Response by Marta G. Rivera-Ferre

Although Dr Wager does not address directly my original article in his correspondence (Rivera-Ferre, 2008), a response to his comments is nevertheless useful to explain my position on the IAASTD report. His article, in my view, is symptomatic of the broader compartmentalization of knowledge among commentators in the agricultural sciences: researchers in the natural sciences are often not aware of the socio-economic and environmental contexts of their research. The IAASTD has produced a comprehensive report that analyses and describes many, if not all, of the economic, ecological and social functions and potentials of agriculture, which, together, form the three classical pillars of sustainability. A key conclusion from the report is that agriculture as

a whole has suffered from insufficient attention given to, in particular, the environmental and social factors, including maintenance of farmers' livelihoods.

The increasingly specialized technologies that are being used in some agricultural production systems are the result of a paradigm that focuses on productivity and further commodifies the agri-food chain from agriculture to food. In this context, genetically modified (GM) crops are simply the latest technology that accentuates the commodification of agriculture at the possible expense of social and environmental sustainability, including the economic sustainability of farming communities. I agree with Dr Wager that GM crops are wrongly singled out for criticism, while there are many other problems with current agricultural practices that also deserve critical attention.

In my opinion, GM crops are actually a symptom of a different problem: a model of agriculture that does not adequately consider agricultural ecosystems in a wider context before applying knowledge and technology. Such a context can normally be well-defined by the social, environmental and economic sciences, which means that an analysis in collaboration with experts from these disciplines should be performed before developing any new technology. In addition, the technology has to work for the farmers and the communities who will use it, so they too need to be involved at very high levels. So, where in fact might Dr Wager and I disagree? Possibly on how we formulate the problems to be solved and the role of technology in solving them. This is the rational conclusion of the IAASTD report, which gives an important role to biotechnology but does not equate all biotechnology with GM crops.

In my opinion, there are several considerations that should be taken into account before using GM organisms to produce food, feed or industrial products. First, what are the requirements of local communities? To answer this question, we need to involve and promote the participation of stakeholders to make the scientific decision-making process more democratic, as the IAASTD report recommends. Second, solutions should be matched to the social context in which they are to be implemented, and should respect and collect historical perspectives, the traditional knowledge of indigenous and local farmers, as well as any possible impediments to effective use. Finally, we must consider the ecological context, including the impact of various

technological solutions on endemic and autochthonous species of seeds and animal breeds, and the effect of environmental conditions—such as weather, soil or the wild fauna—on the efficacy of the technology. Of course, these considerations are not exclusive to GM crops; over-irrigation, pesticides and fertilizer use, for example, also have an impact in a social context and on the environment.

In a second phase, we should perform a cost-benefit analysis. Would it be cheaper from all perspectives—economic, environmental and social—to apply a technological solution or are there other, equally efficient, context-specific options that could fulfil the same function? Such a thorough analysis of all the relevant factors would allow us to find productive and efficient solutions, including, of course, the use of new technologies whenever these match local conditions and local cultures. It is this type of integrated approach to agriculture that the IAASTD report details, and it requires that we listen to many different perspectives, options and solutions to provide greater diversity in decision-making and the scientific process; after all, is not diversity the basis of sustainability?

Perhaps the problem begins with the reductionist paradigm that underlies much of the research on agriculture. When researchers apply for funding, they are making both conscious and unconscious decisions based on the type of agricultural systems with which they are most familiar or in which they think the funding body is likely to be interested. It is particularly significant in wealthy countries because of the increasing role played by the private sector in funding agricultural research, which naturally leads to a focus on agroecosystems that suit the needs of business. More generally, all decisions, even in research, are influenced by paradigms. This is well understood by social scientists, but is perhaps not apparent knowledge in the culture of the life sciences. For this reason, as life scientists, we should be more willing to work with our colleagues in the social sciences; they complement our work and contextualize our research. In my view, it is extremely important for us to define and be aware of the paradigms under which we choose to work, and to understand the broader social, economic and environmental consequences of our research.

The reductionist and productivist paradigms thus encourage the pursuit of projects that attempt to solve problems with technology, even if a solution could be achieved

by political or other means (Heinemann, 2008a). This approach is different to one based on a paradigm that regards agriculture as a more complex system. To give an example, let us assume that our objective is to increase food production generally. We could achieve this goal either by the intensification of agriculture under a productivist paradigm or by improving more traditional practices under an agroecological paradigm. I will not comment on whether one particular approach is more efficient or more sustainable, but will just point out that, even if we focus only on yield, as Dr Wager mentions in his letter, numerous scientific studies support the idea that the productivity of sustainable agriculture—of which organic is but one type—can be increased and adapted to local contexts (Badgley *et al*, 2007; FAO, 2007; Pretty *et al*, 2003; Diop, 1999). Hine *et al* (2008), for example, concluded that organic agriculture in Africa can increase both productivity and income for local farmers, as well as improve social capital without causing environmental damage. Other studies found that the yields of ecological agriculture can be maintained, even with reduced use of nitrogen fertilizers (Tonitto *et al*, 2006).

The IAASTD report's support of agroecological practices as a potential solution to hunger and malnutrition might be one of the reasons that some with a vested interest in industrialized agriculture have been strongly critical of it. However, a true discussion of the topic would start by recognizing that technological advances and the ensuing increases in food production over the past decades have not done away with hunger and poverty: ironically, 75% of under- or malnourished people are actually those who produce food (Scherr, 2003). Therefore, the problem is not primarily a lack of food and, as such, cannot be solved by simply increasing yields, whether by sustainable agriculture or GM crops. We need to seriously analyse why many of the world's poor are still hungry before we can develop efficient solutions, technological or otherwise.

Given the disparity of results and opinions, and the complexity of the issue, the decision to support one type of agriculture or another requires something more than a purely technical analysis. Personally, I prefer a focus on sustainable agriculture because this approach is context-dependent and does not only focus on a single objective—increasing yield or decreasing contamination, for example—but on an integrated

management that fulfils several of these objectives. This management is more knowledge-intensive and so requires an important effort from the scientific community, farmers and other stakeholders.

To explore this point in more detail, we can consider the example of Golden Rice that Dr Wager mentioned in his correspondence. In this case, the problem to be solved is malnutrition owing to a deficiency of vitamin A in the diet. The approach proposed by the IAASTD would first try to understand the reason why these people suffer from vitamin A deficiency and would analyse their agricultural production systems, the local diet, their economic and social situation—in the past, the present and foreseeable future—as well as any other relevant factors. In a final step, it would consider the consequences of using genetically engineered rice as a solution: for example, the social and environmental consequences of freely distributing GM rice to farmers. Are we increasing the dependency of small communities on a technology that they cannot produce or modify? Is Golden Rice a technological charity with potentially severe consequences, such as making local farmers even more dependent on developed countries and seed companies, or does it truly promote their self-sufficiency and allow them to maintain their own seed stocks and pursue locally informed breeding programmes? All these aspects should be considered before we make massive

investments in particular technologies lest we waste resources and miss other more complex, but cheaper, cultural, political, ecological and technological opportunities. I would apply the same logic to drought-resistant plants (Heinemann, 2008a). If the present model of agriculture and global food production has contributed to a reduction in biodiversity, should we continue in this direction? There are still many plant varieties that are more tolerant to drought conditions than related preferred crop varieties, and it might therefore be wiser and more efficient to use local varieties in a manner that farmers can sustain, rather than to invest in research to develop GM drought-resistant varieties of preferred crops.

In conclusion, given the strategic importance of food and agriculture, the extent of the problem and the many different interests, it was clear from the beginning that the results of the IAASTD would not satisfy everyone (Heinemann, 2008b). However, we should not engage in economic or technical discussions for the sake of controversy; rather, we should focus our efforts on generating scientific knowledge to improve the situation of poor and subsistence farmers, and to solve the problems they face at their cause, even if this forces us to challenge classical structures and research paradigms. In the end, history has shown that the most revolutionary findings of science have traditionally been against mainstream positions.

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