Environmental Issues and Farming in Developing Countries

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Paper prepared for presentation at the 13th International Farm Management Congress, Wageningen, The Netherlands, July 7-12, 2002

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ABSTRACT

Formerly a rich-county preoccupation, dealing more explicitly with environmental concerns around agriculture is becoming a mainstream concern for developing countries. Concerns arise with all the major resources underpinning farming, such as land and water which are selectively reviewed here but most attention is concentrated on the soil resource and carbon sequestration possibilities. The results of some environmental interventions constitute public goods at variously local, regional and global levels and thus provide a rationale for potential engagement for governments and development agencies.

INTRODUCTION

Environmental issues were seldom mentioned in the same breath as farming when many of us were getting into the business of farm management. Indeed, one can search in vain for any mention of "environment" in the classic farm management textbooks from the 1940s to the 1970s (e.g., Heady and Jensen 1954, Vincent 1962, Rae 1977). But with the emergence of explicit concerns for the environment by the 1980s, things greatly changed in the more-developed countries (MDCs), when all concerned with agriculture had to get serious about addressing such issues, and this has been reflected not only in farm management teaching (e.g., Casavant and Infanger 1984), but has become a major theme (almost an industry in itself) in the scientific, economic, social and policy environments surrounding agriculture (e.g., Cocks 1992, Johnson and Bouzaher 1995, Oliver et al. 1996, Pannell 2001).

Progress in the less-developed countries (LDCs) has been slower (e.g., Matlock 1981, Hoben 1996, Pingali, Hossain and Gerpacio 1997, Jodha 1998, Leach, Mearns and Scoones 1999), and is yet more shallow in the treatment accorded such issues, notwithstanding many rallying calls (e.g., Harrison 1987, Conway and Barbier 1990, Cleaver and Schrieber 1994, Cleaver 1997, Anderson 2002) and the profound significance they have in many situations, as will be partially charted in what follows. Perhaps, through matters related to incomes and public debate, much of agriculture in the developing world has yet to reach the "environmental transition" (Antle 1994)? There are, of course, many pressures on LDCs to "conform" to MDC "reforms" in the environmental domain, including from much of the international development community, such as the World Bank. Given my role in the Bank, and by way of further introduction, let me draw from two of the Bank's recent analyses of strategic imperatives.

In the first, *Vision to Action* (World Bank 1997) featured among its major goals **Sustainable natural resource management** and included among its guidelines

> "Security of land and water rights is actively promoted. Restricting land rentals hurts the poor, so their access may need protection. Land reform is needed where land distribution is highly unequal. Decentralized, participatory and market-assisted approaches to land reform are preferred. … On the global environmental agenda, the Bank is mainstreaming the relevant international conventions including the Convention to Combat Desertification, and the Conventions on Climate

Change and Biodiversity; and, it is working towards capturing the benefits that sustainable land management provides in conserving biodiversity, sequestering carbon, and reducing global warming. Neglected areas of land management … are also being tackled …"

In an update that has just been completed, a new strategy, *Reaching the Rural Poor* (World Bank 2002), lays out (among others) the following themes:

"Improving Agricultural Productivity and Competitiveness. Agriculture depends fundamentally on natural resources and has an important role in their conservation. The deteriorating land and water base in many regions presents a concern for many producers, and wider public awareness of environmental issues is bringing urgency to conservation issues—many global in nature. Increasing the productivity of water use in agriculture and improving irrigation systems performance in a sustainable manner is a key strategic goal. Protecting natural resources and the environment will require greater efforts to ensure sustainability of intensive agricultural production systems, and carefully manage natural resources in less-favorable and more fragile production environments.

Sustaining Natural Assets—for Richer Livelihoods and Continuing Growth. To promote the maintenance and restoration of natural assets in rural areas, the Bank's recently developed environment, forestry, and water strategies give overall guidelines for approaching these rural natural resource management issues, and set the framework for linking rural development with environment, forest, and water management. The Bank's objectives for improving the sustainable use of natural assets include:

- Reducing land degradation
- Improving water management
- Sustaining production of forest products while protecting the environment
- Incorporating consideration of climate change into rural development planning.

The strategy promotes an innovative approach to optimizing the use of the natural resource base to meet agricultural productivity goals and to protecting the long-term productivity and resilience of natural resources."

Such is the nature of the institutional commitment to these themes. Let me elaborate a selected few of them from a personal perspective.

THE ENVIRONMENT AND CONTEMPORARY FARMING

There is growing recognition—perhaps fueled in part by perceptions and prejudices nurtured in rich countries—of the magnitudes and trends of environmental problems, particularly of pollution and resource degradation, in the less-wealthy parts of the world, where the problems of poverty stubbornly persist, with their destructive consequences for both human development and resource sustenance (Lutz et al. 1998, World Bank 1992, 1995, 2000, 2002b). Persistent poverty (with its accompanying excessive discounting of the future, low investment rates, and degradation of natural resources) is widely believed to lead to growing environmental problems, and consequently a growing need for analysis of potential interventions (e.g., Farrington and Mathema 1991, Crosson and Anderson 1993, Sanders, Southgate and Lee 1995, Greenland 1997).

The history of agriculture is littered with failures that, with the advantage of hindsight, involved inadequate recognition of the resource issues and environmental dimensions involved, and led to notably large negative consequences for many key resources. One can begin near the dawn of agriculture and reflect on, say, lower Mesopotamia in its early role of major world granary (Dregne 1983). It then had a large population, an aggressive military sector, and good-quality structures and administrative controls that could seemingly have led to efficient and maybe sustainable irrigation of food and fiber crops. Whether it was inadequate understanding and control of the factors leading to salinization, insufficient control over wood logging and deforestation generally, or other resource-management issues that led to this agro-environmental disaster, may never be clearly known. Similar difficulties befell the Samarians a couple of thousand years ago, and many others since (Vasey 1992). Some observers believe that many analogous land-use tragedies are in still in the making today. To take just the Aral Sea and surrounding areas as one example, or the Lake Victoria Basin for another, the demonstrated human capacity to deal effectively with such complex environmental processes (and relevant policies) leaves much to be desired.

Agriculture and Water Resources

Water, a resource notable for its importance to several sectors and thus involving key issues of conjunctive use, is highlighted here as an initial agricultural resource issue. There has been a proliferation of studies of water management and marketing, and of the political economy of water resources (e.g., Dinar 2000), through to analysis of regulatory interventions to address health consequences of polluted water from both aquifer and surface sources (e.g., Crosson and Anderson 1992, 1999). In MDCs, this is a well-established field of endeavor.

Issues of resource degradation, especially through phenomena such as salinization, seemingly represent a rapidly accelerating field of analytical endeavor. Management of water resources is receiving belated research attention, and appreciation has grown for the effectiveness of community action groups such as water-users associations in making much more efficient use of the scarce resources, once they are effectively organized (Dinar and Loehman 1995). Major challenges of pricing both water and related services electricity persist in many parts of the world, such as South Asia. Social-science research workers have much to offer through improved understanding of governance and rights issues of many natural resources that are held as common property, or are subject to open access (e.g., Crook 1994, Ostrom 1994, Kerr et al. 1997).

Much has been written in recent decades about the problems of land and water degradation (e.g., Chisholm and Dumsday 1987), and a lot of it is rather alarmist in nature, and sometimes (if done in institutes such as Worldwatch) is extremely alarmist in the pseudo-quantification of the extent of problems. There is no doubt that land is degrading in highly visible manners in many parts of the world, but whether this constitutes a really significant element of lost productivity is more of a moot point. Crosson and Anderson (1995), generalizing in a less than ideal manner from earlier U.S. work of Crosson (1983), have argued, for instance, that the overall aggregate effect may be relatively modest, once due allowances are made for the resilience of different land types and for the productivity consequences of different types of erosion.

The situation for water may not be so sanguine in part because there are many more pollution issues involved in the water resource and competition between users is typically much less regulated than is the case for the land resource. The rates of degradation of the water resource are probably typically much greater than those for the corresponding soil resources. The extent of any such rates of land degradation must, for the moment at least, remain a solid research question in itself as challenged, for example, by Biot et al. (1995) and Anderson (1999). The economic significance of contemporary and past degradation of these two crucial resources is surely significant. In a global food security sense, however, they may be construed as relatively minor and, for instance, even if the degraded lands could be repaired beyond presently imaginable possibilities, they would still make only modest contributions to the overall performance of the farming sector.

Pollution of surface and sub-surface waters comes from many sources and may involve biological agents, such as viruses and microorganisms, causing infectious diseases in some extreme cases (Hertzman 1995, p.45), through to abiotic pollutants. Some of the latter are directly linked to farm sources, with one of the most widespread cases being nitrates traceable to intensive livestock operations with inadequate treatment of effluents (de Haan, Steinfeld and Blackburn 1997, de Haan et al. 2001). When used as human drinking water, the result is unacceptable rates of methemoglobinemia in newborns. Many rural groundwater supplies are at risk in hotspots from the Americas to the Urals, and needed interventions range from monitoring systems, through regulatory frameworks, to effective enforcement. Policy analysts must deal with public-financing matters such as how to get the polluter to pay, technological aspects including economies of size and scope for treatment possibilities, as well as the uncertain nature of health damage functions and valuing losses of aquatic life and habitat potentially affected.

In similar vein, there is a strong case that can be made for realistic analysis of the many activities that are sometimes suggested in the context of positive intervention on environmental grounds to deal with many aspects of the negative externalities created in the agricultural sector (e.g., Reardon and Vosti 1997). Water-driven soil erosion, fueled by inappropriate cropping practices and upper-watershed deforestation, with its overtly negative consequences for loss of downstream reservoir capacity and interference with port operations, for instance, is a case that in recent decades has witnessed much neglect and considerable under-investment in control measures by both involved communities and society at large (Anderson and Thampapillai 1990). The analytical work needed is challenging, however, in part because of the technical evaluation and economic valuation difficulties that must be overcome (Dixon et al. 1986, Fisher and Thorpe 1990).

One promising development that is of increasing significance for farmers in developing countries is the set of crop tillage practices sometimes described as “conservation (or no-till) tillage”. These practices, which involve minimizing conventional tillage and relying on crop residues as mulch cover, are being adopted and adapted in a growing number of developing countries such as Brazil and South Africa (Pieri et al. 2002). The practices make more efficient use of scarce rainfall and yield benefits of better soil organic buildup (discussed below), especially in semiarid areas (e.g., Scopel et al. 2001).

Externalities and Agriculture

Here concerns relate to biophysical phenomena that lead farmers to contribute items that have broad environmental consequences. Some examples will illustrate. High rates of use of pesticides for controlling fungal and insect diseases of crops, for example, may lead to high levels of toxic residues entering the non-agricultural environment. Depending on the nature of the compounds and their transformation in the environment, they may variously be dangerous or more benign for short or long periods. The question of vulnerability also encompasses the age, literacy and sensitization of those who grow, process and consume affected agricultural products and deal with polluted resources. The increasing use of Integrated Pest Management (IPM) offers some hope for a gradual reduction in global use of pesticides (e.g., de Haen 1997), but this hope depends on considerable deepening of human capital across literally billions of resource-poor farmers, with the accompanying investment in basic and technical education and extension, as well as sustained investment in appropriate agricultural research. In spite of now decades of active proselytization, IPM has yet to become a major contributor to farm productivity and better environmental management. Some of the implementation challenges and problems are insightfully addressed by Pingali, Hossain and Gerpacio (1997).

Yet other externalities arise from operations on a more pervasive scale, especially those agricultural processes that supply gasses implicated in the Enhanced Greenhouse Effect (EGE). Two cases are singled out here for the difficult challenge they pose to both technical and policy interventions. Methane derives from several natural processes such as vegetation decomposing in swamps, but in terms of quantities contributed to the atmosphere it is human-controlled/managed farming processes that are most significant. The two that are both large and difficult to address are inundated rice paddy fields and ruminant livestock emissions. Growing rice under other than flooded conditions is technically feasible but not economically so for the foreseeable future in the vast rice fields of Asia. Better prospects may be in store for potentially economically attractive biochemical methods of reducing methane production from the rumen of commercially managed sheep and cattle (de Haan, Steinfeld and Blackburn 1997). Many policy and implementation questions remain to be answered by concerned analysts, however.

All this said, while agriculture does have some pollution problems to confront, it should not be inferred that the sector is a major polluter. The problems, while locally significant, are minor compared with those emanating from the mining and manufacturing sectors, and are only modest on a global scale. But those of us concerned with sustainable farming around the world must not shirk our responsibilities to address “our” environmental difficulties urgently and effectively.

Soil Degradation

Soil degradation takes many forms, ranging from wind and water erosion through to “chemical” erosion which, in turn, encompasses pollution of soils by invasion of salts (salinization) through to pollution from excessive application of agricultural chemicals or unintentional application of other substances, perhaps not usually connected with agriculture (e.g., El-Swaify 1999). One of the more subtle forms of chemical degradation concerns reduction in the plant nutrient content of soils. This process is a feature of farming systems where the export of nutrients (in, say, harvested plant parts such as seeds or fruits or even whole plants tops in the case of hay and some woody species) is not matched by the replacement of these nutrients from natural resources, such as fixation of atmospheric nitrogen or through decomposition of parent rocks to yield available forms of nutrients such as phosphorus and potassium, as well as the many important micronutrients essential for plant growth.

In modern industrial agriculture, the replacement of such nutrient outflows is a routine feature of contemporary fertilizer practice and one that is increasingly informed by accurate measurement of the status of soils through testing programs. This happy situation does not, however, apply to many parts of the less-developed world. The major case in point, as insightfully analyzed by McIntire, Bourzat and Pingali (1992), is the non-commercial farming areas of Sub-Saharan Africa, where application of inorganic fertilizers is minimal and, excepting some cash crops, typically zero, and application of organic fertilizers from farm (e.g., confined animals) and other sources (such as household wastes) is also highly limited because of problems with adequacy of supply or from scarcity of labor resources that might be used to make such applications.

The net result of such phenomena in many parts of Sub-Saharan Africa, for instance, is a diminished level of soil fertility that, in turn, is quickly translated into reduced soil "health" because of diminished organic matter levels that, in turn, predispose a more erosive situation with negative consequences deriving from rainfall impact and water flow, and analogous effects from wind, leading ultimately to other forms of soil degradation. These concerns have long troubled World Bank staff (e.g., Anderson 1992, Yates and Kiss 1992). The situation may, however, be approaching crisis levels in many countries and should thus be high on the research agenda of those concerned with efficient management of natural resources in this part of the world, as well described by Sanders, Shapiro and Ramaswamy (1996). The region is also attracting increasing attention of food-policy analysts because of the growing problems of food insecurity and the rather dismal prospects for improvement over coming decades.

Many potential interventions have been proposed for ameliorating the situation. Some observers emphasize concern for increased infrastructural investment, which could lead to reduced transport costs for imported nutrients and thus for potentially more profitable and extensive use of inorganic fertilizers, even by resource- and cash-poor smallholders (e.g., Reardon and Vosti 1997). Others see more immediate potential in technological innovations such as micro-doses of inorganic fertilizers, as has been championed in Niger (e.g., Abdoulaye and Sanders 2002).Yet others have called for interventions to exploit more aggressively the considerable deposits of rock phosphates in many countries of Sub-Saharan Africa (Sanchez 1994, Sanchez et al. 1996). The general proposal is that, even with only mild processing, such as through partial acidulation, these deposits could be pressed into valuable productivity and environmental service for many forms of African farming (e.g., Matlon and Adesina 1997).

An extreme version of the latter idea, and one that links to several others discussed herein, is that, through the increased biomass created through such fertilizer intervention, there could be significant sequestration of atmospheric carbon, and that such a process might be potentially justifiable on grounds of the positive global externalities of reducing atmospheric carbon dioxide levels, and thus also the consequent EGE that is postulated to be associated with this and other gasses. It has been suggested by some enthusiasts that this would be a valid form of investment for new sources of "green funds" such as those managed by the Global Environment Facility (GEF). For resource-poor "carbon farmers" it could be a win-win situation, with their actions doing useful things for themselves and their resources as well as for the global commons.

One of the related themes stems from the increasing possibilities of conservation tillage or no-till (NT) cropping in contributing to soil carbon sequestration, as noted briefly above. The positive contribution to the CO_2 atmospheric balance constitutes an indirect environmental benefit generated by NT systems, by decreasing CO_2 emission and by enhancing C sequestration above and below the ground surface. The decrease in CO_2 emission is a consequence of improved crop residues management, i.e., largely by not burning residues. NT farming practices dramatically decrease CO_2 emission (up to 80%) compared to a plowed soil, which stimulates the oxidation of soil organic matter. In addition, significant decrease in CO_2 emission is expected from the reduction in fuel and energy consumption in NT farming (Pieri et al. 2002).

Carbon sequestration is yet to be fully accepted as a means of mitigating climate change (e.g., Watson et al. 1998). However, recent data show a significant contribution to reducing atmospheric carbon from improved soil management (Lal et al. 1998). The rate of C sequestration is from 0.2 t/ha/yr to more than 1 t/ha/yr, depending on climatic conditions, soil characteristics, and the quality and quantity of the plant cover, This potential for C sequestration may possibly attract companies and utilities interested in offsetting their own emissions of green house gases, through the application of the Clean Development Mechanism (the Kyoto Protocol). Lal (1999) cautions that this carbon sink is finite and if taken up aggressively could be filled in just a few decades. Any such carbon market has yet to be articulated in the case of soil C and the GEF, for instance. Needless to say, any major shift to NT farming systems will involve a diversity of changes in socioeconomic and institutional conditions in many countries.

To determine whether or not such interventions are really justifiable requires, however, careful analysis at both a conceptual and empirical level. The costs of such intervention must be carefully accounted to assess their true worth vis-à-vis other potential investments. The opportunity cost of international and national public funds committed to such purpose may be high indeed, and it is possible that other forms of environmental intervention may be more worthy, implying a need for cogent analytical work to inform policy and decisions in this domain.

PRODUCTIVITY STUDIES, RESOURCE ISSUES AND INCOMPLETE INFORMATION

Conventional measurements of productivity, usually construed in a rather static sense, tend to exclude relevant inputs and outputs in their composition of variables. Much reported productivity growth potentially reflects measurement error of things that are not properly accounted. Many of these are externalities that are conveniently disregarded by decision makers, as well as economists. Some of the externalities associated with agriculture may be positive, such as the amenity value provided by agricultural landscapes to tourist, recreational and other viewers/users but many are negative, such as some of the negatively impacted resource situations described above. Whatever may be the precise nature of the externalities, routinely computed productivity indexes are likely to be misinterpreted, particularly as measures of increased productive capacity, because of the mis-accounting of key status variables, especially those associated with natural resources. It is thus critical for farm management economists in attempting to do their job properly to make more accurate assessments of true productivity changes, and thus to generate more appropriate policy advice through better appraisal of changes in the stocks of natural resources associated with various agroecosystems and alternative technologies. It could be that the high rates of return to public-sector agricultural research are indeed still valid but, to actually realize such high returns in a comprehensive sense requires that analysts pay closer attention to the environmental factors that have been excluded from most past analyses.

The needed broad-based studies should be predicated on the fact that farmers are, as is well understood by this gathering, rational, and it must be recognized by analysts that it may be both privately and socially optimal for farmers to accelerate their consumption of stocks of farm resources, such as soil fertility, and in this way achieve seeming boosts in conventionally measured productivity, while possibly compromising the value of their resource base, at least in the short run (Alston, Anderson and Pardey 1995).

Market and non-market valuations can complicate these types of analyses and it will thus be important for such applied economists to deal with the many measurement challenges associated with the relevant public goods and externalities, and to address in particular the nature of property rights. Such rights are sometimes so ill-defined to lead farmers to deliberately choose to degrade their land (that is to say, land for which they have at least temporary managerial control) whereas a clear definition of such rights could lead to a natural custodial attitude to management (Sjaastad and Bromley 1997). All of these effects are related to the degree of **technological uncertainty** perceived and some of these uncertainties relate to the reversibility or otherwise of particular forms of damage to the natural-resource base.

The theory of optimal resource management is most elaborately worked out for cases where there is complete certainty about all aspects of decision making, including the state of the resource and the future consequences of any action. Such a situation is, however, seldom confronted in practice, and for the great majority of environmental problems and their analyses, there is considerably less-than-perfect information and thus much uncertainty surrounding many aspects of the decisions (Fisher and Thorpe 1990). Surprisingly, there has seemingly been little application of subjective probability calculus to describe the state of uncertain knowledge in the environmental domain.

The theory of public choice under uncertainty is clear about how to deal with uncertainty under particular situations. When the risks associated with any particular policy or decision are small relative to an appropriate macroeconomic aggregate, analysts should use appropriately assessed **expected** values of involved uncertain quantities, such as damage parameters, life cycle details, etc., and thus the formalities of the analysis then collapse to something approaching the case of certainty, except for the use of mean rather than deterministic point values. The important thing here is that the consequences of the risk should be relatively small and also relatively independent of the performance of the relevant macroeconomics variables. For many environmental issues then, a social analysis can be adequately executed in terms of **mean** values, but their computation may well involve quite explicit consideration of the full probability distribution of at least each underlying uncertain variable, and perhaps some joint distributions as well (Hardaker, Huirne and Anderson 1997). Such risk accounting will be especially required for what might be categorized as the "downside risk" considerations, which must inevitably be confronted in environmental assessment work.

The complement to the above is that, when risks are large (in a relative sense) and especially so if they are highly positively correlated with the relevant macroeconomic measure, it is no longer adequate to use just carefully assessed means, but rather other methods that reflect the full range of values of all the uncertain quantities need to be used. Sometimes such analyses will take the form of ad hoc stochastic simulation methods. Social risk aversion needs to be brought to bear in such situations, and this may not be an easy thing to do well and defensibly. The Precautionary Principle (Cameron and Werksman 1991) is one approach to acting responsibly in the face of uncertainty and lack of "full" scientific knowledge (Young 1993), but it may be really too cautious (Chisholm and Clarke 1994). Others, especially minimax-type criteria, imply an extreme, if not pathological, degree of risk aversion on behalf of society and thus are unlikely to be relevant to most concrete phenomena. Risk aversion effects at a more modest and empirically relevant level should, however, at least be considered in environmental policy analysis, even if this might inevitably take the would-be analyst into a more complex, probably expensive and subjective approach.

CONCLUSION

With the increasing recognition of the importance of the environment to both present and future welfare of the species on the planet, resource issues have risen to a more prominent position in the research, teaching and analytical agenda surrounding farm management. Farm management economists are now necessarily also "resource economists"—a reality that has been now recognized in many parts of the academic and professional world.

The resources of relevance to farming must, however, be broadly conceived. In their review of key resource issues threatening global agriculture, Crosson and Anderson (1995) have advanced the view that the real threat is not so much the degradation of natural resources per se, but rather the degradation of the capacity of societies, especially those in LDCs, to assemble systematically the requisite knowledge embodied in the people, technology and institutions that will be necessary to meet the challenges of sustainable higher productivity facing farming. They contend that the threat of degradation of the knowledge resource should be a primary focus of agricultural development policy. There are worrying trends in the extent of investment (especially public) in knowledge systems (Pardey and Beintema 2001) but there is still ample opportunity for both public and private entities to undertake the needed enduring investments in knowledge production that can underpin future growth of the global agricultural sector and its responsible resource management for future generations.

In a world in which a central unifying theme is a commitment to strong and early growth that brings a harvest of economic benefits to all individuals, it is worth noting that other things grow too and must receive some attention along the way. It is clear that, with a proliferated nuclear-weapon capability, the capacity for polluting large parts of it and thus to damage the global environment in a major way that may be disturbingly persistent has significantly increased. One need look no further than Chernobyl for a hint of possible outcomes (Hertzman 1995, p. 37), and for non-nuclear, agriculture-linked cases, perhaps that of Bhopal is even more instructive (Morehouse 1994).

Whether we like it or not, the environment is squarely now part of the agenda of contemporary farming everywhere, and is thus adding to the challenge of all those seeking to make farming more successful. Governments have responsibilities to assist with the provision of environmental public goods and development agencies too should play supportive roles, especially when the public goods have a global character.

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MINI-BIO

Emeritus Professor Jock R. Anderson left home (and the farm he still owns) at Monto, Queensland, Australia, in a quest for knowledge in agricultural science, at the University of Queensland, St. Lucia, Brisbane. He pursued this quest with a twist towards farm management in undertaking a PhD in agricultural economics at the University of New England, Armidale, where he stayed on as a staff member until 1989, including as Professor of Agricultural Economics, and Dean of the Faculty of Economic Studies. Anderson joined the World Bank in 1989, where he now serves as Adviser, Rural Strategy and Policy. He is an elected Fellow of: the Australian Institute of Agricultural Science; the American Agricultural Economics Association; and the Academy of the Social Sciences in Australia.