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The theory and practice of performance indicators for sustainable food security: a checklist approach

Abstract

This article proposes a set of sustainability indicators based on a combination of economic, social and health data that meet three tests: the indicators are simple, measurable and capable of being extended to workers in the field. They result from a scoring model which ranks the progress of agricultural projects in three key areas: (1) sustaining improvements in agricultural productivity while minimizing negative impacts on soil and water quantity and quality or biodiversity; (2) sustaining expected farm-level profits while minimizing worker health and safety risks; and (3) sustaining improvements in rural economic and social conditions while distributing these benefits widely.

Keywords: sustainability indicators, agricultural project checklists.
JEL Classification: Q10, Q12, Q5, Q57.

Introduction

The search for sustainable methods in modern agriculture has led governments, non-governmental organizations (NGOs), private sector companies and farmers to develop myriad indicators in the search for more holistic management. Despite these many efforts, no standard approach or synthesis has emerged. This article proposes such a synthesis, based on a combination of economic, social and health indicators that meet three tests. These are that the sustainability indicators are simple, measurable and capable of being extended to workers in the field.

The indicators result from a scoring model in which informed judgments rank the progress of agricultural projects in three key areas: (1) sustaining improvements in agricultural productivity while minimizing negative impacts on soil and water quantity and quality and biodiversity; (2) sustaining expected farm-level profits while minimizing worker health and safety risks; and (3) sustaining improvements in rural economic and social conditions while distributing these benefits widely. The indicators rely on no single discipline, and involve agronomic, economic, health and welfare concerns. Yet they address the most important areas for continuous improvement and innovation in agriculture necessary to achieve sustainable food security for all. Before developing the indicators in detail, we place them in the larger context of the food security challenge.

1. The sustainable food security challenge

One of the central criticisms of new agricultural methods is that they are unsustainable in environmental and social terms. "Sustainability" is a mutable concept. Here, we define it as a method of production capable of replication and success over the foreseeable future, imposing tolerable ecological stress (for agriculture is by its nature stressful) and allowing reasonable and assured economic returns for both farmers and communities. Sustainable agricultural intensification is a central concern because growing human populations need to produce sufficient calories to sustain their livelihood, and they need the assurance that this production will be there tomorrow, without threatening the natural environment that we share. It is important to realize that sustainability can be appraised with only approximate scientific certainty through estimates of how new methods affect land and people based on local knowledge and often without large amounts of data.

A 2011 study by a global team of scientists put the food security challenge in stark terms, warning that growing populations, incomes, meat consumption and biofuels will all place unprecedented demands on world agricultural and natural resources, requiring simultaneous increases in food production and reductions in environmental damages due to agriculture (Foley et al., 2011). On the one hand, this will require dramatic improvements in agricultural productivity. On the other hand, these improvements must be coupled with increased efficiency and reduced damages to biodiversity, soils and water resources. Even with recent gains in agricultural productivity, roughly 1 of 7 people living in poverty are chronically hungry, about 1 billion of the earth's current population. Attention must also be paid to the potential health hazards of the agricultural production system and the economic and social fabric within which the system operates (Clay, 2011).

Historical perspective on the need for such a holistic approach is offered by the experience of the Green Revolution in the Punjab region of Northwest India. The new short-stem wheat and hybrid rice varieties, introduced in the 1960's and 70's, resulted in dramatic improvements in yields and food security. An assessment conducted by a World Bank economist estimated productivity growth from 1961 to 1994 at between 100 and 200 percent (Murgai, 2001). However, the economic and environmental gains were partly offset by substantial increases in nitrogen and phosphorous fertilizer applications, overuse of pesticides and unsustainable groundwater pumping for irrigation. In the last ten years, groundwater has fallen in many areas of the Punjab to levels that threaten continued high yields. Water quality has also suffered, resulting in contaminated drinking water in local villages. High yielding hybrid crop varieties grown in monoculture in the Punjab are vulnerable to weeds and pests. Poor agronomic practice often leads pesticides and herbicides to enter water sources, and may contribute to increased risks to human health, including cancer (Zahm & Ward, 2011)[1]. Punjabi soils have also been depleted by constant and intensive irrigation and cultivation, requiring major infusions of nutrients. As a result, both salinization and waterlogging are now common problems (Postel, 1989).

Even so, the profits of local farmers have clearly risen, although the debt incurred resulting from purchases of inputs such as fertilizer, chemicals and high-yielding seeds, has made these profit streams somewhat less secure. And studies analyzing health impacts of agricultural modernization in the Punjab report concerns over worker health and well-being (Kaur & Sinha, 2011). Finally, while local economic development in the region is indisputable, there remain concerns over the extent to which economic benefits are widely shared, or are concentrated in the landowning classes (Vatta, Garg & Sidhu, 2008).

Many of those responsible for extending agricultural technologies believe that in order to confront these types of food security challenges, a more holistic approach is needed in which projects developing new agronomic solutions are part of an integrated, sustainable production system. Such sustainable food security efforts will require indicators measuring the impacts of new farming methods and technologies on resource use and efficiency, on the health and wellbeing and risks of new solutions and on extending rural development benefits to include as large share of the local population as practicable. This paper develops a set of such indicators as a "sustainability checklist".

2. Why a checklist?

In a now famous study of innovations in the delivery of medical care and technology, Atul Gawande, a surgeon at the Harvard Medical School, has advocated the use of simple checklists to prevent medical errors and provide for physician and medical staff accountability (Gawande, 2010)[2]. One of his key observations is that it is possible quickly to overwhelm medical staff with too many requirements and protocols and that such over-bloated guidelines generally fail to have much effect. As he noted of the World Health Organization's (WHO) voluminous official standards for safe surgical care, which were carefully written and well considered but had at best trickled out into the world: "for most patients in Bangkok and Brazzaville, Boston and Brisbane, little had changed" (2010, p. 92). These efforts, which resemble some of the government sustainability indicator initiatives described below, fail Gawande's three key tests: that indicators are simple, measurable and transmissible. As he notes, checklists made up of such indicators "not only offer the possibility of verification but also instill a kind of discipline of higher performance" (2010, p. 36).

The essence of successful use of simple indicators is to balance judgment with procedure. In what follows, the procedure advocated to assess agricultural projects relies largely on the judgment of field workers, but equips them with a procedure by which to evaluate ongoing projects and to verify and instill higher and better performance. The reason for such a checklist in the transfer of agricultural methods is that such transfers of knowledge result in many economic, social and institutional impacts – most of them leading to improvements in levels of living, but some creating significant challenges. Modern agricultural methods are so different from traditional ones that they threaten established practices. Those helping to implement these methods increasingly find that navigating the transition from low-input, low-yield farming to higher inputs and yields requires a basic understanding of sustainable agricultural systems at the farm and community level and of the trade-offs between improved agricultural methods and the health and wellbeing of the land and the people who work on it, so as to make the agricultural transition as beneficial in social and environmental terms as it is economically and agronomically.

3. Sustainability indicators: state of the art

The first stage of work involved a review of other efforts to develop sustainability indicators. Many of them were described in terms of what *others should be doing but are not*, without much appreciation for the difficulties of implementation. In some cases, large bureaucratic entities (including governments, consulting firms and NGOs) capable of pouring human and financial resources into their develop-

[1] See also B.P. Singh (2008). Cancer deaths in agriculture heartland: a study in Malwa Region of Indian Punjab, University of Southampton, U.K. International Institute for Geo-Information Science.

[2] See also A.B. Haynes et al. (2009). A surgical safety checklist to reduce morbidity and mortality in a global population, *New England Journal of Medicine*, Vol. 360, pp. 491-499.

ment, propose highly complex indicators that are very difficult to implement with available resources in the field, analogous to the WHO surgical guidelines discussed above.

However, these efforts offered insight into the specific challenges of an integrated approach to sustainable food security (see Appendix). In particular, the Food and Agriculture Organization (FAO) developed a set of good agricultural practices and "Save and Grow" indicators. Unilever, working with the University of Aberdeen, developed software to assist farmers to calculate their impacts on greenhouse gas (GHG) emissions. The Sustainable Food Laboratory, a consortium of organizations, developed indicators of agriculture's impacts on GHG emissions, water, biodiversity and soil health. Several detailed indicators of water scarcity were developed by academics at the University of Arkansas. Rainforest Alliance and a consortium of private sector food and agriculture organizations analyzed sustainability impacts on a commodity-by-commodity basis and in terms of their relevance to stakeholders. Finally, the categories developed in the United Nations Development Programme's Human Development Index (HDI), applied at a more disaggregated level, can help evaluate rural economic impacts and the social effects of agricultural transition on health, education and welfare.

After evaluating these efforts and based on our own experience, we sought indicators at the farm and community level that measured achievement in terms of three metrics. First is the efficacy of the new methods in raising agricultural production, balanced against impacts on soil and water quality and biodiversity: the "resource efficiency index". Second are the benefits of reliable profitability to farmers, balanced against the new methods' impacts on human health and safety: the "better solutions index". Third are improvements in human development in rural economies from adopting the new methods, balanced against the extent to which these improvements are shared by others in the affected area or region: the "rural economy index".

The motivation behind these indexes was recognition that a technology focus alone was insufficient in grappling with sustainable intensification and food security. Food security reaches into issues of environmental security, social security and even energy security. Therefore, the domain of project assessment needs to include the impact of new agricultural methods on the land and natural environment and on the people who use new methods to improve their productivity. The overriding idea is to integrate production goals with environmental and social sustainability. The indicators then lead to a "checklist" for project evaluation.

The resulting evaluation framework links three key elements of a sustainable intensification of agriculture (SIA) triangle (see Figure 1). The SIA triangle recognizes the linkages of agricultural technology to land, from this technology to people, and the interactions between people and their land and community. The measured outcomes are represented by the three sides of the triangle referred to as (1) resource efficiency index; (2) better solutions index; and (3) rural economy index.

New methods can improve agricultural, environmental and social outcomes by raising the level of these indicators, which can be monitored to know if performance is improving and can offer evidence to a wider set of stakeholders that a systematic effort is underway to deliver agricultural solutions sustainably. Before proceeding, specific consideration will be given to the proliferation of ever-more complex sustainability indicators and standards, in contrast to the rapidly expanding understanding of the role of simple checklists.

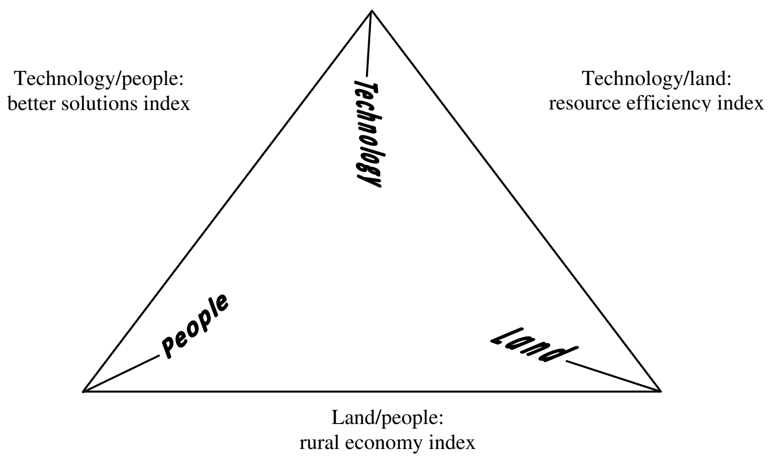

Fig. 1. Sustainable intensification and food security triangle and indicators

4. Indicators of sustainability are in excess supply

As noted, there are many indexes and standards purportedly measuring sustainability. A search of the literature, focusing especially on agricultural development projects, revealed thousands of such indicators (Esty & Winston, 2006; Martland, 2012). Hass, Brunvoll and Hoie (2002) writing for the OECD in their "Overview of Sustainable Development Indicators used by National and International Agencies" divided them into three "pillars of sustainability": economic, social and environmental. Indicators were then evaluated according to three criteria: policy relevance, analytical soundness and measurability. These three pillars are matched quite closely with the proposed indicators below. However, because the OECD criteria apply primarily to public and government projects, large, data-intensive evaluations are often involved. France, for example, developed 307 indicators and five main sustainability "themes": balanced growth, maintaining human and institutional capital, local and global coordination, inequality reductions and applications of the "precautionary principle"[1]. In many respects the French exercise, involving huge quantities of data and hundreds of civil servants, is exactly what we seek to avoid in preference for simple, relatively easily constructed indicators of project success or improvement.

In a World Bank overview, "Indicators of Environment and Sustainable Development: Theories and Practical Experience", Segnestam (2002) describes project-based indicators in terms of project inputs, components, outputs and long-term impacts. Here, most project inputs will relate to new agricultural methods combined with land and human labor and capital, so that the evaluation will revolve around outputs (e.g., yield gains) and long-term impacts (e.g., improved economic security).

5. The integration model expanded

Returning to the three-sided sustainable intensification of food security (SIA) triangle, it is possible to formulate indicators based on each key interaction. The Resource Efficiency Index provides a 1-10 scale measuring sustained and improved productivity on the land, relative to impacts on soils, water quality and quantity and biodiversity. The Better Solutions Index provides a 1-10 scale measuring reliable profitability for farmers, relative to the risks they may bear if adopting new methods. The Rural Economy Index provides a 1-10 scale measuring sustained and improved rural economic conditions relative to how widely the improvements are distributed in the local economy.

6. The resource efficiency index: technology/land interactions

New agricultural methods affect the productivity of the land on which they are deployed. New seed varieties, crop protection products, planting or harvesting technologies, improved irrigation methods and even financial interventions will be reflected in improving agricultural performance and improved resource efficiency per hectare.

G.A. Larson and the first author developed relatively straightforward methods, based on a soil-productivity index (PI), to determine changes in land productivity before and after the adoption of conservation methods (Runge, Larson & Roloff, 1986). The same type of index can be used to provide a neutral assessment of impacts on efficient resource use before and after the adoption of a specific method. The original PI was based primarily on scientific assessment of various soil features such as water capacity and root distribution[2]. A less formal approach, based on sustained improvements in yields (and resource efficiency generally) without significant damage to or loss in soils, water or biodiversity can be estimated empirically by field personnel trained in biology, agronomy and soil science using basic soil testing and yield estimates. For example, an ideal index of 10/1 would represent optimal yields gains of 20-30 percent (10) with no evidence of damage or loss in soil, water quality and quantity or biodiversity (1). The index value would be:

$$Resource\ Efficiency\ Index = \frac{Productivity\ impacts}{Losses\ in\ soil\ and\ wather\ quality\ and\ quantity\ or\ biodiversity} = \frac{10}{1} = 10\,.$$

[1] France was an official test nation for the UN Commission on Sustainable Development Indicators. See "Les Indicateurs de développement durable", http://www.un.org/esa/sustdev/indi4fr.htm.

[2] The soil-scientific PI model uses a normalized index from 0.1-1.0 to estimate

$$PI = \sum_{i=1}^{r} (A_i \cdot C_i \cdot D_i \cdot WF_i)\,,$$

where A is sufficiency of available water capacity, C is the sufficiency of bulk soil density, D is the sufficiency of pH, WF is the weighting factor representing idealized root distribution and i is the time period. See K.L. Flach. Modeling of soil productivity and related land classification, Soil Conservation Service, USDA, Washington, D.C.

If this ratio remained relatively constant (allowing for season-to-season changes in temperature and moisture) then it is sustainable over time[1].

Yield improvements can be measured versus the average yield in the region. A score of ten, for example, would be given if the average yield with the new agronomy is constantly 20-30 percent higher than the reference fields. Soil quality and biodiversity improvements can also be assessed through visual examination of soil structure and carbon content[2]. Water quality and water retention in the field can be measured by visual assessment of soil surface structures (e.g., formation of gullies) and simple run-off water and collection. More highly qualified field workers may apply more precise methods. Generally, the index will compare the resource efficiency of various agronomic methods as well as improvements over time. The key to estimating the impact of the new methods on the index is what happens to the ratio before and after their deployment, and whether an improvement is sustained over time.

7. The better solutions index: technology/people interactions

The best measure of new methods of production is secure and reliable profit. Hence, if the interaction of new methods with the people employing them raises expected profits, the result is an opportunity to improve human wellbeing. However, one of the principal criticisms of modern agricultural technology (and a central criticism of the Green Revolution) was that reliance on high-input agriculture increases the risks of farming and threatens the health and safety of those employing the new methods. These risks fell into several categories. The first is increased financing risk because a package of inputs had to be purchased, usually on credit; the second was the agronomic risks that arise when rainfall is variable and water management is poor, so that varieties requiring the right mix of inputs might perform worse in stressed conditions than native varieties. The third is risk due to management, in the sense that some farmers do not have adequate training for the new technologies. Hence, the profit impact of the new method must be based on an expectation (mean) of increased returns and not too much increase in the risk (variance) with which these expected returns occur[3]. If the expected profit impact of the technology has a maximum value of 10 (note that assured profit is a judgment, not an absolute measure) and carries few risks to worker health, safety or labor conditions the denominator will be near 1. The index value is given as:

$$Better\ Solutions\ Index =$$

$$= \frac{Expected\ \ profit\ impact}{Low\ worker\ health\ and\ safety\ risks} = \frac{10}{1} = 10.$$

While expected profit estimated as a variable distributed with mean and variance is conventional, worker health and safety risks are somewhat more difficult to calibrate. An accepted method widely used in industrialized country settings, but less so in developing countries, is a health impact assessment (HIA) designed to minimize negative and maximize positive health effects (Joffe & Mindell, 2005). In an application in Central Africa, evaluating the International Finance Corporation's (IFC's) Standard 4 (community health and safety), IFC procedures were followed using the "HIA Toolkit" (Winkler et al., 2010).

This involved both qualitative and quantitative evaluations of health risk and a community health management plan (CHMP) to mitigate the identified risks. Such risk assessment relies on published literature, local data and stakeholder (farmer) inputs[4]. Using the IFC guidelines for health assessments, twelve environmental health areas merit consideration, summarized in Table 1.

It should be noted that mitigating the health risks of agrichemicals may raise other risks, thus offsetting reductions in the target risk. In a study evaluating this risk/risk trade-off that considered public health effects of bans on organophosphate and carbonate pesticides, new risks were identified resulting from acute toxicity and cancer to farmworkers from substitute chemicals and mortality due to reductions in profits and incomes (Gray & Hammitt, 2000).

[1] This ratio is based on informed judgment, and not taken directly from scientific soil parameters (although based on them). It corresponds to a 10 point version of a normalized scoring model.

[2] E.g., Graham Shepherd: Visual Soil Assessment (VSA). http://www.carbonfarming.org.nz/documents/VSASummaryStatement.pdf.

[3] One approach dominant in the literature is to use a "certainty equivalent" measure of profit (quasi-rents). See R. Pope, J.P. Chavas and R. Just (1983). Economic welfare evaluation for producers under uncertainty, *American Journal of Agricultural Economics*, Vol. 65, No. 1, pp. 98-108.

[4] See IFC (2009). "Introduction to health impact assessment", http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_GoodPractice_HealthAssessment.

Table 1. Environmental health areas (adapted from FFC guidelines, 2009a)

No	Environmental health area	Description
1	Communicable diseases	Transmission of communicable diseases (e.g., acute respiratory infections, pneumonia, tuberculosis, meningitis, plague, leprosy, etc.) that can be linked to inadequate housing design, overcrowding and housing inflation
2	Vector-related disease	Mosquito, fly, tick and lice-related diseases (e.g., malaria, dengue, yellow fever, lymphatic flariasis leishmaniasis, human African trypanosomiasis, onchocerciasis, etc.)
3	Soil-, water- and waste-related diseases	Diseases that are transmitted directly or indirectly through contaminated water, soil or non-hazardous waste (e.g., diarrhoea) diseases, schistosomiasis, hepatitis A and E, poliomyelitis, soil-transmitted helminthiases, etc.)
4	Sexually-transmitted infections. including HIV/AIDS	Sexually-transmittted infections such as syphilis, gonorrhoea, chlamydia, hepatitis B and, most importantly, MIV/AIDS
5	Food- and nutrition-related issues	Adverse health effects such as malnutrition, anaemia or micronutrient deficiencies due to, e.g., changes in agricultural and subsistence practices, or food inflation, gastroenteritis, food-borne trematodjases, etc.
6	Non-communicable diseases	Cardiovascular diseases, cancer, diabetes, obesity, etc.
7	Accidents/injuries	Road traffic or work-related accidents and injuries (home and project related): drowning
8	Veterinary medicine and zoonotic diseases	Diseases affecting animals (e.g., bovine tuberculosis, swinepox, avian influenza) or that can be transmitted from animal to human (e.g., rabies, brucellosis. Rift Valley fever, monkey pox, Ebola, leptospirosis, etc.)
9	Exposure to potentially hazardous materials, noise and malodours	Exposure to heavy metals, pesticides and other compounds, solvents or spills and releases from road traffic: air pollution (indoor and outdoor); noise pollution and exposure to malodours
10	Social determinants of health	Including psychosocial stress (due to e.g., resettlement, overcrowding, political or economic crisis), mental health, depression, gender issues, domestic violence, ethic conflicts, security concerns, substance misuse (drugs, alcohol, smoking), family planning, health seeking behaviour, etc.
11	Cultural health practices	Role traditional medical providers, indigenous medicines, and unique cultural health practices
12	Health system issues	Physical health infrastructure (e.g., capacity, equipment, starting levels and competencies, future development plans): program management delivery systems (e.g., malaria-, TB-, HIV/AIDS-initiatives, maternal and child health, etc.)

Source: Winkler et al. (2010, p. 55).

8. The rural economy index: land/people interactions

The final indicator used to evaluate new methods is their role in improving rural economic and social attributes. The specific impacts of the project will typically include raised household levels of living and community level benefits such as extended life expectancy and increased access to education and training with 10 as the highest score. The motivation behind the Rural Economy Index is the more aggregative approach of the UNDP's Human Development Index (HDI), in which social welfare is considered in terms of levels of living defined not just in narrow economic terms, but improved access to health care, education and economic security.

The HDI is a composite of three factors: life expectancy, education levels and income purchasing power (Mannis, 2011). Since the HDI is calculated on a 0-1 scale, it is readily converted to a 10-point scale. All three factors comprising the HDI are measured according to a general formula in which the minimum is subtracted from the maximum, becoming the denominator, and the minimum is subtracted from the actual to form the numerator. For life expectancy, a fixed minimum and maximum were established at 20 and 85 years, respectively. For example, if local surveys reveal a life expectancy of 45 years, the life expectancy factor is:

$$Max - Min = 85 - 20 = 65;$$

$$Actual - Min = 45 - 20 = 25,$$

$$\frac{25}{65} = .385 .$$

Then, the maximum and minimum values for the education factor are set at 0 percent and 100 percent for adult literacy, which provides two-thirds of the measure, together with a one-third weight given to enrollment in secondary and tertiary schools. For the income purchasing power factors, the minimum and maximum are set at 100 dollars and 10,000 dollars per annum per person[1]. The HDI is then computed as the average of the three factors, and is scaled to a maximum value of 1, converted in our case to 10.

The denominator of the Rural Economy Index is a measure of the inclusiveness with which these benefits are felt, or how widely they are diffused. High levels of adoption or diffusion in the denominator correspond to low numbers on a 1-10 scale. This is a direct analogy to the Gini Coefficient, which measures the inequality of income distribution on a scale from 0 (total equality) to 100 (complete inequality). The more widely diffused these benefits, the lower is the score; the more narrowly diffused these benefits, the higher is the score. Hence,

[1] The average world income purchasing power is $5.71. In national-level calculations of HDI, this is taken as a threshold and any income above it is discounted using a formula for the marginal utility of income. See R. Lagard, S. Nickell and G. Mayraz (2008). The marginal utility of income, *Journal of Public Economics*, Vol. 92, pp. 1846-1857.

$$Rural\ Economy\ Index = \frac{Rural\ economic\ and\ social\ impacts}{High\ levels\ of\ diffusion} = \frac{10}{1},$$

which would represent the best case.

9. The parsimony of the approach

One of the important features of the proposed approach is that an evaluation of a project can be performed on the basis of six considered judgments, which together define the three index numbers. In some cases it will be possible to collect more detailed data through field testing, sampling, household surveys, health impact assessments and the like. Because those making the judgments are likely to be close to the project details, they will possess the richest information set with which to render them. The method therefore will allow both comparisons of agronomic practices and the relative improvements associated with method A versus method B over time.

Building from a checklist of six categories of information, then combining them into three ratios varying from 1 to 10, will reflect critical *trade-offs* between each numerator and denominator and between the three indicators as a whole. First are the trade-offs within each index. For example, the Resource Efficiency Index may show that new methods can substantially boost yields but also stress soil, water or biodiversity, leading such improvements to be transient and unsustainable. Similar trade-offs in the Better Solutions Index will occur if profit improvements are offset by risks to human health and safety. In the case of the Rural Economy Index, trade-offs are between gains in rural levels of living and the extent to which these gains are widely shared.

Second, the indices can highlight the direction of change over time. For example, better management practices can raise the Resource Efficiency Index by boosting output, reducing resource costs or both. Similarly, the Better Solutions Index can rise as profits rise, and/or as worker health and safety improves. And the Rural Economy Index can increase as the rural indicators of human development improve, benefits become more widespread, or both.

Finally, the indices can – when taken together – provide an overall measure of progress toward sustainability. The three added together will measure progress from subsistence to sustainable agricultural production methods, which will reveal that overall sustainability is not achievable only by maximizing one of the three indexes, but all three. Productivity, profit and rural development all need to be advanced and maintained for an innovation to be regarded as sustainable. A "final score", with a maximum of 30, is thus a composite judgment on the indicators.

In order to see how each of the indexes is performing a visual representation can be shown as a cobweb polygon or web diagram (Muetzelfeldt, 2011). In this case the three indicators are shown as points on vectors circumscribed by a circle showing their theoretical maximums at scores of 10.

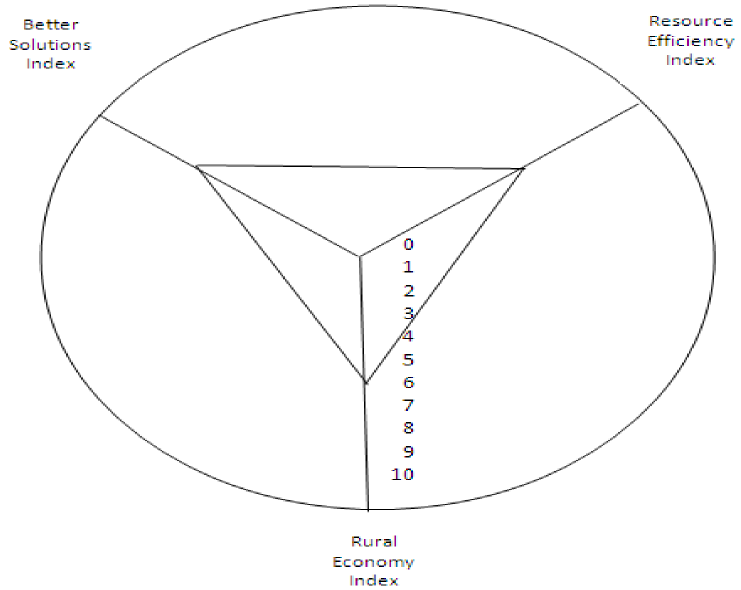

Fig. 2. Web diagram of performance indicators for sustainable food security

Of course, these indicators cannot account for everything, and they are not intended to do so. For example, integrated solutions boosting production and profits will be amplified if farmers gain access through expanded trade to larger markets, whereas expanded productivity *without* increased access to markets can mean *lower* prices and profits. In addition, infrastructure – physical, social and institutional, will facilitate the transmission of technology solutions and wider inclusion of rural populations. The implication is that integrated strategies should be coordinated with collaborative agreements with governments and private partners. These relationships are beyond the reach of (although they will affect) the measure of success.

To summarize, for each project, a set of relative judgments can be made concerning six key issues. These judgments can be made by individuals working as a team or through surveys or by a single person. In general, if teams are assigned responsibility for the 10-point evaluations, the process of discussion itself will bring many issues to the surface that might have gone unnoticed. In the evaluation of the Resource Efficiency Index, two questions must be answered:

1. How has the technology solution affected productivity on a 1-10 scale? The answer: 10 best; 1 worst.
2. How has the technology solution affected resource efficiency and losses in soil and water quality and quantity or biodiversity? The answer: 1 best; 10 worst.

The second evaluation answers two different questions about the Better Solutions Index:

1. What impact does the integrated solution have on expected profits and their variability on a 1-10 scale? The answer: 10 best; 1 worst.
2. Have the expected profit effects been mitigated by risks to human health and safety or labor conditions? The answer: 1 best; 10 worst.

The third evaluation answers two questions concerning the Rural Economy Index:

1. How has the technology led to improvements in rural economic and social impacts? The answer: 10 best; 1 worst.
2. How widely diffused have these impacts been? The answer: 1 best; 10 worst.

These evaluations can then be repeated annually or more often as a checklist to monitor progress and provide for self-evaluation.

Conclusion

Emphasis needs to be given to the early stage of the process outlined above, which is a work in progress. Yet it is hoped that it provides a logical, methodical and internally coherent basis for the evaluation of sustainability that can be deepened and refined with actual use. It is anticipated that some will criticize the approach as simplistic, which criticism is regularly made of checklists. Yet checklists, even simple ones, have been empirically proven to improve performance.

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Appendix

A short list of efforts to develop indicators of sustainability was developed. After an initial screen of the short list of approaches, some indicators were found to focus on issues such as national measures of poverty alleviation, which are to be implemented at the household or community level. Others used measures of environmental or carbon "footprints", based on environmental damage assessments relative to land area or per capita. Such measures lead to odd conclusions: Singapore often emerges as a villain due to its high level of environmental residuals per unit land area, while countries with large populations such as China or large land areas such as Brazil and the United States do better purely because of their population size and geographic expanse. In the end, the studies that follow provided relevant information for integrated approaches to food security and suggested how they might contribute to a checklist going forward.

1. FAO's "Good agricultural practices" and "Save and grow" indicators (http://www.fao.org/prods/gap/home/principles).

These concise descriptions support judgments relating to soil, water and biodiversity and offer a sensible basis for evaluating whether new methods improve (in the case of soil) "the availability and plant uptake of water and nutrients through enhancing soil biological activity, replenishing soil organic matter and soil moisture, and minimizing losses of soil, nutrients, and agrochemicals through erosion, runoff and leeching into surface or ground water." In the case of water, the indicator should consider whether the technology assists in maximizing water infiltration and minimizes runoff, and helps to "manage ground and soil water by proper use". A third area in which FAO's good practices indicators are important relates to crop protection. The FAO description is somewhat long, but includes crop rotation, pest disease balances and, generally, the precise application of agrichemicals by well-trained individuals. Finally, FAO suggests a basis for ecological benefits in its practices for wildlife and landscape. These include the minimization of tillage and agrochemical use with effects on wildlife and the management of water courses and wetlands.

2. Save and grow: FAO's guide to best agronomic practices (http://www.fao/org/ag/save_and_grow/en/2/index.html).

This new and comprehensive guide to best practices provides a solid foundation on which to build indicators in each of the six areas discussed. In many ways, the *Save and Grow* manual could actually become the main field guide for personnel attempting to implement the indicators checklist. Chapter 2, "Farming Systems", offers a detailed assessment of different agroecological systems, based on three technical principles:

- Simultaneous achievement of increased agricultural productivity and enhancement of natural capital and ecosystem services.
- Higher rates of efficiency in the use of key inputs, including water, nutrients, pesticides, energy, land and labor.
- Use of managed and natural biodiversity to build system resilience to abiotic, biotic and economic stresses.

Chapter 3, "Soil Health", gives detailed explanation of the interaction of nutrients and the organic matter in soils. Chapter 5, "Water Management", discusses both rainfed and irrigated water management and the precise and monitored use of water resources. Chapter 6, "Plant Protection", focuses on precision in the application of agrichemicals. A final chapter on "Policies and Institutions" offers an excellent summary of the need for support from these sources in order to achieve best management targets.

3. Unilever's sustainable agriculture: cool farm tool (http://www.growingforthefuture.com/content/Cool+Farm+Tool).

Unilever contracted with the University of Aberdeen to develop a basis for farmers to determine their particular impact on carbon loadings and global warming. This innovative effort nonetheless raises the question of whether farmers might consider such an exercise worth doing, since it has little or no impact on current profitability. The method calculates the greenhouse gas balance of farming, including emissions from fields, inputs, livestock, land use and primary processing. However, the procedure seems oriented to UK farmers, and would be of limited interest to farmers in developing countries.

4. Sustainable Food Laboratory (http://www.sustainablefoodlab.org).

A consortium of business, non-profit and public organizations, this group has made efforts to "measure sustainable agriculture". In its May, 2011 newsletter it discusses both an "energy metric" and "greenhouse gas metric" and a computer simulator resembling that of the aforementioned Aberdeen group's GHG calculator. These were described as being under review by working groups and not yet ready for implementation. In the same newsletter, a representative of the Canadian pulse industry described the results of 34 research interviews leading to its report "Measuring Sustainable Agriculture", which compares the views of farmers and the food industry in terms of what is most worth measuring. Four elements emerged from this report for measuring environmental sustainability, all of which are consistent with the six categories and three indicator ratios developed in the main body of this analysis: (1) greenhouse gas emissions; (2) impacts on water; (3) impacts on biodiversity; (4) indicators of soil health.

5. Sustainability Consortium: "A Review of Water Scarcity Indices and Methodologies," by Amber Brown and M.D. Matlock, University of Arkansas. White Paper No. 106, April, 2011 (http://www.sustainabilityconsortium.org/food-beverage-agriculture/).

This consortium's White Paper from the University of Arkansas provides a useful and detailed assessment of water stress indices, noting (p. 1) that "Selecting the criteria by which water is assessed can be as much a policy decisions as a scientific decision". It then reviews a considerable number of indices, of which the most germane may be "water resources vulnerability indices", specifically the index of relative water use and reuse (Vorosmarty et al., 2005). Cells measuring 8 km on a side are used to calculate the sum of water withdrawals for domestic (*D*), industrial (*I*) and agricultural (*A*) sectors, then divided by the sum of all river and stream discharges (Q_c) in the n^{th} cell:

$$\frac{DIA_n}{Q_{cn}}$$

An index greater than 40 percent is considered a high level of stress.

An alternative, somewhat less precise index, the "watershed sustainability index" (WSI) represents a pressure, state, response relation (Chavez & Alipaz, 2007). It is specific to a watershed, and applies to areas as large as 2,500 km^2, broken into smaller areas. It is the average of four indicators: hydrologic (measured from 0 to 1), environmental (0-1), human life (0-1) and policy (0-1). Each is given a score of 0.25, 0.50, 0.75 or 1.0 and each is equally weighted:

$$\mathrm{WSI} = \frac{H + E + L + P}{4},$$

with a theoretical maximum of 1.

6. SAI Platform: "Agriculture Standards Benchmark Study, 2009", Intertek Sustainability Solutions (http://www. saiplatform.org/uploads/Library/SAI_rev2_final_%20(Benchmarking%20Report)-2.pdf.

This study, commissioned by the SAI Platform composed of Danone, Nestlè, Unilever and 18 other corporate members, reviews 24 different standards employed in various countries (all OECD), including some of the aforementioned (eg., the Rainforest Alliance). It then "grades" these standards in terms of various criteria: whether a "multi-stakeholder process" is involved, "good governance", whether there is a process for "conflict of interest and dispute resolution", etc. It offers no conclusions concerning which of the standards gets the best "marks" nor does it propose specific indicators at the project level.

7. United Nations Development Programme (UNDP). Human Development Reports, The Human Development Index (HDI) (http://undp.org/en/statistics/hdi/).

This alternative to GDP was famously innovated by the late UN economist Mahbubul-Haq with assistance from Nobel-winning economist A.K. Sen. It seeks to go beyond purely economic or material measures of national welfare based on gross income per capita to set "goalpost minimums" for education, life expectancy and wealth and to facilitate comparisons across countries. All of these indicators are measurable using national data. While a landmark achievement highlighting what can be a process of "uneven development" across these dimensions, the HDI is national in scope and thus highly aggregative rather than project-based, although it can be attempted, as proposed in the White Paper, at a more disaggregated level. It underlines that a major focus of project evaluation should be "people and their capabilities". It also normalizes its findings from 0-1, convertible to the 1-10 scale used in this paper.