CHALLENGES FACING SOIL SCIENCE : A VIEW FROM THE OUTSIDE

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I deduce that the speakers for this session had both an easy and a difficult task. As long-practicing soil scientists, they easily discussed the aims, applications, and benefits of soil science. On the other hand, the challenges ahead are more open to interpretation. Let us briefly revisit some of the aims, applications, and benefits of soil science prior to discussing new challenges.

Aims, applications, and benefits

In terms of aims, Dr Sposito was especially clear that soil science –or indeed the many soil sciences and affiliated disciplines– is basic puzzle-solving research "motivated by the simple question: 'What is soil?'" Dr Latham's table concurs in that the aims or objectives of soil science –of any science, in fact– are the generation of knowledge.

As to applications, soil science has clearly contributed to solving a wide range of problems related to food production. Leaving details aside, such solutions have helped to increase productivity, sustain production systems, lower production costs, rehabilitate degraded lands, and conserve soils.

Newer applications deal with environmental quality. Both Drs Sposito and Swift presented lucid discussions of the global CO_2 budget, including different C reservoirs, their means of conversion and contributions to atmospheric C levels. Dr Latham briefly discussed the key role of soil scientists in environmental monitoring as part of the Global Terrestial Observation System (*GTOS*).

Benefits of soil science are equally clear – and substantial. Since we are all consumers, society has gained from increases in food production made possible by the agricultural sciences. At the same time, farmers have benefited from increases in productivity and decreases in production costs. As discussed in the following section, a major challenge will be to follow up on the generation of data on

environmental quality in ways that benefit both land users and society as a whole.

Challenges

From the authors' statements and my work as a social scientist in the CG centers, there appear to be three "new" challenges ahead. The authors addressed these as they turned their attention to "people in systems" (Swift), "responsibilities of soil science towards society" (Pereira de Queiroz Neto), "ecosystem functioning" (Sposito), and "the need for an inter-disciplinary holistic approach" (Latham).

First, I strongly agree with Latham in that soil scientists will have to work in a more interdisciplinary and holistic context if they are to help solve currently important problems.

The "Green Revolution" was made possible largely by disciplinary specialists. Breeders bred new varieties for more favorable areas. Soil scientists dealt with soil constraints. Entomologists worked with breeders on host plant resistance and on pest control. Economists looked at costs and benefits.

Today we necessarily address more complex problems in more marginal areas such as the rainfed lowland rather than irrigated rice lands of Asia and the forest margins of the Amazon. Many new technologies must serve the poorest of the poor and are often knowledge intensive or require new institutional and social arrangements –eg, integrated nutrient management, integrated pest management, soil and water conservation, agroforestry, and participatory or community– based natural resource management.

In soil conservation, the era of testing the USLE and developing technologies ranging from bench terraces to vegetative strips is over. Now we need to know under what conditions can technologies actually be adopted and problems solved –an interdisciplinary problem. Swift went even farther in concluding that soil science needs to move from physico-chemical and reductionist approaches towards an integration with more biological and holistic approaches.

Second, soil science (and other sciences) must face the issue of "trade-offs" which arise from the opposing needs to exploit soil and other resources in ways which benefit individuals and society (eg, food production), on the one hand, and the need to sustain such resources for the benefit of society as a whole (eg, limiting conversion of forests to limit greenhouse gas emmissions and biodiversity losses), on the other.

Swift correctly posed the question, "How should...costs and benefits of modification to natural capital and ecosystem services be valued" from scales spanning nutrient depletion at the field level to global climate change.

Pereira de Queiroz Neto voiced concerns about how the national Brazilian goal to increase food production had been achieved, in many cases, with high environmental costs (eg, fertilizer-induced eutrophism and soil pollution) and with an inequitable distribution of benefits.

Sposito provided an example of production vs plant biodiversity at the global scale: Less developed countries naturally seek increased food production, but are generally located in areas where productivity is naturally low and where plant biodiversity is naturally high. At the same time, most inherently fertile soils are found in the temperate zone. The clear conclusion was that optimizing the conservation of biodiversity and sustainable food production "cannot by achieved within the boundaries of any one country."

Trade-off questions can be posed quite directly. How can we work with hillside farmers to slow soil erosion when benefits

accrue to downstream and future resource users? How do we work with slash-and-burn farmers when they need more rice and the globe wants decreased GHG emissions? How do temperate climate countries with high fossil fuel consumption work with tropical countries with high rates of deforestation and C emissions? How can countries and regions coordinate to balance productivity, equity, and environmental goals? These questions ask how some segments of society are to be induced to give up some "goods" in order to increase benefits to society as a whole.

Third, and closely related to the second challenge, soil science needs to address issues that are important rather than those that are merely interesting, and perhaps must be more "activist" in doing so.

For example and to the extent that poverty, equity, and the global environment are important issues, relatively more attention by soil scientists may be needed in the forest margins rather than the Cerrados of Brazil. Of course, economists have argued quite the opposite–that resources for research should be allocated to areas where the most progress can be made. I am not as confident as the economists, however, that increases in productivity in one area will decrease demands on resources in other areas and, in so doing, result in environmental benefits.

To the degree that science continues to directly confront global issues, however, soil scientists must continue to measure the effects of human activities in terms of soil erosion, land degradation, and C emissions. Soil science should then –as Swift indicates– closely contribute to the valuation of costs and benefits of the human activities; and to the identification of comparative advantages held by different areas (ie, tropics vs temperate zones) in terms of production vs conservation, as Sposito implies.

Finally, soil scientists may have to become more "activist". It appears that you have established that your findings have important global policy implications in terms of regional land use, biodiverity conservation, equity, and the quality of the environment. As such, who else besides you can best argue the validity of your findings and the consequences of ignoring your conclusions in policy discussions shaping the future of the globe?