-

- Three seminars: at Cannington in March, with the emphasis on dairying; Bicton College in May, the theme being the challenges for the Horn of Africa; and the Royal Agricultural University in October, with the theme *Soils: sustainability starts here*.
- The Summer Field Trip will be for three days in the Purbecks in Dorset.
- Agricultural shows. Due to the very poor interest in previous years, we will withdraw from the Devon County Show at Exeter. Our Bath and West Show presence will continue, where the stand will be shared with BOAT.
- Pub discussion meetings. Roger Cozens confirmed that these monthly meetings will continue in 2015.

Presentations

BOAT. David Wendover gave a slide-illustrated overview of BOAT objectives and activities. He confirmed that Cornwall Colleges, which have taken over Bicton College, will continue to support BOAT.

Keith Virgo, TAA Chairman, presented a review of TAA activities in 2014, which he concluded had been a very encouraging year, not least because membership had increased. Keith congratulated the SW Group as being the 'star branch' of TAA. After lunch, Keith gave the Keynote presentation, an update on *Village Ways*, established in 2005 in India as a Village Tourism enterprise. The object is to encourage entrepreneurial spirit in villages to participate in bringing extra income from tourism. Keith presented *Village Ways* to TAA SW in 2008 and it was gratifying to see how the scheme has prospered since then.

Mike Nightingale presented his paper on *IcFEM*, a faith-based NGO established in western Kenya in the late 1980s.

Colin Andrews gave a very brief (due to time constraints) presentation of *Tiyeni*, an NGO which promotes sustainable farming methods in Malawi. More details are provided in *News from the Field*, pages 10-12 of this issue of *Ag4Dev*.

Ray Barlett

Scotland and NE Region seminar on *Crop protection: advances and challenges*

With 30-40 percent of crops being lost to pests, and a food system under pressure from climate change, environmental degradation, population growth, rising energy prices, rising demand for meat and dairy products, competition for land from biofuels, and urbanisation, what can we do about it? In December 2014, we convened a half-day meeting in Newcastle University, attended by around 40 people, to consider this question with the help of two reports from the laboratory and two from the field.

Professor Angharad Gatehouse from Newcastle University reported from the laboratory covering research to develop **biopesticides** based on molecular-level understanding of plant-insect interactions. On current trends, she noted that, by 2015, there will be some 40 countries growing biotech crops, with a global area in the region of 200 million ha. Her presentation invited consideration of the role of biotechnology in achieving future food security.

Professor Rob Edwards from Newcastle University also reported from the laboratory and spoke about current challenges for **herbicides** and weed control. He reported that a lack of innovation in the sector has meant no new active ingredients have been discovered in recent decades. The steady rise of resistance in weed populations to all classes of existing agrochemicals poses a threat to food security.

Nick Evans reported from the field on his work with tree crops across Africa on behalf of farmer organisations, processors and trading companies. He spoke in particular about his experiences with a system of **fruit fly control** on mango in Ghana that is increasing sellable yields and profits to farmers. Fruit fly (*B. invadens*) was first officially identified in Ghana in 2008 and has become the principal pest in the mango industry. Nick explained that successful management of this pest at farm level requires an approach using a combination of orchard hygiene measures, male annihilation as well as protein baiting. Evidence shows that farmers who are able to successfully adopt the multiple strategy have held down reject rate due to fruit fly below 10 percent, compared to levels of 40-60 percent without. For every $1 spent by farmers on control measures (including labour), they have achieved a net $4 increase in sellable yield.

Phil Taylor spoke about **Plantwise**, a multimillion pound food security programme led by CABI, which works to help farmers reduce crop loss due to plant health problems. Plantwise works with local extension and crop protection services, NGOs and other key actors in plant health to provide smallholder farmers with better access to advisory services. By developing a network of plant clinics in remote locations, farmers are able to bring samples of their affected crops and receive a diagnosis and recommendation as to the course of action they should take to improve plant health. The information is provided to the farmer but also retained by Plantwise in their knowledge bank. In this way, a huge database of the prevalence and location of various diseases and pests is being built up.

The key message arising from the four presentations is that there exists a great deal of potential to sustainably reduce current high crop losses due to pests for farmers around the world. A range of both high- and low-tech approaches show significant promise for increasing crop yields over the coming decades and improving food supply at local, national and international levels. The emerging strategy emphasises a focus on the use of preventive rather than curative control measures, which (where possible) are developed and implemented via a process that engages a range of stakeholders within the farming system, including farmers, researchers, industry and the state.

John Gowing

Obituaries

Donald Clifford (Don) Davis, 1942-2014

Don died on 13 October 2014 in hospital at Swindon fifty years after starting his first job in tropical agriculture. Fifty years in more than twenty countries in Africa, Asia, Europe and North America, and forty or so separate assignments. Some were short consultancies, but many were as team leader or project manager for two years or more.

Completing his National Diploma in Agriculture together with the diploma in Agricultural Machinery at Shuttleworth, Don went to Uganda in 1964 as an Assistant Agricultural Officer. Moving to Kenya, he ran an 800 ha mixed farm in the still 'White' Highlands, combining that with an advisory service to African farmers. He then managed a group of dairy farms together with a thoroughbred stud in New York State and, returning to England, worked as a self-employed agricultural contractor for three years.

His first assignment with an international agency was with the World Bank in west Cameroon where he was in charge of developing a 90,000 ha cattle ranch in 1976-78. He then took the Reading University Masters degree in Agricultural Management and was launched into managing, planning, advising and, above all, leading multi-disciplinary rural development projects, notably in Nigeria on the Kano Agricultural Development Project, as one of four zone managers, and on the Mambilla Plateau, and then in Sudan, in south Darfur, as head of agricultural development.

In 1989, Don worked for a year in northern Pakistan advising the UN on agricultural alternatives to narcotics for smallholders, and then in 1992 went to Albania as an input supply specialist for the European Commission in a country just freed from Enver Hoxha's communist dictatorship. Here he met, and in 1999 married, Admira Mara, a crop protection advisor at the Ministry of Agriculture in Tirana. Admira, after obtaining a Masters Degree in Agricultural Management from Reading University, soon joined FAO in Rome as a Programme Officer. Although Don worked as hard as ever, it was mostly on shorter assignments and nearer home: Romania, Bosnia, Georgia, Armenia, Azerbaijan, Kosovo, with occasional forays to central Asia and especially Afghanistan where he spent 18 months as Emergency Area Manager in Jalalabad. More recently, he returned to Africa with short assignments in Uganda and Tanzania.

Home was now not just Rome, but Aldbourne on the Marlborough Downs, where Don had bought a house in 1990. Here, between overseas sorties, he was even busier as a parish councillor and tree warden, and continued his programme of fell walking until he climbed all the Monroes (peaks of 3000 ft or more in Britain). He had always been a keen and gifted photographer, especially of scenery, for which he won many prizes. Glaciers in the Karakoram to the Wiltshire Downs, their range reflected his own varied and committed life.

As a married man moving into his seventies, Don seemed to his many friends as active as ever, not least at TAA Southwest regional meetings. His early death came as a surprise to so many of us who relied on the periodic visits 'from the field' of a youthfully energetic and supportive friend. He will be much missed.

Simon Gillett

Andrew Seager

We have received news of the death of Andrew Seager on 9 December, 2014. Andrew served as Agricultural Officer in Somaliland, 1951–59, and in Northern Rhodesia 1959–60. He was FAO Farm Management Adviser, Nigeria, 1960–63, and with the FAO Investment Centre, Rome, 1963–73. He finished his overseas career as an Agriculturalist with the World Bank, 1973–86. A full obituary is in preparation, and will be included in *Ag4Dev25*.

Corporate Members' Page

The Plant and AgriBiosciences Research Centre (PABC) at the National University of Ireland, Galway, joins the Tropical Agriculture Association (TAA)

The TAA is pleased to welcome the Plant and Agricultural Biosciences Centre (PABC) at the National University of Ireland Galway (NUI Galway) as a new Corporate Member.

The PABC (website: www.plantagbiosciences.org) is composed of inter-disciplinary researchers, research groups, companies and institutions sharing a common interest in fostering and promoting plant and agricultural biosciences innovation. A unifying theme of the PABC is the promotion of plant and agricultural biosciences for sustainable development to meet social and economic challenges internationally, including in developing countries. The PABC is composed of over 30 research groups in NUI Galway, plus additional research groups from other Irish universities and research institutions.

The PABC has significant research collaborations underway with the CGIAR involving agricultural research for development activities. The PABC is a member of Agrinatura, the Platform for African European Partnership on Agricultural Research for Development (PAEPARD), and the European Plant Science Organisation (EPSO). International research partners include ICRISAT, IITA, CIAT, the Climate Change, Agriculture and Food Security (CCAFS) programme, Bioversity International, and Concern Worldwide. PABC members have established the one-year taught Master's degree in Climate Change, Agriculture and Food Security (MSc CCAFS) in collaboration with the global CCAFS initiative. Agricultural research for development PhD projects in the PABC include research in Malawi, Nigeria, Kenya and Gabon on:

- bean iron/zinc biofortification;
- labour saving technologies for women smallholders;
- maize vitamin A biofortification;
- East African Highland banana breeding;
- Guinea yam genetic diversity;
- Social impacts of seed exchange systems.

The NUI Galway based members of PABC have attracted over €35 million in competitive research grant income on agri-related projects since 2009. Between 2009 and 2014, the NUI Galway PABC research groups have either graduated or have agri-related research underway involving 100 PhD students. Since 2009, PABC Principal Investigators based at NUI Galway have generated over 600 peer-reviewed scientific papers on plant and agri-related innovations.

As a corporate member of the Tropical Agriculture Association (TAA), the PABC at NUI Galway is keen to develop research partnerships and alliances with other TAA members, research groups and agricultural research for development researchers.

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Reminiscences and Reflections

Why did we carry out soil surveys?

Hugh Brammer

Hugh Brammer worked for 22 years on soil surveys in the Gold Coast/Ghana, East Pakistan and Zambia, then for 13 years as FAO Agricultural Development Adviser in Bangladesh. Following his retirement in 1987, he worked on the Bangladesh Flood Action Plan, a global study of arsenic contamination of soils and crops, a Bengal Maps Study, climate change in Bangladesh, and wrote ten books on Bangladesh's physical environment and agriculture.

Gold Coast/Ghana

I was recruited in April 1951 to carry out a reconnaissance soil survey of the Accra Plains to assess the suitability of the soils for irrigated agriculture, using water from the proposed Akosombo hydropower dam on the Volta River. My first boss, Cecil Charter, was then in the process of setting up what became, on 1 June 1951, the Department of Soil and Land Use Survey (SLUS) with specific aims and objectives: see Box 1. That is the only occasion when I recall that the objectives of the soil surveys in which I was involved were specified.

Charter had been engaged in soil surveys to assess the suitability of the Gold Coast's forest soils for cocoa production. In the absence of professional soil surveyors, he had trained a large number of middle-school leavers in traverse-line cutting and measuring, Abney-levelling, sampling soils at 10-chain intervals (1 chain = 22 yards = ca 20m) along traverse lines 1¼ miles apart, and recording vegetation and land use in a ¼-acre circle around each soil sampling point. Soil samples and records were brought back to a base camp each day (Figure 1) where he or a trained senior assistant described and identified the soils, and eventually mapped the results in soil associations. In each major soil association, detailed surveys were made of 1 x ¼-mile sample strips across the grain of the country, sampled at 4-chain intervals along parallel traverses 4 chains apart, mapping soil series: see Brammer (2011), Figure 2. Later, in flatter savannah areas, sample strip lengths up to 2½ miles sampled at 10-chain intervals were used to cover complete toposequences. Reconnaissance soil surveys were carried out on a drainage basin basis (an example of Charter's environmental thinking, but most potential report users were organised on a District basis). The available air photos were of poor quality (taken during the hazy *harmattan* season), so were little used, especially in the forest zone.

Figure 1. Examining and describing soil profile samples at a field base camp in the Gold Coast

Box 1
Aims and objectives of the Gold Coast Department of Soil & Land Use Survey

The approved policy of the Department and the factual bases on which this rests are given below:

1. The Gold Coast contains a great number of soils with very diverse properties which must be utilised in different ways if optimum benefit is to be obtained by the community as a whole, both present and future.
2. Soils cannot be considered independently of the topography and vegetation that characterise them.
3. Before a satisfactory land-utilisation policy can be framed, the soils of the Gold Coast must be differentiated, their distribution mapped, their physical and chemical properties determined by analysis, their characteristic relief and drainage studied, their distinctive vegetation investigated and their suitability for different forms of utilisation assessed.
4. It is not possible to map individual soils in the Gold Coast, but only associations of soils, owing to the nature of the country and its vegetation, the relative shortage of communications and the manner in which agriculture is conducted in the country.
5. Surveys must be carried out by systematic and standardised methods if results of permanent value are to be obtained.
6. In the forest zone, cocoa is the crop of major significance, whilst timber exploitation, subsistence agriculture and minor export crops are of secondary importance.
7. In the savannah zones, subsistence cropping is of major importance, whilst stock rearing is increasing in importance in some areas.
8. Communications exert an important influence on land use, and road distribution should be related to land potentialities.
9. A number of agricultural schemes are being initiated employing scientific techniques for which fundamental information regarding oils, topography and vegetation must be available if failure is to be avoided.

The reconnaissance survey reports were prepared with the objective that Agricultural and Forestry Officers could use the information for planning or assessing their District-based programmes and activities. The detailed sample strips were located and described with a view to their being used as agricultural research and/or demonstration sites, but I doubt that they were ever so used. Separate, objective-specific reports were prepared for surveys of proposed development areas, research stations, forest plantations, *etc*.

East Pakistan

After leaving Ghana in April 1961, I was recruited by FAO as Deputy Project Commissioner for East Pakistan on the FAO/UNDP Soil Survey Project of Pakistan and arrived there in September 1961. The Project Commissioner may have received instructions from FAO on the aims and objectives of the proposed surveys, but I do not recall seeing them. He organised training programmes for newly-recruited national staff, 20 of them from East Pakistan. He was a former member of the US Soil Survey and taught their methods. In East Pakistan, I was joined in 1964-65 by three FAO soil surveyors and later by two FAO Associate Experts.

Surveys were carried out on a District or Subdivision basis, with priorities decided each year at a meeting of project staff and government officials. Because of seasonal flooding, the field season was limited to the period December-May. Good quality air photos were available and were used to select traverses, at *ca* 5-mile intervals, and on which to mark sampling points. Traverses were sampled as frequently as found necessary in order to identify soil series and important soil phases (but not the US soil types) and to map soil associations. In practice, the interval between traverses varied between about 2 and 8 miles depending on the complexity of geomorphic patterns seen on air photos and experience gained with time. This sampling intensity enabled reconnaissance surveys of Districts/ Subdivisions averaging about 2,000 sq miles to be covered in a 5-months field season.

Each field team consisted of a FAO soil surveyor and four national soil surveyors, plus labourers to dig holes and carry samples. Two parties comprising two national surveyors plus labourers went out each day to survey and sample selected traverses, with the FAO surveyor joining one of the teams each day. Soil profile samples were collected and brought back to the field camp each day, as had been done in the Gold Coast/Ghana, in order for the team leader to inspect samples brought in from both traverses and identify the soils. Samples from dug pits were sent to the soils laboratory for routine analyses, and type samples of profiles for each new soil series, phase or variant were retained in partitioned boxes for use during report preparation and eventual storage in the soil correlation room and museum. Reports were written in the 'office' season.

I spent time each field season visiting three District/Subdivision soil surveys in order to provide guidance, quality control and national soil correlation. Towards the end of the 1960s, as the FAO field staff completed their (usually) three-year assignments, national team leaders took over surveys under my continuing guidance and supervision, and they completed the (by then Bangladesh) survey early in the 1970s after my departure in April 1971. In total, 33 District/ Subdivision reports were published.

The survey reports were designed so that the findings could be used for crop programme planning by the provincial Department of Agriculture and other relevant government agencies, and as basic information for use by agricultural and other research agencies. Crop suitability assessments were made for a range of adapted crops on a 1—4 scale. The US Bureau of Reclamation's land classification system was adapted to cater for the year-round, seasonally-flooded, cropping environment in East Pakistan. Because of the maps they contained, the reports were classified as 'restricted' - and not issued to the public.

Early experience showed that personnel in expected user agencies had difficulty in using the technical information in the reports. This was, in part, because they did not have sufficient background education in what we would now term environmental sciences to understand the information, but it was also because of institutional blinkers. The first reports had been in conventional narrative style, so I changed them to present the soil association and land capability descriptions in tabular format, hoping that that would make it easier for readers to understand and use the information. That didn't seem to work, either. So, while continuing to publish formal District/Subdivision reports, I later spent much effort in seeking ways to present our information to potential users in other forms, including District/ Subdivision summaries of development possibilities in less technical language and format. At the end of my assignment, I wrote up my experience in two FAO technical reports to government *(Soil Resources; Agricultural Development Possibilities)*.

On leaving East Pakistan, I do not recall being satisfied that our soils, crop suitability and land capability information was being used for any of its intended purposes (although my own experience was regularly tapped by World Bank and other donor visitors). The only possible benefit that I am aware of was from technical articles that I wrote for the *Pakistan Journal of Soil Science* and the lectures describing our findings that I used to give in the Dacca University Soil Science Department which, I hope, eventually influenced students in their careers. At that time, soil science was not taught as a field science. None of my original recruits in 1962-63 had seen a soil profile, and only one had seen a topographical map. I presume that similar deficiencies prevailed in other education institutions.

Zambia

After my evacuation from East Pakistan in April 1971, FAO eventually seconded me in January 1972 to the post of Senior Soil Scientist in the Ministry of Rural Development in Zambia. The objective was for me to introduce a team of Norwegian soil scientists to tropical soils. In the event, the Norwegian team did not arrive for over a year, so I spent the intervening time carrying out soil surveys of various degrees of intensity and for various purposes, often alone except for a driver/assistant to drive and operate a power-auger mounted on a Land Rover (Figure 2). In the end, I spent two years in Zambia instead of the one year originally planned.

I was not instructed either by FAO or by government officials in what to do. I was the expert! The sites for survey were selected in consultation with a senior

Figure 2. Inspecting power-auger sample with driver/ assistant and Land Planning Officers in Zambia

planning officer in the Ministry of Rural Development. The Ministry's main interest was in soil conservation, and my surveys were mainly so focused, small-scale and either in existing developed areas or in proposed new settlement areas. The intended users were primarily Land Planning Officers.

My travels through 51 of the country's 52 Districts also enabled me to do much exploratory work. As a result, before my departure in January 1974, I was able to draw a new soil map of Zambia and produce both technical and popular reports on the soils of Zambia. I did eventually introduce the Norwegian team to soil surveying in a tropical environment, and I also trained a British Land Planning Officer in soil survey techniques.

Postscript

I did not know it then, but – at 48 – that was to be the end of my soil surveying career. On my departure from Zambia, FAO planned to send me to carry out soil surveys in Sierra Leone. However, at the request of the World Bank, I was sent straight back to Bangladesh to help the government and donors in identifying areas suitable for the new high yielding rice varieties (HYVs) and I spent the subsequent 13 years there as an adviser. Most unusually for a soil surveyor, therefore, I was enabled to bring my findings into use for agricultural planning. But that is another story!

Reference

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Reflections of a Soil Surveyor

Keith Virgo

Keith started as a soil surveyor in Sudan in the 1960s, following completion of an MSc in Soil Science at Aberdeen. Subsequently he undertook soil survey and land evaluation assignments elsewhere in Africa, the Middle East, South and Southeast Asia Latterly, he progressed to a broader role in rural development and community-based watershed management, leading technical assistance teams and more recently setting up a rural tourism company in India, with villagers as partners. Keith is currently the Chairman of the Tropical Agriculture Association.

In the beginning

With an MSc in Soil Science (1964), I applied to Hunting Technical Services (HTS) for a job in overseas development. Despite arriving two hours late for my interview, I was appointed as a soil surveyor and, almost immediately, sent out with a soil survey team to the Roseires Dam Project in Sudan. Would that today's graduates could find a post so easily! My dissertation on peri-glacial soils hardly prepared me for being an 'erk' on a team augering and digging pits (by energetic labourers) across thousands of square kilometers of the Blue Nile clay plains (Figure 1). However, over two years, I did learn a lot about navigating by air photos, setting up field camps, repairing Land Rovers, and speaking Arabic! Watching the plethora of birds and identifying vegetation were welcome diversions: interests that I have maintained. Times were different then; one colleague happily carried on-board the VC10 his 12-bore and ammunition – to be used to secure guinea fowl for our camp dinners.

Figure 1. Sudan Clay Plains, 1964

The soils were 99 percent *Vertisols* with their distinctive self-mulching surface, slickensides and almost all 10YR 4/2 (if anyone remembers Munsell Soil Colour Charts). Understanding the soil characteristics was a challenge, and I co-authored an early paper on the subject (De Vos & Virgo, 1969). The irrigation engineers followed close behind us, designing irrigation canals regardless of what the soils team said and we rather felt that we were perforating the clay plains to meet the terms of reference rather than guiding development. After Sudan, I joined a Military Experimental Engineering (MEXE) mission to the Middle East as part of a study to devise a system for advising commanders 'what terrain features can be expected over the hill' – a bizarre but fascinating interlude. I accompanied British soldiers and MEXE scientists from Aden to Socotra by RAF transport: *'no one has landed here for 20 years'*, remarked the pilot. From Socotra to Abdel Kuri, we sailed on a dhow reminiscent of a pirate ship; and we explored the Trucial States (now UAE) before oil had been exploited and when Abu Dhabi was a village of mud-huts, describing landscape units in terms of trafficability.

I returned to the real world with HTS, first in Niger, seeking land suitable for irrigation in the remote Dallol Maouri which had an infinite variety of land forms within an old river floodplain; photo-interpretation with a pocket stereoscope was an invaluable basis for soil mapping. From then on, HTS sent me to projects in Thailand, Swaziland, Cote d'Ivoire, Ethiopia, Somalia and Bahrain. By then, most of the virgin irrigable lands had been exploited; and soil survey had grown up: more

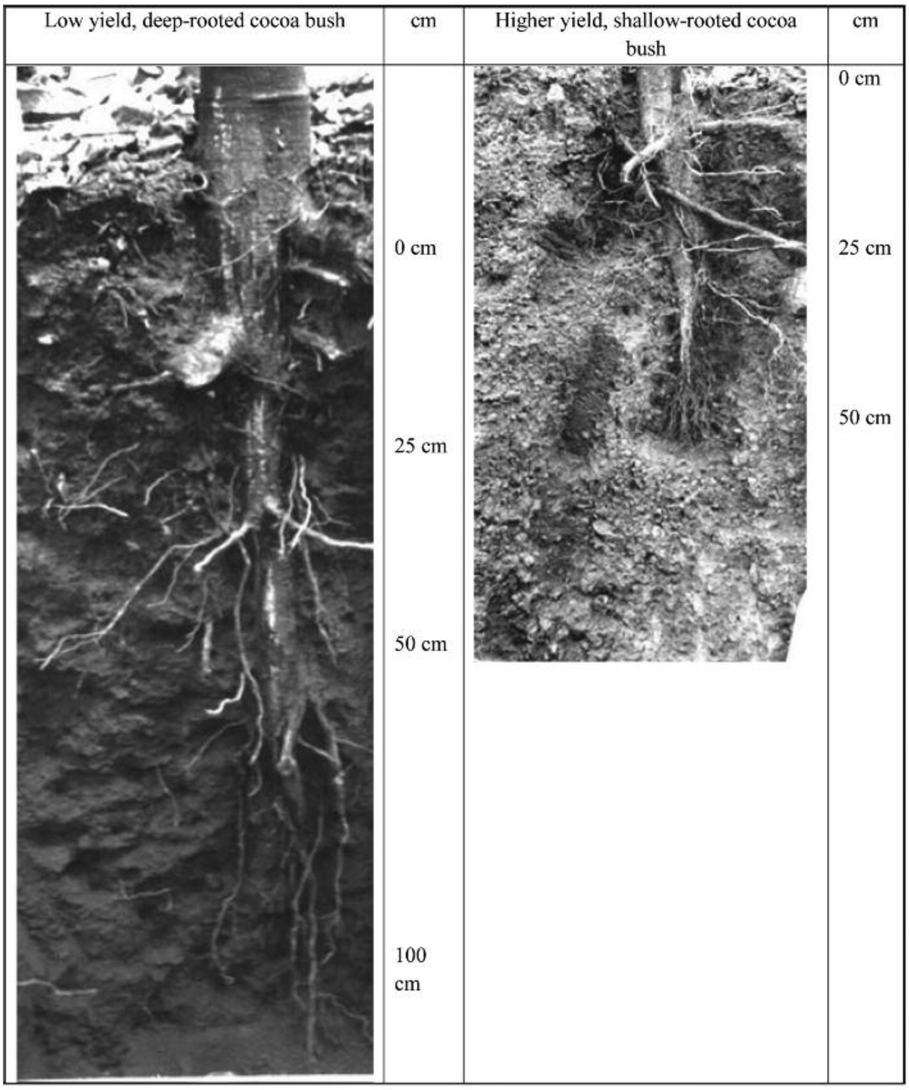

Figure 2. Comparing root penetration of cocoa in Cote d'Ivoire, 1974 (Personal communication: Virgo K, Radcliffe D, Baillie I)

consideration was given to what farmers were already doing and using their experiences when mapping land capability for new development. One lesson we learned in the Yom Basin Study in north Thailand was never to pander to VIPs. We had a visit from an elderly ODA expert and, in deference, sited a pit in the shade with steps down into it – and we were thereafter branded 'soft'! In south Thailand, we were charged with finding farmland for settling loyal Thai rice-growers, taxi drivers and unemployed in the politically unstable border areas where slopes were mostly 30 percent and suitable only for tree crops with requisite conservation measures – so settlers would likely drift home.

On the Blolekin-Zoukougbou Cocoa Project in Cote d'Ivoire, my team (all three still TAA members) was to seek land for new smallholder cocoa farming. One designated area was pristine rainforest, and we managed to persuade government to spare this and use formerly cultivated land. Many of the soils had hardpans of compacted ironstone nodules and, yet, cocoa still grew, raising the neglected question: *'what happens to roots in the soil?'* We excavated around some trees and found that the highest yields were from shallow-rooted trees (Figure 2).

In Swaziland, working with TAA member Tom Boyd and mapping soils for irrigation, we followed the footsteps of George Murdoch. I also worked with TAA member Neil Munro as part of a large ODA rural development project in the upland plateau of Tigray; together we wrote a definitive paper (Virgo & Monro, 1978), still widely cited at the new University of Makalle. By contrast, I went to the Konar Valley in eastern Afghanistan to investigate soils for irrigation expansion – my first real use of satellite imagery. In Somalia, I was reacquainted with my old friends the *Vertisols*. I was involved too with Murdoch Macdonald's drainage project at Jowhar Sugar estate; they were doing field trials, which closely mirrored the soil physical characteristics that I had measured in soil pits: it is always gratifying to know that science and practice conform. I remember using sand and ping-pong balls to measure bulk densities; I also tested whether soil cracks form in the same place each time – they do not (Virgo, 1981). I was once complimented by FAO who said that my soils report was the best on Somalia – I wonder how many there were? I also recall discussions with the airfreight official at Mogadishu when sending home soil samples for analysis: he did not have a box to tick for 'soil', so we settled for 'rare earths'. This was a time of food shortages because of the conflict with Ethiopia (1977-78) but, being based in a banana estate, my family (including our dog) got by on banana-based dishes.

A year in Bahrain introduced me to the

7th Approximation (*7th Abbomination!*); *Calcic Gypsiorthids* with up to 60 percent gypsum and hard calcium carbonate layers provided a fascinating exercise in soil classification, but anyone wanting to cultivate high-value crops would be better to adopt nutrient-film techniques or import soil!

My final assignment with HTS was with the 'Gang of 8' UK consultants to western China to undertake a feasibility study for irrigation which, in the event, turned out to be designing a mink farm (Figure 3). No problem: we were consultants and could turn our hands to anything. One memorable event was singing *Auld lang syne* to our local team at a military airfield surrounded by Red Army personnel – they thought we had made up the song about the 'Ho Lan Shan Project' that we had worked on!

Figure 3. Soil Sampling, Yingchuan, China, 1979

From soil survey to rural development

From 1980, I joined WS Atkins and my soil involvement evolved into managing broader rural development and watershed projects firmly based on community participation – basically leaving communities to work out what soils could grow. I was, however, involved in soil terms on a big fruit-tree project in Syria where D-8 bulldozers were used to gouge limestone hillsides to enable planting of pistachio trees. In Egypt, I was involved in training a local agency in irrigation planning, during which a labourer had his fingers blown off when his auger hit a land mine; and in a soil survey of the north Sinai peninsula, which was largely salt with a bizarre backdrop of ships transiting the Suez canal (Figure 4).

Figure 4. Soil survey near Suez Canal, Egypt, 1984

Lessons learned

So what were the lessons learned? Soil survey is an art, involving endless agonising over putting order into chaos, mapping the spatial distribution of soils and then deciding if mapping units are fit for cropping. I came to the conclusion that development planners need to know what is unsuitable and best avoided; soil surveyors need to say 'yes' or 'no' — the finer details are less significant. In Sudan, virtually all the land was useable but we needed to classify and differentiate soils as an intellectual exercise to maintain our sanity. The focus was on soil physical structure and trying to make sense of the distribution of soils of similar type and their probable suitability for specified land uses. We did not pay enough attention to root behaviour in soils or, indeed, soil biology — subjects that are only now coming to the fore.

Being a soil surveyor develops a valuable sense of physiography, landscape relations, links with crops and indicator plant species, and an ability to read much more into maps and air photos or satellite imagery. Botany and bird watching are pastimes that fitted well with soil survey.

In a personal sense, as a soil surveyor I was privileged to visit remote places, untouched environments, amazing scenery and warm-hearted local people before some of the places became tourist destinations. It was also my pleasure to work alongside so many colleagues who became members of TAA. And where have all the soil surveyors gone? Perhaps the tide is turning as we now recognise that there is more to soil than subangular blocky and 10YR 4/2.

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Upcoming events

Bicton Overseas Agricultural Trust / TAA SW

Date and time: 7 May 2015, 10.00 – 16.00

Details: The Annual Bicton Seminar which has the theme *Agricultural challenges in the Horn of Africa*. Part of a 6 week residential course run by BOAT for senior staff involved in Agricultural Training Institutes and Rural Development Projects in the developing world. Anyone who has experience in the region and is keen to participate is requested to contact the organisers.

Venue: Bicton College, East Budleigh, Budleigh Salterton, Devon, EX9 7BH

Contact: Further information and booking please contact David Wendover
david_wendover@hotmail.com
http://www.boatagtrust.co.uk/

Seminar on Global Food Security to 2050, Cambridge

Date and time: 14 May 2015, 14.00

Details: Provisional announcement for a joint TAA-CambPlant-Humanitarian Centre- CCF seminar on the theme of assuring food security to 2050, including implications for climate change and biodiversity loss. Two presentations are proposed: (a) managing the demand side and (b) ensuring sustainable agriculture from the supply side. More details will be posted.

Venue: Hughes Hall, Pavilion Room, Cambridge

Contact: TAA East Anglia Group. For more details contact Keith Virgo at eastanglia_convenor@taa.org.uk.

ISRIC – Spring School on Mapping and Assessment of Soils

Date: 18 – 22 May 2015, 10.00

Details: ISRIC - World Soil Information will organise a Spring School on digital soil mapping, soil assessment and classification for soil and environmental scientists, students, soil experts and professionals in natural resources management. This spring school is a contribution to the Global Soil Partnership implementation. It will consist of two five-day courses that are run in parallel.

Venue: Wageningen Campus, The Netherlands

For Registration and Details: http://www.isric.org/content/isric-spring-school-2015

ISCO 2015 conference

Date and time: 31 May – 5 June 2015, 10.00

Details: The 18th ISCO conference theme is *Achieving sustainability through conservation in a changing world*. Topics to include: soil conservation for mitigation and adaptation to a changing climate; sustainable solutions; impacts of soil erosion and conservation on soil health and organic carbon sequestration; conservation agriculture; basic soil erosion; socio-economic dimensions of soil conservation; sustainable intensification of food production; soil degradation (salinisation, sodification, desertification); soil conservation in non-agricultural settings (urban and forestry). Mid-week technical tour of soil and water conservation research projects at the USDA Jornada Experimental Range and in the Sacramento Mountains to look at post-fire soil stabilisation projects.

Deadlines: 16/02/2015, abstract submission;
01/05/2015 last day to register.

Venue: El Paso, Texas, USA

Contact: Contact and information from Scott VanPelt (scott.vanpelt@ars.usda.gov)

TAA 10th Hugh Bunting Memorial Lecture

Date and Time: 8 June 2015
Pre-Lecture Visit 16.00
Buffet/Wine Reception 20.00

Details: Introduced by Professor Julian Park the lecture will be presented by Trevor Nicholls, CEO of the Commonwealth Agriculture Bureaux International (CABI) under the title: *Going the extra mile: helping smallholder farmers obtain the knowledge they need to lose less and grow more*. Under his leadership CABI has set its mission as strengthening global capacity for problem solving in agriculture and enabling poor rural farmers in the developing world improve productivity, quality and income. A non-exec director of three biotech firms, he has experience of building international genomic and life science businesses. His qualifications include a BA and DPhil in Biochemistry and Diploma qualifications in Marketing (CIM) and Company Directorships (IoM).
The HBML will be preceded by a visit to the University Dept of Meteorology

Tea will be provided before the lecture and it is hoped that members and friends will be able to attend the double bill.

A £10/head donation for the buffet will be appreciated.

Venue: John Madejski Lecture Theatre, Agriculture Building, Earley Gate, University of Reading, RG6 6AH, UK

Details from the website:
http://www.reading.ac.uk/about/find/about-findindex.aspx

RSVP: Linda McCarthy
Tel: 0118 378 4549
email: l.mccarthy@reading.ac.uk

Harvest the Future – International Symposium

Date: 14 – 17 June 2015

Details: An immersive symposium on innovative solutions for small-scale food production. Includes methods of scaling and adapting useful technologies, understanding the experience of a variety of producers across Latin America, Africa and the Middle East.

More Details and Registration:
http://www.cvent.com/events/harvest-the-future/event-summary-2da3aa22ad1e4383a8ea71fd9970cbf1.aspx

Venue: Hilton Rose Hall Resort, Montego Bay, Jamaica.

Planning for Climate Change Conference, London

Date and Time: 25 June 2015, 09.00

Details: Following on from the success of our Inaugural Conference in December 2014, the Planning for Climate Change Conference Team is organising a follow-up. The key focus will be to debate and discuss the key issues that face communities when it comes to adapting to climate change and addressing the problems and opportunities that Climate Change brings. We plan to have up to 10 speakers plus up to 100 delegates.

More details from the website: http://www.planforclimatechange.uk/london-2015/4587746571

Venue: The University of London, UK

To register as a delegate or speaker email:
planningforclimatechange@gmail.com

Soil functions and climate change

Date and Time: 23 – 25 September 2015

Details: International Congress about soil functions and climate change, specifically the thermal and hydraulic impacts on coupled hydraulic, biological and chemical processes under various land-use systems which will alter soil properties.

There is a need for detailed analysis of the role of the soil structure, its functions and changes under various climatic conditions in order to define the boundary conditions for reliable predictions in a changing environment. This first congress will deal with such interactions and necessary topics of soil physics, chemistry, biology and coupled processes which will be essential for more accurate prediction of soil processes and functions.

Venue: Christian Albrechts University, Kiel, Germany.

Details at the website: http://www.soils.uni-kiel.de/de/sustain-2015

Registration: http://www.soils.uni-kiel.de/de/sustain-2015/registration

2nd International Global Food Security Conference, NY

Date and Time: 11 - 14 October 2015

Details: The conference aims to deliver state-of-the-art analysis, inspiring visions and innovative research methods arising from research in any of a wide range of disciplines. Join us in this exciting opportunity to ensure that the best science is garnered to support the emergence of the Sustainable Development Goals.

Further Details:
http://www.globalfoodsecurityconference.com/index.html

Deadline for abstracts 8 May 2015,
Go to this website:
http://www.globalfoodsecurityconference.com/submit-abstract.html

Venue: Cornell University, Ithaca, New York, USA.
http://www.globalfoodsecurityconference.com/conference-venue.html

Registration:
http://www.globalfoodsecurityconference.com/conference-register.html

Tropical Agriculture Association
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If you are reading someone else's copy of *Agriculture for Development* and would like to join, or would like to encourage or sponsor someone to join, then please visit our website at http://www.taa.org.uk/

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http://www.taa.org.uk/membership
Alternatively an application form can be downloaded, completed and sent to:
TAA Membership Secretary, 15 Westbourne Grove, Great Baddow, Chelmsford CM2 9RT.

Step Two - Membership Type: Decide on the type of membership you require – see the details and subscription rates below:

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Bank details are available from: treasurer@taa.org.uk

Step Four - Access to website and Journals: When application and payment has been received then the Membership Secretary will contact you with your membership number and log-in details for you to fully access the website and journals.
The latest journal will be sent to full members.

For membership enquiries contact: membership_secretary@taa.org.uk

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