

# DEVELOPMENT OF METRICS TO MEASURE AGRICULTURAL SUSTAINABILITY

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## ABSTRACT

*Field to Market, The Keystone Alliance for Sustainable Agriculture* ([www.fieldtomarket.org](http://www.fieldtomarket.org)) is a collaborative stakeholder group of producer organizations, agribusinesses, food and retail companies, conservation organizations, universities, and government agency partners that are working together to develop a supply-chain system of metrics for measuring agricultural sustainability. In 2009, *Field to Market* released a report on national-scale trends in environmental resource indicators for corn, cotton, soybean, and wheat production in the United States. *Field to Market* has also developed The Fieldprint Calculator, an online education and awareness tool which helps growers evaluate their farming decisions in the areas of efficient land use, soil conservation, water use, energy use and greenhouse gas emissions. Multi-stakeholder involvement in the development of these metrics and tools has engaged the entire United States supply chain in discussions on how to define, measure, and promote agricultural sustainability.

## INTRODUCTION

Nearly all estimates of future demand for agricultural goods suggest a need to double agricultural production by 2050, if not before, in order to maintain adequate supplies for a growing world population that will use its expanding income to purchase fiber products and to diversify diets with more meat, dairy, fruits and vegetables (FAO, 2006). *Field to Market, The Keystone Alliance for Sustainable Agriculture* believes this increased production must be accomplished in a manner that does not negatively impact – and actually improves – overall environmental and societal outcomes. *Field to Market* is a collaborative stakeholder group of producers, agribusinesses, food and retail companies, conservation organizations, universities, and government agency partners that are working together to develop a supply-chain system for agricultural sustainability. The group was convened and is facilitated by The Keystone Center, an independent, non-governmental organization specializing in collaborative decision-making processes for environment, energy, and health policy issues.

As an initial step, the group defined sustainable agriculture as meeting the needs of the present while improving the ability of future generations to meet their own needs by focusing on these specific, critical outcomes:

- Increasing agricultural productivity to meet future nutritional needs while decreasing impacts on the environment, including water, soil, habitat, air quality and climate emissions, and land use;
- Improving human health through access to safe, nutritious food; and
- Improving the social and economic well-being of agricultural communities.

It is within this context that the group is developing metrics to measure the environmental, health, and socioeconomic outcomes of agriculture in the United States at the national, regional, and individual field scales. These metrics will facilitate quantification and identification of key impact areas and trends over time, foster productive industry-wide dialogue, and promote continued progress along the path toward sustainability.

## **NATIONAL TRENDS: ENVIRONMENTAL RESOURCE INDICATORS REPORT (JANUARY, 2009)**

In 2009, *Field to Market* released a report on national-scale trends in environmental resource indicators for corn, cotton, soybean, and wheat production in the United States. The report is available online at <http://www.fieldtomarket.org>. The report will be updated in 2012 to include the most recent publicly available data and to incorporate potatoes and rice. The updated report will also include trends for socioeconomic indicators associated with production of commodity crops in the United States.

Table I includes the national scale outcomes modeled in the 2009 report (the shaded cells) as well as the additional environmental, health, and socioeconomic outcomes at national, regional and local scales that are considered important measures of sustainability. Our future plans and objectives for developing international scale metrics have not yet been defined, however *Field to Market's* 2009 report was recently adapted for Canadian field crops to explore trends over time for eight different Canadian crops including wheat, oats, lentils, canola, peas and flax (Serecon, 2011).

## **METHODS OVERVIEW**

Using publicly-available data, national-scale metrics were developed to measure outcomes for five environmental indicators: land use, soil loss, irrigation water use, energy use, and climate impact (greenhouse gas emissions). The metrics were applied to quantify environmental outcomes for four commodity crops – corn, cotton, soybeans, and wheat – produced through agricultural practices in the United States.

The national scale was chosen as a starting point for benchmarking the overall environmental performance of particular crops. National level environmental indicators can provide perspective and prompt industry-wide dialogue that is ultimately relevant to more localized investigations and efforts. *Field to Market* focused initially upon the four commodity crops because they constitute a majority of

agricultural crops currently harvested in the United States. An outcomes-based approach was selected because it can provide an inclusive mechanism for considering the actual impacts and sustainability of diverse agricultural products and practices.

**Table I. Components of a Complete Sustainability Index.** *Field to Market* has produced metrics for measuring environmental outcomes at the national scale (shaded cells). Specific socio-economic and health and safety outcomes are given as examples only.

	Environmental Outcomes							Social and Economic Outcomes							Health and Safety Outcomes			
	Land Use	Soil Loss	Water Use	Water Quality	Energy Use	Climate Impact	Biodiversity	Producer Income	Labor	Productivity	Competing Land and product uses	Rural Character and Quality of Life	Availability	Post Harvest Loss	Consumer Demand	Return of Value to Producers	Nutrition (access to calories, etc)	Safety
International Scale																		
National Scale	x	x	X		x	x				x								
Regional Scale																		
Local Scale																		

*Field to Market* recognizes that water quality and biodiversity are key environmental areas of concern for agriculture, and is currently developing metrics to measure the successes and continued challenges for these areas. The 2009 report provided an overview of our progress to-date in developing a water quality indicator.

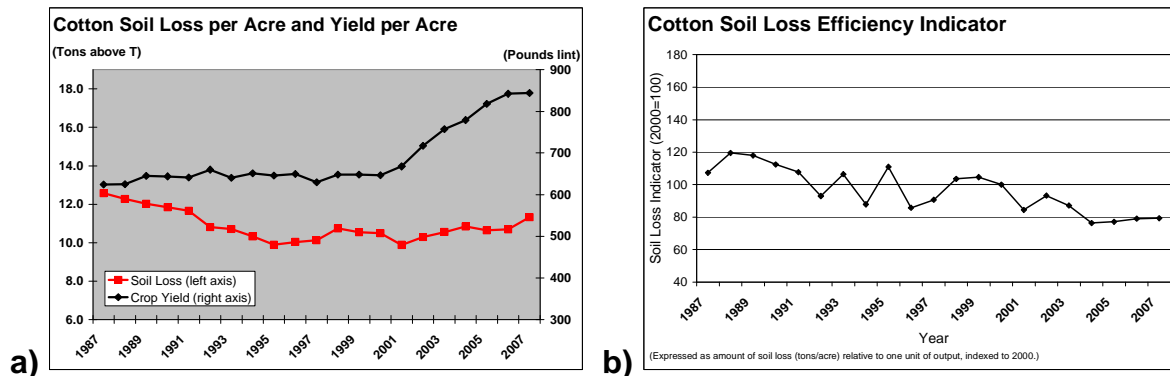
The 2009 report was reviewed by 17 peer reviewers from government agencies, universities, and the United States agriculture sector.

**RESULTS OVERVIEW**

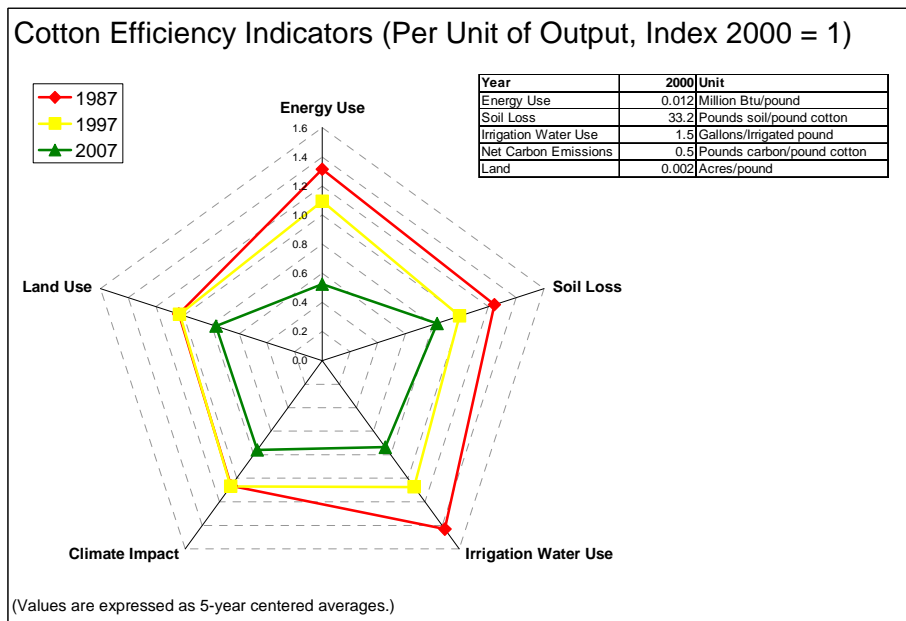
Results were presented for the years 1987-2007. The results for each indicator (land use, soil loss, water use, energy use, and climate impact/carbon emissions) are displayed for each crop in two formats: 1) Resource indicator (use or impact) per acre and crop productivity per acre (yield) (Figure 1a), and 2) “Efficiency” indicators showing resource indicator (use or impact) per unit of output, benchmarked to the year 2000 (Figure 1b). Total annual use or impact indicators were also presented as an appendix to the report.

All approaches are valuable, as resource use or impact indicators can show change over time independent of yield, and efficiency measures – resource indicator

measures over output – can show change in use or impact over time relative to our ability to meet productivity demands. A summary of efficiency indicator results for each crop is also presented in a spidergram that demonstrates the change in “footprint” over time of all of the efficiency indicators (Figure 2).



**Figure 1. Examples of Indicator Charts: (a) Per acre resource use or impact and per acre productivity and (b) Resource efficiency (resource use/ unit of output, indexed to the year 2000)**



**Figure 2. Summary of Cotton Efficiency Indicators**

## REPORT DISCUSSION AND CONCLUSIONS

*Field to Market* anticipates that the approaches presented in the 2009 report can be refined to better measure impacts on natural resources in addition to the efficiency of use of the resource. The group also anticipates that these approaches can be

adapted to quantify environmental outcomes for other crops and agricultural products and be inclusive of a full range of agricultural technologies and practices ranging, for example, from organic to conventional methods.

The report does not define a benchmark level for sustainability, and thus cannot conclude whether we have achieved “sustainability” in agriculture or how far we might have to go. However, the environmental resource indicators provide tools by which to describe progress or lack of progress at the national scale in terms of total environmental impacts as well as resource efficiency. They also provide a context for further focusing in on specific challenges and regions and generating processes for achieving continuous improvement.

It is too soon in this process to draw major conclusions about the data reported in 2009. This report marks our first step in establishing some benchmarks and baselines for overall performance, and a forthcoming update will build out our understanding of trends over time. However, we can begin to see some positive trends emerge and also identify areas where we would like to see stronger trends and continuous improvement.

Gains in productivity per acre (yield) over the past decade in most of the crops have generally improved overall efficiency of resource use. Soil loss trends (both per acre and per unit of output) have improved significantly in all crops. In addition, corn has seen modest to significant improvements in water use per acre and in water use, energy use, and carbon emissions per bushel. Cotton and soybeans are making progress in reducing irrigated water use, energy use, and carbon emissions per acre and per unit of output. Wheat’s energy use per bushel has decreased, its water use per bushel has remained relatively flat, and its carbon emissions per acre and bushel have seen larger increases.

In the future, we hope to better understand the relationship between outcomes, trends and the practices and other factors that are driving them. This understanding will enhance our ability to achieve improved outcomes performance.

## **FIELD LEVEL ANALYSES: THE FIELDPRINT CALCULATOR**

*Field to Market* has also developed The Fieldprint Calculator, an online education and awareness tool which helps growers evaluate their farming decisions in the areas of efficient land use, soil conservation, water use, energy use and greenhouse gas emissions. The Fieldprint Calculator is available at [www.fieldtomarket.org](http://www.fieldtomarket.org).

First launched in 2009, with a new version released in January, 2012, The Fieldprint Calculator allows individual corn, wheat, soybean, cotton, and rice growers to explore relationships between management practices and outcomes, and allows farmers to compare their own Fieldprint results against national, state, and county averages (Figure 4). Farmers can also save their information and compare the environmental impact of different management decisions or scenarios on their operation.

The online tool is free, voluntary and confidential.

The new version of the Calculator streamlines data entry and improves consistency of use by incorporating familiar tools with useful updates identified by growers themselves. The goal is to achieve balance between simplicity and accuracy.

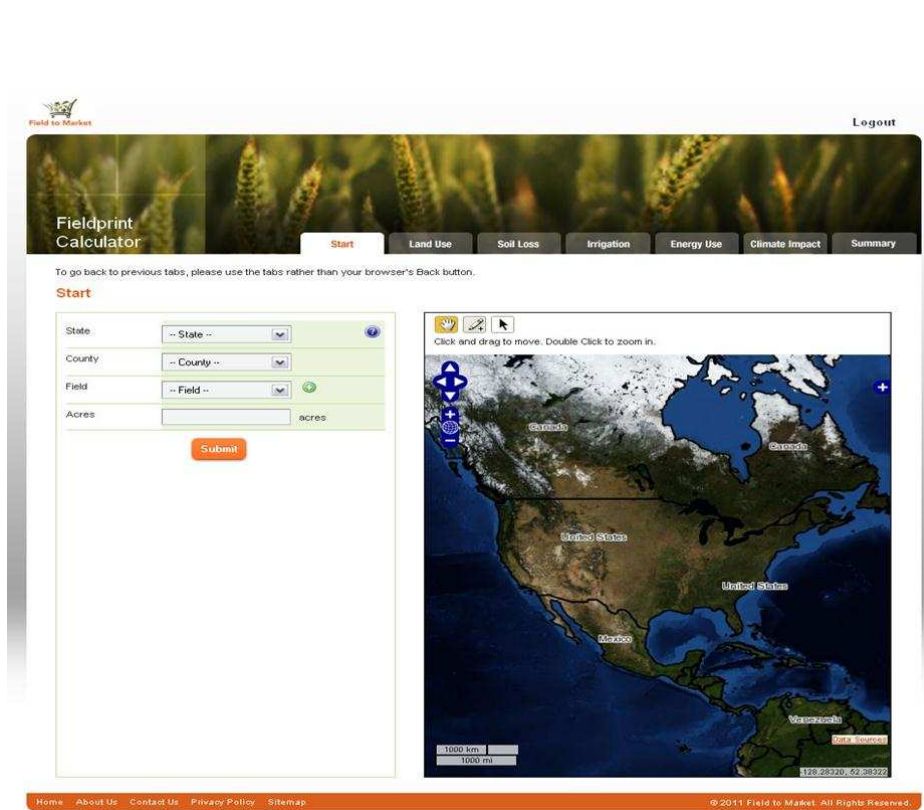
Interactive mapping and GIS technology allow growers to zoom-in and specifically identify the field they want to analyze. This improves the accuracy of field acreage estimates and automatically generates soil type, field slope, and climate information from United States Department of Agriculture's Natural Resource Conservation Service (NRCS) databases. (Figure 3). Advanced algorithms and expanded datasets allow growers to compare their data against county, state, and national averages for similar operations.

By incorporating the NRCS RUSLE2 tool (USDA, ARS, 2010) (Revised Universal Soil Loss Equation, Version 2), growers can more accurately identify their farm's management system for improved analysis of the various soil, energy, and greenhouse gas outcomes associated with their management systems. By incorporating the NRCS Soil Conditioning Index (SCI) (USDA, NRCS Soil Organic Matter) (USDA, NRCS, 2003), growers can identify the likelihood that their fields are gaining or losing soil carbon.

Growers can enter up to five years of crop rotation data allowing for a better picture of their long-term approach to conservation management. User experience and ease of use have been improved through interface upgrades and updates to step-by-step Q&A sections.

Because local and peer-to-peer comparisons are perhaps the most important and relevant to growers, ongoing pilot programs have been established to learn more about the potential use of the Calculator and to identify future improvements. For example:

- National Cotton Council of America and Cotton Incorporated are working with cotton growers in Louisiana and Texas to utilize the Fieldprint Calculator and identify opportunities through local conservation programs.
- Corn growers in Nebraska worked with Bunge and Kellogg Company to use the Calculator to validate sustainable practices and identify areas of improvement within the company's Frosted Flake production. Also, Syngenta and rice growers in the Southeast have worked together to determine opportunities to improve sustainable practices and realize economic benefits.
- The Van Buren Conservation District, The Coca-Cola Company, The Nature Conservancy, and World Wildlife Fund are supporting a pilot project in the Paw Paw Watershed of Michigan while General Mills and Syngenta are also working with farmers in Idaho. The projects are designed to help improve the tools Field to Market provides to growers as well as educate growers on how to tell and improve their own sustainability story.



**Figure 3. Fieldprint Calculator Start Screen.** Users select their location and then enter information about their practices.



**Figure 4. Fieldprint Calculator Summary Screen.** Users compare their results to national, state, and county averages.

## CONCLUSIONS

*Field to Market's* metrics and tools provide a science-based, outcomes-based approach to evaluating average trends and field-specific sustainability outcomes. These approaches can form the basis of well-informed conversations on sustainability throughout the supply chain and can be utilized to identify and advance opportunities for sustainability improvements.

Multi-stakeholder involvement in the development of these metrics and tools has engaged the entire supply chain in discussions on how to define, measure, and promote sustainability. These processes can be replicated outside of the United States, provided adequate data resources are available, to offer data-driven solutions for sustainability challenges worldwide.

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