The science of soils:
achievements from the Africa Capacity Building Initiative (ACBI) programme

Healthy soils are vital to life on earth and are the foundation of our food system. But our soils are also under threat, with climate change and poor land management reducing soil biodiversity and increasing pathogens and pests, with an increased risk to animal and human health.

Two consortia within the Africa Capacity Building Initiative (ACBI) took soil as their focus. One looked at biodiversity within soils, particularly the prevalence and role of the dominant tropical soil insects (ants and termites). The other looked at how soil management affects agricultural yield, crop quality and their content of minerals essential for human health. Both projects made new discoveries, providing an evidence base for improving the health of both soil and people in sub-Saharan Africa.

One key finding related to the role played by termites in breaking down organic matter in hot, dry climates. Termites are a vital part of soil biodiversity, with around ten thousand different species of termite found across Africa. Termites help to maintain soil health by breaking down organic matter, burrowing through the soil and moving it around.

One ACBI consortium, involving researchers from Gabon, Ghana, South Africa and the UK, studied the role of termites in three different sites across sub-Saharan Africa. They looked at their prevalence in different types of cocoa plantations in Ghana and in areas of savanna in Lope National Park in Gabon. In South Africa, they eradicated ants and termites from one-hectare areas of savanna to understand better the impact they have on the ecosystem and to identify if other organisms would move in to replace them.

Image: RS-FCDO ACBI-funded PhD student, Mr Fidéle Ondo, in the field sampling termites in Lope National Park, Gabon.

Professor Kate Parr from the University of Liverpool was the UK's lead researcher on the project. She said: "Although ants and termites are so common, we still don't know exactly how critical their role is to healthy soils and the ecosystem in different landscapes, and that's what our project wanted to find out. This was the first time that an experiment suppressing their numbers was carried out in a savanna – so the findings have global significance."

Image: Dr Stephen Adu-Bredu, PI at CSIR-FORIG consortium partner, with RS-FCDO ACBI-funded PhD student, Mr Gabriel Quansah, standing next to a termite mound in Ghana.

Image: SoFIA consortium members identifying termites in the laboratory.

The team found that termites are much more important in dry, hot places than we had previously thought and are the dominant decomposer of dead wood. Furthermore, ants indirectly control the process of decomposition by predating on termites, which is contrary to traditional thinking that climate and litter quality are the most important factors. They also found that through predation and competition, ants determine what other invertebrates can co-exist with them and in what numbers, and so play an important role in how the ecosystem functions.

The ACBI project enabled the African partners – the University of Pretoria, the Forestry Research Institute of Ghana and the National Parks Agency of Gabon – to invest in training and equipment to strengthen their capacity in ecological monitoring. The team played a key role in a global experiment to identify the most important factors in the decomposition of wood, providing the project with the only data submitted from Africa.

"Without the capacity built through the ACBI, we wouldn't have been in a position to take up this new opportunity," said Professor Parr. "Most work on decomposition has looked at temperate climates where microbes are usually the most important player. But the data from our African sites, which were hot and dry, showed that termites had more impact on decomposition than microbes, overturning conventional wisdom. As climate change is changing temperatures around the globe, understanding the effect of this on soil biodiversity and health is increasingly important – and termites are a key part of this."

The consortium's ACBI research has so far resulted in more than 80 publications in high impact journals. 69% of these have been published with open access, making them freely accessible to researchers in the countries where termites are most prevalent.

Image: RS-FCDO ACBI-funded PhD student Dr Ivy Ligowe at the Chitedze Research Station, Malawi, in April 2017, showing the effects of soil management treatments on the growth of maize.

Professor Parr said: “Our ACBI project ran for over five years, much longer than many funding schemes allow and this has enabled us to quantify impacts over a longer time period and draw out more significant findings as a result.

The longer period also gave our students a much stronger foundation on which to build their academic knowledge and profile, through the training provided as part of the programme, in termite identification and data management for example, and through the research itself.”

Professor Martin Broadley, from Rothamsted Research, also believes the structure of the ACBI programme helped to ensure high quality scientific outputs.

He was one of the lead investigators from the ACBI consortium that studied a different aspect of soil composition: how human management of soil and the environment affects the yield and quality of crops, in particular their take-up of minerals essential for human health. The project involved the University of Nottingham (where Professor Broadley was based at the time), the University of Zimbabwe, the Zambia Agriculture Research Institute with the University of Zambia, and Lilongwe University of Agriculture and Natural Resources (LUANAR) in Malawi.

In Malawi, the consortium looked at two elements important for human health – selenium and iodine – studying how they are affected by soil processes and management. The researchers found that applying both minerals to the soil or leaves of green vegetables and maize increased their uptake of selenium and iodine. This brought them close to a potential dietary supply equivalent to recommended levels, but uptake was very dependent on soil acidity. For green vegetables, once selenium had been applied, it only remained available for plant uptake for 28 days. For maize, one application increased uptake in maize for that season, but did not last into the following year.

In Zambia, the team looked at how the soils and crops grown by smallholders in the Copper Belt are affected by contaminants from the mines, such as copper, cadmium, and lead. They found that some soils were highly contaminated by copper, and that pumpkin leaves accumulated concentrations above the recommended maximum allowable limit for human consumption, while only minor concentrations were accumulated in maize grain. Applying lime and manure reduced the bioavailability of all heavy metals, including copper, but not sufficiently to make pumpkin safe to grow in this area.

Image: Consortium members utilising agronomic biofortification for smallholder farmers at Hwedza field site, Zimbabwe, in November 2017.

In Zimbabwe, the consortium studied different soil management techniques by smallholder farmers and showed that use of mineral fertilisers combined with cattle manure and leaf litter could potentially reduce zinc deficiency by half – a significant finding in a setting where 68% of people are estimated to suffer from zinc deficiency, which can cause health problems such as stunting, impaired cognitive development and increased susceptibility to infection

Although the ACBI project finished in 2022, related research by the partners is set to continue until 2025. The partnerships and capacity built through the ACBI project led to the team being awarded a £5 million grant from the Bill and Melinda Gates Foundation for the 'GeoNutrition' project. This research followed on from the ACBI work, looking further at how fertilisers can be used to enrich crops with selenium and zinc and the impact of this on human health in areas where deficiency in these important micronutrients is widespread.

"We designed the GeoNutrition project using ACBI as a model, with a similar focus on PhD students working across the different partners," said Professor Broadley. "The two projects have seen substantial research outputs in terms of open access papers, with our most successful, a paper in Nature in 2021."

Of the papers published by the consortium, 87 % had an African lead author, and 90% of the papers are freely accessible online without the need for a journal subscription.

Dr Patson Nalivata, lead investigator at LUANAR in Malawi said: "The ACBI funding gave us a solid base and enabled us to carry out high quality research. We're continuing to build on that, as our scientific achievements and increased capacity helped us gain further funding. Now the students who gained their PhDs through the ACBI are working as post-doctoral researchers in these new projects, ensuring that ACBI has a lasting legacy." .

The Royal Society-FCDO Africa Capacity Building Initiative (ACBI) is a pilot programme funded by the UK Government's Foreign, Commonwealth and Development Office in collaboration with the Royal Society to increase the research capacity of universities and research institutes in sub-Saharan Africa.