The Contested Vision for Agriculture's Future: Sustainable Intensive Agriculture and Agroecology

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THE CONTESTED VISION FOR AGRICULTURE’S FUTURE: SUSTAINABLE INTENSIVE AGRICULTURE AND AGROECOLOGY

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I. INTRODUCTION

In the 1990 United States Farm Bill,1 Congress defined sustainable agriculture as:

[A]n integrated system of plant and animal production practices having a site-specific application that will, over the long term: (A) satisfy human food and fiber needs; (B) enhance environmental quality and the natural resource base upon which the agricultural economy depends; (C) make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; (D) sustain the economic viability of farm operations; and (E) enhance the quality of life for farmers and society as a whole.2

For purposes of this Article, the 1990 congressional definition of sustainable agriculture is a useful, satisfactory definition. Midwestern agriculture in the United States faces a future in which Congress and American society assuredly will evaluate its agricultural practices and performance by the five criteria set forth in the 1990 definition. Moreover, agriculture worldwide will also face a future in which global society will evaluate agricultural practices and performance by a very similar, if not identical, set of criteria. Agriculture in the Midwest and around the world must move in a “sustainable” direction along the lines set forth in the 1990 definition, even if societal actors, domestically and internationally, modify the definition as time passes and conditions change.

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Sustainable intensive agriculture meets the five criteria of the 1990 congressional definition. By adding the word “intensive,” there is additional focus on how to achieve sustainable agriculture. More particularly, sustainable intensive agriculture emphasizes that modern science and modern technology are crucial components in achieving sustainable agriculture. Sustainable intensive agriculture builds upon the agricultural developments of the past century and modifies those developments to better account for advances in scientific knowledge and technological advances affecting agriculture. By building and modifying these developments, sustainable intensive agriculture aims to increase agricultural productivity, reduce negative agricultural impacts on the environment, improve agricultural prosperity, and enhance societal benefits through abundant, affordable, safe, and nutritious foods, fibers, fuels, and other agricultural products.3

In contrast to sustainable intensive agriculture, other individuals promote a vision for agriculture rooted in the term “agroecology.” As defined by one proponent,

Agroecology is both a science and a set of practices. It was created by the convergence of two scientific disciplines: agronomy and ecology. As a science, agroecology is the “application of ecological science to the study, design, and management of sustainable agroecosystems.” As a set of agricultural practices, agroecology seeks ways to enhance agricultural systems by mimicking natural processes, thus creating beneficial biological interactions and synergies among the components of the agroecosystem.4

In the goals for agriculture, sustainable intensive agriculture and agroecology have much in common. But in the methods, practices, and performance to achieve sustainable agriculture, these two visions for the future of agriculture are quite disparate.5

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4. Human Rights Council, Report Submitted by the Special Rapporteur on the Right to Food, U.N. Doc. A/HRC/16/49 (Dec. 17, 2010) (Olivier De Schutter), available at http://www2.ohchr.org/english/issues/food/docs/A-HRC-16-49.pdf. When this author speaks of proponents of agroecology in this Article, the author refers to those proponents cited in footnotes 5, 7 & 8. The author is aware that there are disagreements within the movement for agroecology and that not every faction is as strongly opposed to modern science and modern technology as the proponents of agroecology cited in those three footnotes.

While sustainable intensive agriculture can adopt and be complementary to most of the practices of agroecology, the proponents of this practice are explicit that agroecology rejects sustainable intensive agriculture, in particular sustainable intensive agriculture’s emphasis on modern science such as biology and chemistry, and modern technologies such as transgenic crops and manufactured inputs. Similarly, other proponents of agroecology derisively describe sustainable intensive agriculture as a modern, post-World War II techno-science culture that adopts a centralized top-down path for poverty and hunger alleviation. These same proponents support agroecology, a practice that frames poverty and hunger as social, behavioral and political, and emphasizes a localized bottom-up path for poverty and hunger alleviation. As these authors state in their conclusion, “We find limitations to top-down innovation because of largely productivist objectives.”

II. WHAT IS AT STAKE?

Why does it matter that there are competing visions of agriculture? Why does it matter that sustainable intensive agriculture posits a vision that emphasizes modern science and modern technology with agricultural production as the primary goal for agriculture? Why does it matter that the proponents of agroecology posit a vision that emphasizes social, behavioral, and political dimensions with agricultural production as, at best, a secondary goal for agriculture?

It matters because the Food and Agriculture Organization of the United Nations reported that in 2009, over one billion people were undernourished. It matters because hundreds of millions more people

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8. Quist et al., supra note 7, at 508.

9. Quist et al., supra note 7, at 507. What Quist and co-authors name as “top-down innovation” is what this author calls sustainable intensive agriculture.

today are malnourished even if they are not hungry. It matters because the world’s population, presently at seven billion people, will likely rise to between nine and ten billion people by the year 2050. Almost all of these additional people will be citizens of developing countries, not developed, wealthy countries like those in Europe and North America. As Gordon Conway stated about this “chronic crisis”:

The fundamental drivers [are] the increasing demand for food: population increase, rising per capita incomes [changing food habits to more meat, more processed foods, and higher value foods], and the competing demand for biofuel crops; and the deficiencies of supply caused by rising input prices, land and water scarcity and deterioration, slowing productivity gains and climate change.

The question thus facing the United States, global society, Midwestern farmers, and farmers worldwide is as follows: which vision for agriculture provides the better path forward to meet the challenges of demands for food and supply of food? This Article argues that sustainable intensive agriculture, including its complementarity with agroecology, provides the better path forward.

The author reiterates that sustainable intensive agriculture can adopt and is compatible with most of the practices of agroecology. Sustainable intensive agriculture can and will learn from and can and will adopt best management practices developed in agroecology. It is agroecology, as defined by many of its proponents, that explicitly excludes modern science, modern technology, and a production orientation for agriculture. Indeed American conventional farmers already use agroecological practices, though the farmers are more likely to call them conservation practices. Sustainable intensive agriculture is technologically neutral. Agroecology with its exclusions is not.

11. Id. at 8.
12. Id.
13. Id.
14. Id.
15. See generally Des Keller, Conservation and Stewardship Showcase, PROGRESSIVE FARMER, Feb. 2013, at 14; U. Lehner, Good Stewardship = Good Profits, PROGRESSIVE FARMER, Jan. 2013, at PF-42. Indeed, this author hopes that the discussion favoring sustainable intensive agriculture will show that it embodies the goals of agroecology by meeting the criteria of sustainable agriculture, as quoted in the first paragraph of this Article, from the 1990 U.S. Farm Bill.
III. SUSTAINABLE INTENSIVE AGRICULTURE

Looking at the five criteria for sustainable agriculture as set forth in the 1990 Farm Bill,\(^{16}\) does sustainable intensive agriculture fulfill these five criteria?

A. CRITERION A: SATISFY HUMAN FOOD AND FIBER NEEDS

Agricultural production can rise through two methods: extensification and intensification.\(^{17}\) In extensification, farmers expand the amount of land farmed and by farming more land can produce a greater amount of agricultural harvests. In intensification, farmers use technological inputs such as fertilizers, improved seeds, and herbicides/pesticides to increase the amount of agricultural harvests per acre.

While a simplified history, it is accurate to say that farmers increased the amount of agricultural harvests primarily by extensification until well into the twentieth century.\(^{18}\) Beginning in the early twentieth century and especially after World War II, farmers adopted technology at a rapid rate. Since World War II, farmers have increased the amount of agricultural harvests primarily by intensification.\(^{19}\) Using the concept of total factor productivity, agricultural outputs have quadrupled since 1910 while inputs have remained relatively steady.\(^{20}\) But the inputs since 1910 have changed drastically from inputs primarily in labor to inputs based on technology such as mechanization, seed, chemicals, and irrigation. With this great increase in productivity, farmers have fed and clothed more people than ever before in history. Agricultural intensification based on science and technology has been the primary means by which agricultural supply has significantly increased over the past sixty years.

One particular manifestation of agricultural intensification applicable to the developing world is the agricultural productivity increase called the Green Revolution.\(^{21}\) Farmers in Mexico, the Philippines, and parts of Asia greatly increased their yields in wheat and rice with improved seeds through modern plant breeding and a package of inputs such as fertilizers and irrigation.\(^{22}\) Hundreds of millions of peo-


\(^{17}\) D. Southgate et al., The World Food Economy 41 (Blackwell Pub. ed., 2007).

\(^{18}\) Id. at 52.

\(^{19}\) Id. at 56.

\(^{20}\) Id. at 51 fig.3.1.

\(^{21}\) See Conway, supra note 10, at 41.

\(^{22}\) See id. at 43, 46, 48 (stating that Mexico’s yields of rust resistant wheat increased to the point where imports of foreign wheat were no longer needed, Pakistan
ple avoided starvation because farmers produced more staple foods and sold them to food consumers at declining prices. After calling the Green Revolution an undisputed success, Gordon Conway summarized its achievements by stating that “global production of cereals has risen from 900 million tons in 1960 to 2,500 million tons in 2009, faster than the rise in global population over the same period from 3.1 billion to 6.9 billion . . . .”

Yet, Conway acknowledges that the Green Revolution had less impact on the poor than was expected, was more localized in its reach (particularly in its reach into Africa and African farmers), and had environmental problems and resource degradation effects. For these reasons, Conway calls for a “Doubly Green Revolution.”

One facet of the “Doubly Green Revolution” is plants and crops developed through modern breeding techniques, including genetic modification. Crops created through genetic modification have been adopted widely with excellent results for increased production.26 From 1996 to 2010, genetically-modified crops have increased production to global output by 275.5 million tons for the four major genetically modified crops. Moreover, genetically-modified crops have benefitted farming operations large and small, high-tech or low-tech, in developed or developing countries with increased production and improved economics. As one research paper stated in summary, “No evidence that [genetically-modified] technology benefits more developed than developing countries was found. Indeed, the agronomic and economic performance of [genetically-modified] crops versus conventional crops tends to be better in developing countries than for developed countries.”

While the studies cited in the preceding paragraph provide evidence that genetically-modified crops have already benefitted farmers and food security, modern plant breeding offers much hope for the future. Modern plant breeding has not exhausted its potential for increasing agricultural production for food security. Not every

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23. Id. at 61-62.
24. Id. at 62.
25. Id.
26. See, e.g., id. at 169 (stating that hybrid rices in China have dramatically affected rice production).
improvement in plant breeders’ laboratories or controlled field trials will be successful in farmer’s fields, yet modern plant breeding will keep developing crops—some of these crops will be successful. Seven examples of the developments in the pipeline should be sufficient to make the point about hope for the future:

- RNAi technology for controlling insect-transmitted virus in cassava;\(^30\)
- Selective breeding of fast-growing strains of Nile Tilapia;\(^31\)
- “Wheat modified to resist aphids”;\(^32\)
- New rice strains for Africa by modern cross-breeding of Asian and African varieties;\(^33\)
- Pearl millet, a grain similar to sorghum and a subsistence grain in Africa and Asia, developed to be resistant to ergot disease;\(^34\)
- Cassava in Nigeria with multiple resistance to various viruses, bacterial blights, and insects;\(^35\) and
- Plant photosynthesis for changing inefficient C3 plants such as wheat and rice into efficient C4 plants such as maize, sorghum, and sugarcane. This photosynthesis gene research focuses on direct yield improvement in contrast to the six earlier research projects that focused on indirect, effective yield improvement by reduction of pests and diseases.\(^36\)

At this point, a crucial difference between sustainable intensive agriculture and the proponents of agroecology becomes evident. Those who favorably view sustainable intensive agriculture support the con-


\(^{36}\) Press Release, Cornell Univ., Newly Discovered “Scarecrow” Gene Might Trigger Big Boost in Food Production (Jan. 24, 2013), available at http://www.pressoffice.cornell.edu/pressoffice/releases/release.cfm?r=72281 (“Cornell University researchers have taken a leap toward meeting those needs [food supply and food security] by discovering a gene that could lead to new varieties of staple crops with 50 percent higher yields.”).
tinued and expanded use of science and technology to reach every farmer in the world. The proponents of agroecology call for a fundamental rethinking of agriculture, specifically to reorient agriculture away from the science and technology of modern plant breeding.

**B. CRITERION B: ENHANCE ENVIRONMENTAL QUALITY AND THE NATURAL RESOURCE BASE**

By its activities, agriculture is "unnatural." Unlike hunters and gatherers, agriculturalists purposefully disturb the surrounding environment in order to produce food, fodder, fiber, and fuel for human uses. Thus, agriculture entails external impacts on the environment. As people have grown wealthier and have learned more about environmental interconnections, humans have begun to worry, and rightly so, about the negative impacts of agriculture. Humans have started to seek ways to practice agriculture while reducing negative impacts on the environment. As we move into the future with food demands, agriculture needs to meet those demands while simultaneously reducing its external impacts on the environment. This is the second criterion of sustainable agriculture.

Evidence about sustainable intensive agriculture, especially genetically-modified crops, already shows reduced impact on the environment and the natural resource base in three ways particularly worth considering.

First, by providing farmers with herbicide-tolerant crops bred through both classical breeding and genetic modification techniques, sustainable intensive agriculture has allowed farmers to manage competition weeds more easily. Farmers who use herbicide-tolerant crops are able to choose to move to reduced-tillage or no-till agriculture, a practice where farmers do not disturb the soil by ploughing.

Environmental benefits from reduced tillage systems are numerous: less erosion, less sediment and its attached chemicals in water, rebuilt soils, reduced carbon footprint (less greenhouse gases) by reduced

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38. See generally Garnett & Godfray, supra note 5; De Schutter & Vanloqueren, supra note 6; Kershen, supra note 3.

39. See, e.g., Wade Givens et al., Survey of Tillage Trends Following the Adoption of Glyphosate-Resistant Crops, 23 Weed Tech. 150, 150 (2009), available at http://www.gri.msstate.edu/publications/docs/2009/03/6134givens_2009_tillage_trends.pdf (“Overall, producers in a crop rotation that included a GR [glyphosate-resistant] crop shifted from a relatively more tillage-intense system to reduced-till or no-till systems after implementing a GR crop into their production system.”).
equipment emissions, improved water retention, and water conservation on fields.40

Second, sustainable intensive agriculture has reduced pesticide usage in agriculture through insect-resistant crops, benefiting both the environment and human health.41 Insect-resistant crops are designed so that the impact on pests comes from the plant itself rather than through the application of external pesticide sprays. Therefore, it is not a surprise that the reduction in pesticide use in fields planted with insect-resistant crops has been impressive. Moreover, due to the reduced pesticide sprays, the environmental impact on the field has declined while the environmental quality has improved.42 Particularly in developing countries, the reduction in pesticide use and pesticide spraying has meant reduced pesticide exposure for farmers, and farmers’ health has improved.43 Regulatory agencies have required an insect-management strategy, usually a refuge approach, for genetically-modified insect resistant crops. This strategy reduces the risks for insects developing resistance to the insect-resistant crop.44

Third, through the adoption of insect-resistant crops, sustainable intensive agriculture has improved the environmental impact of agriculture on beneficial insects. Insect-resistant crops lead to reduced use of broad spectrum insecticides. Insect-resistant crops carry genes


41. Brookes, supra note 27, at 35; Mannion & Morse, supra note 28, at 752. The author limits this paragraph to pesticides and insect-resistant crops. While herbicide-tolerant crops also have shown a beneficial environmental impact, measured by environmental impact quotient rather than quantity amount, the continuous, heavy use of glyphosate raises the issue of weed evolution so that the weeds become resistant to the applied herbicide. Farmers will need careful herbicide management to handle weed resistance. Compare Fernandez-Cornejo, supra note 40, and Brookes, supra note 27, at 35, and Mannion & Morse, supra note 28, at 752 (making the clear distinction between quantity of glyphosate used and the environmental impact quotient of glyphosate), and Charles Benbrook, Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years (The Organic Center ed., 2009) (the word “pesticide” is in the title but the report focuses almost exclusively on the herbicide glyphosate without distinguishing quantity from environmental impact quotient).

42. See, e.g., Brookes, supra note 27, at 35.

43. Pray et al., Five Years of BT Cotton In China – The Benefits Continue, 31 Plant J. 423, 423 (2002) (“Over 4 million smallholders have been able to increase yield per hectare, and reduce pesticide costs, time spent spraying dangerous pesticides, and illnesses due to pesticide poisoning.”).

44. For a brief explanation of the refuge approach, see generally Understanding Evolution: Refuges of Genetic Variation: Controlling Crop Pest Evolution, Understanding Evolution (Feb. 11, 2013), http://evolution.berkeley.edu/evolib/article/agriculture_04.
that target specific crop pests. With better targeting of pests by the crops and reduced use of broad spectrum insecticides, farmers using sustainable intensive agriculture have increased the insect biodiversity in their fields. The beneficial impact from insect-resistant crops affects not only the field planted with the crop, but also neighboring fields not planted with an insect-resistant crop. Due to a “halo” or “spill-over” effect, neighboring fields also have increased numbers of beneficial insects. Neighboring fields consequently gain better biological control of crop pests through extra beneficial insects that farmers must control to protect their plants and their yields. Sustainable intensive agriculture is a multiple win for biodiversity with insect-resistant crops.

These three examples of the environmental benefits of sustainable intensive agriculture serve as a reminder that sustainable intensive agriculture adopts goals of agroecology. Reduced-till and no-till, reduced pesticide usage, and beneficial insects emphasize that sustainable intensive agriculture and agroecology can be complimentary in agricultural development.

C. CRITERION C: EFFICIENT USE OF RESOURCES AND INTEGRATION OF NATURAL BIOLOGICAL CYCLES AND CONTROLS

A previous section of this Article addressed the question: what is at stake? Criterion C of sustainable agriculture adds another dimension to that question. To meet food demands between now and 2050, many estimate agricultural food output will have to increase fifty percent without greatly expanding in land base, using fewer resources, and with reduced water usage. Criterion C is not seeking increased production per unit of land; criterion C seeks an increased production per input of resources—something akin to a life-cycle assessment of agricultural production. Many in agricultural development phrase this challenge by saying that agriculture will have to produce more


46. Mannion, supra note 28, at 754.

47. Id.

48. Id.

49. Life Cycle Assessment, EPA, http://www.epa.gov/nrmrl/std/lca/lca.html (last visited Jan. 29, 2013) ("LCA [(life cycle assessment)] is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service by: Compiling an inventory of relevant energy and material inputs and environmental releases; Evaluating the potential environmental impacts associated with identified inputs and releases; Interpreting the results to help you make a more informed decision.").
with less or that agriculture will have to produce more with a reduced environmental footprint.  

Farmers around the world, but particularly in developed countries, have adopted science and technology for intensification for the past sixty years. Currently, agricultural researchers are able to use the life-cycle assessment to compare modern agriculture to other forms of agriculture and comparatively assess the environmental impacts. Measured by per unit of product (for example kilogram of milk or billion kilograms of beef), the comparisons are decidedly in favor of a lesser environmental impact for intensive agriculture now than for the less-intensive agricultures of yesterday. The figures for a lesser environmental impact are striking and thus worth quoting. With respect to beef:

Modern beef production requires considerably fewer resources than the equivalent systems in 1977, with 69.9% of animals, 81.4% of feedstuffs, 87.9% of water, and only 67.0% of the land required to produce 1 billion kg of beef. Waste outputs were similarly reduced, with modern beef systems producing 81.9% of the manure, 82.3% CH4, and 88.0% N2O. . . . The C [carbon] footprint . . . was reduced by 16.3% compared with equivalent beef production in 1977.

And with respect to dairy production:

Modern dairy practices require considerably fewer resources than dairying in 1944 of animals, 23% of feedstuffs, 35% of the water and only 10% of the land required to produce the same one billion kg of milk. Waste outputs were similarly reduced with modern dairy systems producing 24% of the manure, 43% CH4 and 56% N2O . . . The carbon footprint . . . in 2007 was 37% of the equivalent milk production in 1944.

Studies using similar methodologies that compare impacts between beef production strategies (conventional, natural, and grass-fed in one study and calves weaned to feedlots, calves weaned to pasture

50. For a thoughtful review and discussion of the points presented in this paragraph, see CONWAY, supra note 10, at 227-306, 329 (discussing pests, soil, water, climate change, and greenhouse gases).


52. Beef Production, supra note 51, at 4250.

53. Dairy Production, supra note 51, at 2160.

for background growth before feedlots, and calves finished on pasture in a second study\(^{55}\) determined that the smallest environmental impact was for conventional beef production and for feedlot-finished beef.

At this point, the proponents of agroecology would point out that the cited studies measured units of output, or “the productivist objectives,” and would reject these studies in favor of other metrics. Indeed, the authors of the calves study caution,

[W]e do not consider costs and benefits related to variables like job creation or quality of life, nor do we address a spectrum of proximate ecological considerations, including biodiversity impacts, or concerns such as animal welfare. Our results should therefore not be taken as stand-alone metrics of the sustainability of feedlot versus pasture-finished beef production in the US Upper Midwest.\(^{56}\)

Recognizing the agroecological criticism does not diminish the findings of these studies that intensive agriculture has significant environmental benefits for meeting food demand and food security for the present and future human populations. Societies can decide to value other metrics, but those societies must also face the negative environmental impacts, the reduced food supply, and the increased risk of food insecurity. Nor does recognizing the agroecological criticism diminish these findings showing that modern agriculture satisfies criterion C of sustainable agriculture.

Modern plant breeding has several traits in the developmental pipeline that would efficiently use resources and imitate natural biological systems if successfully developed and transferred to farmers. Five examples serve as evidence of pipeline traits for sustainable intensive agriculture that would fulfill criterion C:

- Drought tolerance for plants;\(^{57}\)


\(^{56}\) Pelletier, *supra* note 55, at 388.

Nitrogen use efficient plants;\textsuperscript{58} Phosphorus efficient plants;\textsuperscript{59} Nitrogen-fixing cereals;\textsuperscript{60} and Plant photosynthesis for changing C3 plants into C4 plants.\textsuperscript{61}

Each of the developmental projects listed focus on using natural resources more efficiently and more sustainably. If these developmental plants come into existence, sustainable intensive agriculture will use less water and fewer fertilizers such as phosphorus and nitrogen in producing the food quantity and the food security needed in coming years. Consequently, science and technology offer realistic hope that sustainable intensive agriculture will have new plants available to cope with the stresses and demands of resource limitations and climate changes, thereby fulfilling criterion C. The proponents of agroecology with their “productivist objection” reject all five of these research endeavors as technological fixes based on reductionist thinking.\textsuperscript{62} The reason this author can confidently state that the proponents of agroecology reject all five of these research endeavors is because each of these research endeavors uses transgenic techniques to achieve the desired goals.

D. CRITERION D: SUSTAIN ECONOMIC VIABILITY OF FARM OPERATIONS

Criterion D presents the question of what it means to sustain the economic viability of farm operations. If criterion D means that every farmer remains on the farm as a farmer, then this author suspects that both sustainable intensive agriculture and agroecology will flunk.


\textsuperscript{60} News, Major Investment to Persuade Bacteria to Help Cereals Self-Fertilise, John Innes Ctr. (July 15, 2012), http://news.jic.ac.uk/2012/07/cereals-self-fertilise/.

\textsuperscript{61} Press Release, Cornell Univ., Newly Discovered ‘Scarecrow’ Gene Might Trigger Big Boost in Food Production (Jan. 24, 2013) (on file with author), available at http://www.pressoffice.cornell.edu/pressoffice/releases/release.cfm?r=72281 (“If C4 photosynthesis is successfully transferred to C3 plants through genetic engineering, farmers could grow wheat and rice in hotter, dryer environments with less fertilizer, while possibly increasing yields by half, the researchers said.”).

this criterion. After all, the goal of both forms of agriculture should be the alleviation of poverty through agricultural development.\textsuperscript{63}

Agricultural development entails changes in the agricultural sector. In developing countries, these changes will include social and economic transitions from a population trapped in subsistence agriculture to a population free to adopt other occupations and lifestyles.\textsuperscript{64} Many farmers, and particularly their children, assuredly will leave the agricultural sector to pursue lives in non-farm occupations and urban locations.\textsuperscript{65} Certainly sustainable intensive agriculture promotes the goal of agricultural development for the purpose of getting rural people out of poverty.\textsuperscript{66}

If criterion D means agricultural development for the purpose of getting rural people out of poverty, the following three measures show that sustainable intensive agriculture satisfies economic viability for farm operations.

First, many studies exist discussing the economic impact of genetically-modified crops for farmers. In an on-going series of studies by PG Economics,\textsuperscript{67} the 2012 report in the series stated:

In 2010, the direct global farm income benefit from biotech crops was $14 billion. This is equivalent to adding 4.3\% to the value of global production of the soybean, maize, canola and cotton crops. Since 1996, GM technology has increased farm incomes by $78.4 billion. . . . In 2010, 54.8\% of the farm income benefits were earned by farmers in developing countries. The vast majority of these income gains for developing country have been from GM IR cotton and GM HT soybeans. Over the fifteen years, 1996-2010, the cumulative farm income gain derived by developing country farmers was $39.24

\textsuperscript{63} Two books that have influenced this author and whose themes are relevant to criterion D are as follows: Paul Collier, The Bottom Billion: Why the Poorest Countries Are Failing and What Can be Done About It (Oxford Univ. Press ed., 2007); Juma, supra note 37. While agricultural development is important for poverty alleviation, Collier’s book drives home the point that agricultural development by itself will not be sufficient. Other factors—civil wars, the resource curse, geographic isolation, and bad governance—will have equal, if not more important, impacts on poverty alleviation.

\textsuperscript{64} See, e.g., Southgate, supra note 17, at 147-61.

\textsuperscript{65} For example, some farm children freed of daily farm labor will aspire to become professional athletes. If that dream ends, they may decide to become lawyers and law professors—a more easily attainable career goal.

\textsuperscript{66} See Conway, supra note 10, at 329-30, 335, 338.

billion, equal to 50% of the total farm income during this period.68

Two other recent studies confirm positive economic benefits from genetically-modified crops. A 2011 report from the Ecologic Institute in Berlin concluded,

Due to the strong variations between regions and the additional varying factors found in the analysis that influence results on economic performance of GM crops . . . any generalized conclusions on the economic performance of GM crops for the whole world would inevitably be misleading. However, positive economic benefits have been observed for a number of countries, which is in line with other review studies (e.g. Carpenter, 2010, Gouse et al., 2009, Bennett et al., 2004a, Fernandez-Cornejo et al., 2005, and Qaim, 2009) and explains the high adoption rates of GM crops in these countries.69

A 2012 report from the European Commission, Joint Research Centre made these summary points about the global economic impact of genetically-modified crops:

Economic models have been developed to estimate the global economic welfare creation of [genetically-modified] cultivation and the distribution of its benefits among stakeholders. The data presented in the workshop show that HT soybeans generate 3 billion USD per year, distributed between the consumer/processors (50%), the adopting farmers (28%) and the innovating biotechnology section (22%). . . . In recent years a geographic shift of farmers’ benefits was observed from the initial situation where benefits were concentrated in the USA, Canada and Argentina to a situation where small farmers in a variety of developing countries are obtaining more benefits from the technology.70

Second, farmers, particularly subsistence farmers, are very sensitive to the risk of fluctuations in yield. Farmers do not want and would have a difficult time surviving economically if the harvest varies greatly from one year to another. Therefore, one facet of the economic viability of farm operations is to control this risk of yield fluctuations—called in recent years “resilience.”71 Studies now exist showing that genetically-modified crops improve the resilience of

68. Brookes & Barfoot, supra note 27, at 37.
71. Conway, supra note 10, at 98 fig.5.3 (defining resilience as “the capacity of an agricultural system to withstand or recover from stresses and shocks”).
farmers both in developed and developing countries.\footnote{See generally Michael D. Edgerton et al., \textit{Transgenic insect Resistance Traits Increase Corn Yield and Yield Stability}, \textit{30 Nature Biotechnology} 493, 493 (2012), \url{http://211.144.68.84:9998/91keshi/Public/File/49/30-6/pdf/nbt.2259.pdf}; Mannion & Morse, supra note 22, at 754; Gregory Regier et al., \textit{Impact of Genetically Modified Maize on Smallholder Risk in South Africa}, \textit{15 AgBioForum} 328, 334 (2012).} As one study stated,

Moreover, another but often overlooked fact is the capacity of [genetically-modified] crops to reduce variability of production and related income year on year, a characteristic which lends stability to farm incomes and facilitates planning. . . . In such circumstances [genetically-modified] varieties can provide a degree of insurance for the farmers in that they may help to stabilize outputs in the face of environmental uncertainty given that the farmers have to commit inputs such as land and labour.\footnote{Mannion & Morse, supra note 28, at 751, 754.}

Third, farmers know their own fields and know their own economic interests. Farmers are aware of the risks and benefits of the practices that each farmer adopts individually for his or her farm. Farmers will not adopt or continue to use a farm practice that does not provide benefits. Looking at farmer adoption rates around the world clearly indicates that farmers, when given access to genetically modified seeds, adopt sustainable intensive agriculture in overwhelming numbers. The International Service for the Acquisition of Agri-Biotech Applications ("ISAAA") publishes yearly the most comprehensive report on farmer adoption rates of genetically modified crops. In the report for 2011, the ISAAA wrote:

A 94-fold increase in hectarage from 1.7 million hectares in 1996 to 160 million hectares in 2011 makes biotech crops the fastest adopted crop technology in the history of modern agriculture. . . . The most compelling and credible testimony to biotech crops is that during the 16 year period 1996 to 2011, millions of farmers in 29 countries worldwide, elected to make more than 100 million independent decisions to plant and replant an accumulated hectarage of more than 1.25 billion hectares — an area 25\% larger than the total land mass of the US or China—there is one principle and overwhelming reason that underpins the trust and confidence of risk-averse farmers in biotechnology—biotech crops deliver substantial, and sustainable, socio-economic and environmental benefits.\footnote{Clive James, \textit{ISAAA Brief 43-2011: EXECUTIVE SUMMARY: GLOBAL STATUS OF COMMERCIALIZED BIOTECH/GM CROPS: 2011}, at 1 (2012), \url{http://www.isaaa.org/resources/publications/briefs/43/default.asp}.}
Proponents of agroecology downplay this ISAAA data, ignoring that farmers are credible managers of their own lands and lives.\textsuperscript{75} In India, where the debate between proponents of sustainable intensive agriculture and proponents of agroecology has been intense, two researchers commented on the farmers and their choice for sustainable intensive agriculture as follows:

Studies may disagree, but do have a centre of gravity, a central tendency. That centre of gravity is a clear refutation of the “failure of Bt cotton” narrative. But as important as formal studies is this grounded empirics of farmers trying out new ways to cope with a periodically devastating problem. Farmer adoption and diffusion ratify most convincingly the technology behind Bt cotton. There is curiously little attention given to the skill, experience and agency of farmers in assessing the new technology. In this case, their numbers — on yields, pesticide costs and income — accord with the central finding of the bulk of empirical work on Bt cotton. As farmers of necessity must count carefully, their numbers should count.\textsuperscript{76}

The ISAAA counted 16.7 million farmers who have chosen to plant genetically-modified crops. Of these 16.7 million, approximately 15 million were small-scale, poor farmers in developing countries and 1.7 million farmed in developed countries. Regarding developing countries (to use two examples), ISAAA counted 7 million Indian farmers (average 1.5 hectares of land) growing Bt cotton (i.e., cotton with a genetic trait from an ubiquitous soil bacterium *Bacillus thurengiensis*) on 10.6 million hectares of the 12.1 million cotton hectares (i.e. 88%). In China, seven million small-scale poor farmers (about 0.5 hectares of land) planted 3.9 million hectares of Bt cotton — equivalent to 71.5% of Chinese cotton.\textsuperscript{77}

\textbf{E. Criterion E: Enhance the Quality of Life for Farmers and Society}

As sustainable intensive agriculture satisfies the first four criterion of sustainable agriculture, it could be argued, \textit{ipso facto}, that sustainable intensive agricultural satisfies this fifth criterion. Satisfying human food and fiber needs, enhancing environmental quality, and making efficient use of non-renewable resources points towards enhancing the quality of life for society. Concomitantly, satisfying the same needs, enhancing the same quality, and achieving the same effi-

\textsuperscript{75} Quist et al., \textit{supra} note 7, at 496-97 figs.19.1 & 19.2.
\textsuperscript{77} James, \textit{supra} note 74, at 36.
cient use of resources points towards enhancing the quality of life specifically for farmers, the subset of society directly involved in agriculture.

Yet, criterion E can also be interpreted to mean enhancing the non-material qualities of life. While neither sustainable intensive agriculture nor agroecology can or should be expected to solve the dilemmas and sorrows of human existence, agriculture should be able to provide a rewarding and satisfying life for farmers—in contrast to daily drudgery and unremitting anxiety. Is there any evidence that sustainable intensive agriculture creates a rewarding and satisfying life?

In a study conducted by the European Commission in the year 2000, four years after genetically-modified crops began to be planted on a commercial scale, the Directorate-General for Agriculture stated the following:

In practice, the most immediate and tangible ground for satisfaction [with genetically-modified crops] appears to be the combined effect of performance (not necessarily measured by yields) and convenience of [genetically-modified] crops, in particular for herbicide tolerant varieties. These crops allow for a greater flexibility in growing practices and in given cases, for reduced or more flexible labour requirements.78

The European Commission Directorate General for Agriculture's identification of performance and convenience as the primary reasons that farmers adopt genetically modified crops is confirmed by other studies.79 A study from the Philippines states the reasons that farmers adopt genetically modified crops in terms that are most relevant to criterion E beneath the heading “Changes in Farmers’ Lives”:

During the FGD [(focus group discussions)] . . . the farmer-respondents were asked to share the changes in their lives brought about by their adoption of biotech corn. As expected the foremost response was increased income. This was probed further by asking the farmers the concomitant changes of having higher income. Their responses, all favorable and reflective of certain improvements in their lives, were as follows:

- Able to pay their loans and debts

78. DIRECTORATE-GENERAL FOR AGRIC., EUROPEAN COMM’N, ECONOMIC IMPACTS OF GENETICALLY MODIFIED CROPS ON THE AGRI-FOOD SECTOR, § 3.1.1 (2000).
THE CONTESTED VISION

• Able to send their children to college
• Acquired home appliances (e.g., TV, computers, refrigerators), vehicles, and even house and lot . . .
• Peace of mind (assurance of harvest as there are no more pests; lesser incidence of theft)
• Farming activities made simpler/easier
• Able to engage in other livelihood activities (e.g., driving public transport vehicle, livestock raising)
• Able to engage in other productive(sic) and activities (trainings and seminars).

These Filipino farmer statements about changes in their lives are powerful testimony of their enhanced quality of life, personally and for their families. In societies where many citizens are farmers, enhancing the quality of life of farmers does mean, ipso facto, the enhancement of the quality of life in society. Thus, the evidence indicates that farmers adopt sustainable intensive agriculture for reasons of performance and convenience. Probing these reasons shows that farmers adopting sustainable intensive agriculture enhance the lives of themselves and their families and, as a consequence, enhance the quality of life for society.

IV. AGROECOLOGY AND THE FIVE CRITERIA OF SUSTAINABLE AGRICULTURE

To this point in this Article, sustainable intensive agriculture has been measured against the five criteria of sustainable agriculture and is found to satisfy those five criteria. Now this Article turns towards agroecology, as described by the proponents of agroecology, and how it measures against these five criteria.

The author again repeats that sustainable intensive agriculture is compatible with many practices of agroecology. But the question worth addressing is whether agroecology, can satisfy the five criteria of sustainable agriculture when the proponents of agroecology reject science and technology for the agricultural sector. Of course the proponents of agroecology have confidence that agroecology can and does satisfy these five criteria, with its rejection and often because of its rejection of science and technology. This author disagrees.

80. Torres et al., supra note 79, at 44.
81. See Conway, supra note 10, at 336-40 (suggesting, through headings, that we can feed the world if: “We Recognize the Need for a New Doubly Green Revolution,” “More Attention Is Paid to Agroecological Research and Development,” and “We Accept that Biotechnology is an Essential Tool in Attaining Food Security.”).
82. See generally Human Rights Council, supra note 5; De Schutter & Vanloqueren, supra note 7; Quist et al., supra note 7.
A. CRITERION A: SATISFY HUMAN FOOD AND FIBER NEEDS

Although agroecology is not identical to organic farming, the proponents of agroecology consistently invoke organic agriculture as the path forward for agricultural production.83 In support of the claim that organic agriculture can feed the world, proponents rely heavily on three sources to support the claim: the Badgley study,84 the Pretty study,85 and the International Assessment of Agriculture Knowledge, Science, and Technology (“IAASTD”) study.86 Good reasons exist to doubt the credibility of the claims by these three studies.

With respect to the Badgley study, a careful analysis focused on wheat indicates that the Badgley study did not cite many comparative studies about organic and conventional wheat production. These uncited studies, including studies conducted by organic organizations, point to wheat yields in organic production being thirty percent to fifty percent lower than conventional wheat production.87 As wheat is a primary staple food, wheat production at thirty percent to fifty percent lower levels would mean a deficient wheat supply for the global human population currently and especially into the future.88

With respect to the Pretty study, a commentary by a Conservation Science Group opined:

While the volume and scope of data presented is impressive, we find that the analysis offers at most weak evidence for what can be achieved by these [resource-conserving] technologies. . . . The analysis gives us some ‘grounds for cautious optimism,’ but provides only a first indication of the potential of new techniques to promote productivity and sustainability. The next step is to go further, to identify general and specific drivers of failure and success, and thereby map the most promising avenues for improving yields while reducing the environmental impact of farming.89

83. See generally Quist et al., supra note 7, at 505-06.
88. Id.
89. Ben Phalan et al., Comment on “Resource-Conserving Agriculture Increases Yields in Developing Countries,” 41 ENVTL. SCI. & TECH. 1054, 1054 (2007).
Another analysis of the Pretty study commented that the Pretty study focused on “resource-conserving” techniques that conventional and sustainable intensive agriculture also use, such as integrated pest management, integrated nutrient management, conservation tillage, agroforestry, aquaculture, water harvesting, and livestock integration into farming systems. Moreover, the Pretty study relied on agricultural projects that used pesticides, herbicides, inorganic fertilizers, and (likely) genetically-modified soybean crops. Consequently, it can easily be argued that the Pretty study may be more supportive of sustainable intensive agriculture than of organic or agroecological farming.

With regard to the IAASTD study, a good sense for its quality may be gained by quoting from three publications about the IAASTD process. The World Bank, a sponsor of the study, summarized its evaluation of the IAASTD study as follows:

The present [World Bank] review rates the overall outcome as moderately unsatisfactory. The IAASTD was a useful experience at the nexus of politics and science. However, agricultural technology – with its complexity, diversity, and politics – proved to be a bridge too far. For the substantial resources used, it did not offer sufficient new knowledge or conceptual frameworks for decision makers; it gave conflicting messages, and, for a 50-year timeframe, underestimated the potential of new technologies.

Furthermore, an international affairs academic described the IAASTD process as follows:

The panel was launched with strong political support and high expectations, but almost everything that could go wrong

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91. Id.
92. Id.
93. WORLD BANK INDEPENDENT EVALUATION GROUP, INTERNATIONAL ASSESSMENT OF AGRICULTURAL KNOWLEDGE, SCIENCE AND TECHNOLOGY FOR DEVELOPMENT: IAASTD (2010).

91. Id.
92. Id.
93. WORLD BANK INDEPENDENT EVALUATION GROUP, INTERNATIONAL ASSESSMENT OF AGRICULTURAL KNOWLEDGE, SCIENCE AND TECHNOLOGY FOR DEVELOPMENT: IAASTD (2010).
did. It became a lightning rod for debates on the role of agribusiness, globalization, biotechnology, and the merits of “science” over “traditional” knowledge. Key governments repudiated the final report. Debate on the merits of the IAASTD still rages in agricultural circles even though the IAASTD is defunct. This article explores the reasons for this failure.94

Two authors with years of experience in agricultural development panned IAASTD and its recommendations as follows: “If developed countries want to follow this [IAASTD] path—and the U.S. rejection of the IAASTD report shows that at least one does not—so be it, but it is a recipe for agricultural stagnation in most developing countries.”95 These same two authors opined that the IAASTD was deficient because:

[...] as a supposedly scientific review, the IAASTD should not have attempted to foist on the world a distinctly second-hand and, we think, second-rate “agroecology” of questionable value, nor should the IAASTD ask for or respect some decidedly anti-development and anti-science views expressed by the many vocal NGOs involved in the process.96

To end this discussion of whether agroecology as intertwined with organic agriculture can feed the world, it is worth referring to two recently published studies using meta-datasets of published organic-conventional comparative crop yields.97 Quoting from the abstract for the de Ponti study:

Our results show that organic yields of individual crops are on average 80% of conventional yields, but variation is substantial . . . . This analysis gave some support to our hypothesis that the organic-conventional yield gap increases as conventional yields increase, but this relationship was only weak . . . . Our analysis was at the field and crop level. We hypothesize that due to challenges in the maintenance of nutrient availability in organic systems at crop rotation, farm and regional level, the average yield gap between conventional and organic systems may be larger than 20% at higher system levels. This relates in particular to the role of legumes in the rotation and the farming system, and to the

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95. Wood & Lenné, supra note 90, at 177-78.
96. Id. at 185.
availability of (organic) manure at the farm and regional levels.\textsuperscript{98}

Quoting from the introductory summary in the Seufert study:

Our analysis of available data shows that, overall, organic yields are typically lower than conventional yields. But these yield differences are highly contextual, depending on system and site characteristics, and range from 5\% lower organic yields (rain-fed legumes and perennials on weak-acidic to weak-alkaline soils), 13\% lower yields (when best organic practices are used), to 34\% lower yields (when the conventional and organic systems are most comparable).\textsuperscript{99}

Even if agroecology, as identified with organic agriculture, averages eighty percent of crop yields of conventional agriculture as the de Ponti study indicates, the global food supply and the food security of human population, at present levels, most likely cannot tolerate a twenty percent reduction in food production. Using the Seufert study of thirty-four percent lower yields on the most comparable farms makes the food supply situation even worse by adopting organic farming.\textsuperscript{100} Moreover, the caveats are strong that agroecology, closely following organic standards, will provide even less production at farm and regional levels and fall farther behind if sustainable agriculture transitions to sustainable intensive agriculture. As a consequence, agroecology, if tied to organic agriculture, would become even less likely to produce adequate food and fiber for the needs of the increased human population from today to 2050.

It can be argued that the comparison in the preceding paragraph is agroecology to conventional or sustainable intensive agriculture in developed nations. If agroecology were adopted in developing nations, where food production on subsistence farms is very low, it could be argued that agroecology would improve agricultural production. Even assuming that point to be correct,\textsuperscript{101} one can still ask why these subsistence farmers are being offered a second-hand and second-rate form of agriculture when agricultural development could offer them sustainable intensive agriculture. As shown in the preceding discussion of criterion E, Filipino farmers are exceedingly pleased and greatly

\textsuperscript{98} De Ponti et al., \textit{supra} note 97, at 1.

\textsuperscript{99} Seufert et al., \textit{supra} note 97, at 229.

\textsuperscript{100} See \textit{id.} ("The average organic-to-conventional yield ratio for our meta-analysis is 0.75 (with a 95\% confidence interval of 0.71 to 0.79); that is, overall organic yields are 25\% lower than conventional.").

\textsuperscript{101} See \textit{id.} at 231 ("[W]e cannot, therefore, rule out the claim that organic agriculture can increase yields in smallholder agriculture in developing countries. But owing to a lack of quantitative studies with appropriate controls we do not have sufficient scientific evidence to support it either.").
benefit by being offered and by adopting sustainable intensive agriculture.\textsuperscript{102}

Agroecology, as defined by the proponents, appears to fail to satisfy criterion A—now and more so in the future.

B. \textbf{C}RITERION B: \textbf{E}NHANCE ENVIRONMENTAL QUALITY AND THE NATURAL RESOURCE BASE

As for the environmental impact of the agroecology, studies provide conflicting evidence about whether agroecology, as intertwined with organic agriculture, provides increased environmental benefits as compared to sustainable intensive agriculture. Two studies found that organic agriculture generally has positive impacts for environmental values.\textsuperscript{103} However, both of these studies cautioned that these benefits are on intensely managed individual fields and may not apply to farm level or the broader landscape level.\textsuperscript{104} Moreover, organic agriculture may perform well per field, but not per unit of production—i.e., the lower production in organic fields means that the actual environmental impacts from conventional or sustainable intensive agriculture are less per bushel or pound of agricultural product.\textsuperscript{105}

In contrast to these two studies, another study was very skeptical of claims for environmental benefits from organic agriculture.\textsuperscript{106} The author of this third study wrote, “It would be difficult to make a case for organic farming on any reasonable basis for environmental benefit compared to well-managed conventional or integrated farms.”\textsuperscript{107} The author concluded that integrated farm management, genetically modified herbicide tolerant crops, and no-till agriculture provide environmentally superior benefits as compared to organic agriculture.\textsuperscript{108}

In a small number of studies for this criterion B it appears that the proponents’ agroecology may have environmental benefits at the field level. However, the three studies do not support the claim that agroecology benefits the environment for the broader landscape (i.e., the natural resource base) in producing the food that society needs. In

\textsuperscript{102} See supra notes 72-73 and accompanying text.


\textsuperscript{104} Bengtsson et al., supra note 103, at 267; Tuomisto et al., supra note 103, at 318.

\textsuperscript{105} Tuomisto et al., supra note 103, at 318.


\textsuperscript{107} Id. at 772.

\textsuperscript{108} See id. at 774-75, 777.
contrast, sustainable intensive agriculture, using complementary practices from agroecology, does benefit the landscape at large.

C. CRITERION C: EFFICIENT USE OF RESOURCES AND INTEGRATION OF NATURAL BIOLOGICAL CYCLES AND CONTROLS

Moving forward, agriculture must produce the needed food, fodder, fiber and fuel and do so while reducing agriculture’s global impact on resources. When thinking of agriculture, the most significant resource is land itself.

To produce agricultural products, crops must have adequate nutrients. Crops take nutrients from the soils in which they grow in all agricultural systems—agroecology, conventional, and sustainable intensive agriculture. Farmers must find a way to replace these nutrients, or within a very few years the land is depleted and useless for agriculture.109 At the same time, crops need nutrients in accordance with the crop cycle so that the growing crop has the specific needed nutrient at the proper time in the growth cycle.110 Nutrient availability at the proper time is crucial to healthy plants and, ultimately, to crop yield.111

By rejecting science and technology and by intertwining with organic agriculture, the proponents of agroecology have restricted agroecology so that it does not use synthetic fertilizers. Agroecology relies instead on either cover crops (organic material ploughed back into the soil—often called “green manure”) or animal manures. The proponents of agroecology also reject modern breeding that develops genetically-modified plants with traits to improve soil-available nitrogen use, nitrogen fixation, and soil-available phosphorus use.

Whether agroecology derives plant nutrients from cover crops or animal manures, agroecology will use larger quantities of land as compared to sustainable intensive agriculture.112 Land must be used to grow the cover crops and land must be available for animal feed and pastures to produce animals manures.113 Land use under the agroecology will likely be not just larger but much larger if

109. See id. at 765.
110. Id.
111. Id.
112. Goulding & Trewavas, supra note 87. Throughout their paper, Goulding and Trewavas make the point that organic agriculture has tremendous difficulties in providing the amount of needed nutrients and the timing of the needed nutrients for the crop cycle. Id.
agroecology must depend to any significant degree on animal manure to gain adequate nutrients for crops.\textsuperscript{114}

When focusing on land use, the evidence is strong that agroecology will be very land inefficient. If that occurs, agroecology will not be able to reduce agriculture’s environmental footprint in the years to come and the opposite will occur; farmers will have to increase agriculture’s use of land in order to meet the demands for food quantity and food security that the increased human population will require between now and the year 2050. Agroecology, as intertwined with organic agriculture, fails to satisfy criterion C of sustainable agriculture.

D. Criterion D: Sustain the Economic Viability of Farm Operations and Criterion E: Enhance the Quality of Life for Farmers and Society

Measuring agroecology against the fourth and fifth criteria of sustainable agriculture can be combined. If agroecology reduces agricultural production by twenty to twenty-five percent, it very likely fails to provide environmental benefits at the farm and landscape scale, and greatly expands the amount of land devoted to agriculture now and more so in the future. This result causes agroecology to fail both the fourth and fifth criteria.

Agroecology could improve the economic viability of farm operations through premium prices for agroecology products, or it could reduce the economic viability of farm operations by trapping most small-scale and resource-poor farmers in on-going poverty and subsistence. Agroecology could enhance the quality of life for farmers who identify

\textsuperscript{114} K.W.T. Goulding and A.J. Trewavas wrote:

To provide 35 tonnes of manure/hectare requires 3.5 adult cattle/ha. There are about 4 million adult cattle in the UK and 4 million ha of arable farmland. (Respective figures in the US are 100 and 200 million.) Thus to provide sufficient anure for high wheat and other crop yields would necessitate increasing the numbers of cattle about 3.5 fold (7 fold in the USA). Their winter consumption of corn and wheat would increase by the same amount and the land devoted to food crops would have to decline. Methane production, a potent greenhouse gas, would also increase. The much larger numbers of cattle would see prices of both meat and milk drop substantially thus increasing the likelihood of increased animal fat in the diet.

Goulding & Trewavas, \textit{supra} note 87. One person commenting on the Mark Lynas Blog stated,

Hi Mark, I actually did the math on shadow land needed to get Nitrogen for the US 2009 maize crop. . . . [One] cow gives 11 T of wet manure per year $= 1.3$ dry tonnes/cow/year. Thus, need 9 ha[ecares] of pasture to get enough N for 1 ha of maize. Thus, the US 2009 maize crop would need manure from some 200 million head of cattle – just imagine the associate methane emissions! Also, to put that number in perspective, the US had 8 million dairy cows in 2010.

Lynas, \textit{supra} note 113.
ideologically with agroecology or could worsen their quality of life by failing to give them a way out of poverty.

Whatever the impact of agroecology on individual farmers and their farm operations, society would not benefit from agroecology under the fourth and fifth criteria because society needs agriculture to increase production, to improve environmental performance, and to reduce ecological footprint. From the perspective of society as a whole, by failing the initial three criteria of sustainable agriculture, agroecology also fails the final two criteria.115

V. CONCLUSION

The contested vision for agriculture’s future between those favoring sustainable intensive agriculture and the proponents of agroecology is a contested vision about agricultural development for developed and developing societies. The contested vision is, at its root, an ideological contest. When one reads the documents of the proponents of agroecology, this author posits that the proponents’ documents supporting agroecology are political statements that have little to do with science and that have the purpose of prescribing a romantic understanding of agriculture upon farmers, whether farmers want that prescribed understanding or not.116 In this author’s opinion, a well-known environmental activist and author, Mark Lynas, captured the tenor of proponents of agroecology when he wrote:

This [the anti-GM movement] was also explicitly an anti-science movement. . . . [T]his absolutely was about deep-seated fears of scientific powers being used secretly for unnatural ends. What we [the members of the movement] didn’t realize at the time was that the real Frankenstein’s monster was not GM technology, but our reaction against it.117

Sustainable intensive agriculture embraces science and technology for agricultural development. Sustainable intensive agriculture

115. See generally Field to Market, Environmental and Socioeconomic Indicators for Measuring Outcomes of On-Farm Agricultural Production in the United States (July 2012), http://www.fieldtomarket.org/report/national-2/PNT_NatReport_A26.pdf. Throughout this Article, the author uses the word “criteria” by which to measure sustainable intensive agriculture and the proponents’ agroecology. The author uses the word “criteria” because lawyers often think in that term when asking whether a practice complies with a statutory definition or legal mandate. Agricultural scientists, including social scientists, are more likely to use the word “indicators” to ascertain whether a particular agricultural practice or technique is meeting defined or preferred goals.


holds the belief that the threats in the years between now and 2050 are not science and technology. Sustainable intensive agriculture holds the belief that the threats are, today and until 2050, the same as for centuries—illness, famine, poverty, war, and death.118

Sustainable intensive agriculture does not claim and cannot deliver a complete solution to these human threats. But sustainable intensive agriculture can alleviate these threats, for individuals and societies, by providing an agricultural system that provides plentiful food, fodder, fiber, fuel, and food security.