

EYOB TESFAMARIAM

From the ground up: a soil scientist dedicated to improving the food production system



Prof Eyob Habte Tesfamariam, an Associate Professor in the Department of Plant and Soil Sciences at the University of Pretoria, has built a career on defining practical guidelines for sludge application in agricultural contexts. Committed to seeing his work applied in practice, he has expanded his scope to systems thinking and influencing the policies that can give his work wings.

Article by Petro Kotzé.

At the core of Prof Tesfamariam's research is the principle that, in natural systems, there is no waste – only underutilised resources, often arising from the absence of integrated, cross-disciplinary approaches to resource use. His work focuses on the recycling of biowastes in agricultural systems, advancing a systems-based perspective that rethinks waste generation by designing for reuse from the outset, and by drawing on the way natural ecosystems function through the integration of floral, faunal, climatic, and edaphic processes.

Tesfamariam is an agricultural systems modeller whose work focuses on understanding how water, nutrients, carbon, gases, and contaminants move through agricultural systems, and how these systems can be designed to enhance resilience in water-scarce environments, particularly under the pressures of climate change. He has, over the past two decades, built a career that has evolved from hands-on fieldwork, digging soil pits and running long-term field trials, to influencing national guidelines and contributing to international research collaborations.

Yet, he maintains that impactful research must be grounded in field realities. Tesfamariam first gained practical experience in the Horn of Africa. After graduating with a degree in Soil and Water Conservation, he worked as a soil surveyor in his birthplace, Eritrea. From 1997 to 2002, he served as head of the Soil and Water Conservation research unit and as acting head of Agricultural Engineering in the Department of Agricultural Research within the country's Ministry of Agriculture. In 2004, however, his career took a decisive turn when he commenced his PhD at the University of Pretoria.

The long road to Sludge Application Rate Advisor

Funded by the Water Research Commission (WRC), Tesfamariam's PhD investigated the safe and sustainable application of wastewater sludge across different crops, soils, and

agro-ecological zones in South Africa. At the time, application rates were largely based on international standards. However, the WRC sought locally relevant scientific evidence to support the development of the first sludge-use guidelines tailored to South African conditions. "We sought to determine the maximum application rates appropriate for agricultural lands," Tesfamariam explains. The research evaluated a range of cropping systems, including rainfed maize, intensive irrigated maize–oat rotations, rainfed pasture, and turf grass systems.

A key outcome of the PhD was the finding that it is agronomically, economically, and environmentally unsustainable to prescribe a single, uniform application rate across South Africa's diverse agro-ecological conditions. This raised a critical follow-up question: how should appropriate application rates be determined for specific soil–crop–climate combinations?

Addressing this question marked the beginning of the next phase of Tesfamariam's long-term collaboration with the WRC, which, he notes, "profoundly shaped my career." Extensive field trials, controlled laboratory and lysimeter experiments, and multi-site studies across South Africa's agro-ecological zones were undertaken to quantify nutrient release dynamics, crop responses, and environmental risks, including nitrate leaching and contaminant accumulation. These datasets were systematically collected and validated across all nine provinces. The integration of this work ultimately informed the development of modelling approaches and a decision-support tool, later called the Sludge Application Rate Advisor (SARA) model.

"It took approximately 15 years," Tesfamariam reflects. The focus then shifted from tool development to technology transfer. Over a period of four to five intensive months, and with the funding support from the WRC, Tesfamariam travelled across all nine provinces, delivering hands-on training to specialists from the Department of Water and Sanitation, agricultural extension officers, and municipal personnel managing wastewater sludge. The aim was to ensure that the tool was not only scientifically

robust but also practically applied in real-world contexts.

The research ultimately informed national guidelines and WRC strategies, contributing to a shift from a purely precautionary approach to a risk-informed framework. This has enabled safer agricultural reuse of biosolids while supporting productivity and safeguarding soil and water resources.

"I began by studying how water and nutrients behave in soils," he says. "But working closely with the WRC from my PhD onwards shifted my focus toward real-world impact."

Grounding research in lived experiences

Tesfamariam's insistence on grounding modelling in lived experiences is rooted in early mentorship. He recalls how his PhD supervisor, the now-retired Prof John Annandale, emphasised that researchers should not hide behind models and software. Prof Annandale, recipient of the WRC Legend Award in 2021, championed an unapologetically applied approach to science. Among his notable contributions is the development of the user-friendly Soil Water Balance (SWB) model, which has been widely used to address water-related challenges within quantitative environmental biophysics research at the University of Pretoria.

The deeply practical philosophy, adopted early in Tesfamariam's career, continues to define his work. "Most of my work is in the field," he says, explaining that models are essentially quantitative representations of observed reality. In this sense, the SARA model is not an abstract construct but a numerical distillation of field-based evidence, designed to reflect the behaviour of real agricultural systems and to address questions of direct relevance to farmers, regulators and policy-makers.

Following the risks

After establishing safe sludge application rates, Tesfamariam's work naturally progressed to examining the long-term consequences of sludge use and other agricultural inputs.

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Prof Eyob Habte Tesfamariam is an agricultural systems modeller and Associate Professor in the Department of Plant and Soil Sciences at the University of Pretoria.

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Tesfamariam's work is based on a practical philosophy, and he described his models as quantitative representations of observed reality. Here, he conducts training on using the Sludge Application Rate Advisor (SARA) model in the Free State. The tool was designed to reflect the behaviour of real agricultural systems and to address questions of direct relevance to farmers, regulators and policymakers.

A key question concerned the fate of heavy metals in the soil–plant–water system over time. His first PhD student tracked these metals through the full soil profile and across different crops, assessing potential risks to human health, plant growth, and groundwater quality. The findings were reassuring: where sludge complied with the South African sludge guideline upper limits, heavy metals did not accumulate to harmful levels in the soils, did not pose health risks through crop uptake, and did not significantly leach to groundwater.

Building on this foundation, the research expanded to soil microbial systems, recognising that microbial communities underpin soil health and long-term sustainability. A subsequent PhD study investigated whether repeated sludge applications affected microbial biomass, diversity or activity. For the high-quality municipal sludge evaluated, the results again indicated stability, with no significant shifts in microbial structure or function.

With these core risks addressed, the research moved into one of the most pressing frontiers in environmental science: emerging contaminants. His students investigated pharmaceutical residues and other contemporary pollutants, including their potential role in antimicrobial resistance, as well as metabolites and transformation products that may persist longer in the

environment.

Field-based studies conducted across 18 farms in three districts of Gauteng analysed soils and groundwater, revealing that these contaminants are already present at very low concentrations in areas that received commercial inorganic fertiliser and animal manure. This pointed to broader anthropogenic sources, particularly routine agricultural practices such as the use of fertiliser and manure.

This recognition that modern contaminants are already embedded within agricultural systems now underpins Tesfamariam's latest research on microplastics. A new PhD project is investigating the contribution of sludge-derived microplastics to agricultural soils, including their characteristics, mobility through the soil profile, potential uptake by plants, and possible pathways to groundwater.

Consistent with his systems-based approach, this body of work follows a clear trajectory: comprehensive monitoring of the soil–plant–water continuum, coupled with quantitative analysis to generate evidence that can inform guidelines and policy for the safe management of sludge and other agricultural inputs in an increasingly complex environmental landscape.

WRC archives



Tesfamariam received a WRC Knowledge Tree award in 2017. Here he is flanked by former WRC CEO, Dhesigen Naidoo and WRC Board member, Prof Aldo Stroebel.

Just as his early WRC-funded PhD research provided the first South African evidence to move beyond imported sludge-application standards towards locally grounded guidelines, his current work on emerging contaminants and microplastics addresses a new gap, where global policy frameworks remain underdeveloped, by generating the field-based data needed to define what “safe” means in practice.

From soil to systems thinking

Over time, Tesfamariam’s work has expanded in scope, moving into increasingly broader scientific and collaborative networks. He has collaborated with several national and international research organisations, including the French National Institute of Agricultural Research (INRA) and the Research Council for Agriculture and Analysis of Agricultural Economies of Italy (CREA). These collaborations extend to his work on assessing the impacts of extreme weather events under a changing climate on maize production in South Africa, as well as identifying appropriate adaptation and mitigation strategies.

He has also worked with researchers from a range of European institutions and universities, including the Czestochowa University of Technology, the Norwegian University of Life Sciences, the Warsaw University of Technology, the VSB Technical University of Ostrava, and the Université de Lille, focusing on biodegradable waste management within a circular economy context. In addition, he has collaborated with Rothamsted Research on greenhouse gas emissions from agricultural systems, and with the International Fertilizer Development Centre on optimising fertiliser use for crop production.

Alongside this expanding network, his research has evolved from a predominantly soil-focused perspective to a broader systems approach. “At this stage, I work at the interface of science and policy,” he says. “It took time to get here. First, you must understand the system. Once you can explain it in a way people can understand, you can translate it into policy or guidelines”. This process requires continuous translation, turning complex, process-based science into practical, usable knowledge.

Looking ahead, he sees his role expanding further. “I would like to work more at this higher level of thinking,” he says, “so that the

impact will be greater.” That may involve deeper engagement in policy spaces, where his long-term, field-grounded insights can inform decision-making at scale.

At the same time, he places strong emphasis on developing people. By supervising postgraduate and postdoctoral researchers, Tesfamariam has helped build a network of scientists and practitioners working in related fields. “The investment in me has led to investment in many others,” he reflects.

He has supervised and co-supervised 30 postgraduate students to completion at Master’s and PhD levels, and is currently supervising and co-supervising a further three MSc and seven PhD students. At the undergraduate level, he teaches Soil Water Relations and Irrigation and at the postgraduate level, Advanced Environmental Soil Physics.

Tesfamariam speaks of the immense satisfaction of seeing his students grow and contribute, proudly noting that many of his former students now hold academic and professional positions across South Africa and internationally. Overall, his significant contributions to research, development, and innovation in sustainable agronomy have led to recognition as a National Research Foundation-rated researcher and his promotion to Associate Professor.

A way of seeing

Beyond the technical depth of his work, Tesfamariam is driven by a strong ethical and personal commitment to caring for the Earth in ways that sustain both ecosystems and the people who depend on them. His career is not only about transforming waste into a resource; it is also about designing systems that enable such transformations to be safe, scalable, and sustainable over time.

“If we expect the Earth to continue to provide for us, we must take care of it,” he says. “My role is to contribute to protect this Earth; to guard and nourish it.” Even after many years in research, this sense of purpose continues to drive him. “Knowing that,” he adds, “makes me even more committed to continue.”



To read more on Eyob Tesfamariam’s research visit: <https://orcid.org/0000-0003-0724-9864>



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Tesfamariam conducting research in the field.