

Mind the (yield) gap(s)

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Abstract This paper explores the origin of the notion of “yield gap” and its use as a framing device for agricultural policy in sub-Saharan Africa. The argument is that while the yield gap of policy discourse provides a simple and powerful framing device, it is most often used without the discipline or caveats associated with the best examples of its use in crop production ecology and microeconomics. This argument is developed by examining how yield gap is used in a selection of recent and influential agricultural policy documents. The message for policy makers and others is clear: “mind the (yield) gap(s)”, for they are seldom what they appear.

Keywords Africa · Agriculture · Productivity · Crop · Ecology

Introduction

What goes around comes around, and in the realms of development discourse and policy, after years of relative neglect, agriculture is once again moving towards centre stage. Whether in response to the predicted effects of climate change, recent global food price volatility, stalling crop yields, or simply a return to “fundamental truths” about the link between agriculture growth and poverty alleviation, at least at a rhetorical level agriculture is firmly back on the agenda. It is however still too early to tell if this renewed interest in agriculture will result in “new departures” or simply a return to “business-as-usual” (de Janvry and Sadoulet 2010).

In either case, for the moment there is an emerging consensus about the importance of investment in agriculture—particularly in sub-Saharan Africa (SSA)—despite much continuing debate and contestation around alternative visions, objectives and instruments. Large or small farms; market engagement or self-sufficiency; fertilisers and GMOs or agro-ecology; favoured or marginal areas—while some of these debates are long-running, they have taken on a new urgency and have been joined by a number of new actors. African governments through the African Union’s Comprehensive Africa Agriculture Development Programme (CAADP), private philanthropy, NGOs and increasingly vocal rural people’s movements (Desmarais 2007; Borras 2010) now contribute to and affect policy processes around agriculture to a degree that was unimaginable just a decade ago. These debates are not simply academic: rather, they represent an important front in the struggle for control of the new African agriculture agenda.

A critical aspect of these debates is the way that the “problem” of agricultural development in SSA has been framed and is being re-framed. As is now widely appreciated, framing—by foregrounding certain issues, policy options, technologies or pathways, while backgrounding others—can impact dynamics and outcomes of policy processes. Framing matters.

In arguing agricultural development policy for SSA an often used framing device is the notion of yield gap (also referred to as “productivity gap”) (e.g. InterAcademy Council 2004; The World Bank 2007; McIntyre et al. 2009; Seck et al. 2010; Godfray et al. 2010; Foresight 2011). Yield gap has disciplinary roots in both economics and crop production ecology, yet today it is used by policy advocates from diverse backgrounds and in a variety of contexts. Apart from anything else, yield gap is perhaps the ultimate example of a “deficit approach” to agricultural development in that it focuses attention on what is not there (in contrast to so-called “asset-based

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approaches”—see Kretzmann and McKnight (1993) and Mathie and Cunningham (2003)). In policy discourse yield gaps are called into existence only to be “filled”, “closed” or “bridged”. Ironically, while yield gaps are usually used to tell a story of deficit, from another perspective, a large yield gap can be seen as desirable, as it holds out promise of what could (or should) be achieved. In contrast, a small yield gap indicates that there is limited potential to increase productivity (Cassman et al. 2003).

This paper explores the use of yield gap as a framing device for agricultural development policy in SSA. The argument is that there is a tension between the notion of yield gap as developed in crop ecology (although even here there is no single or consistent usage) and micro-economic studies, and how it is used in policy discourse and advocacy. Specifically I argue that while the yield gap of policy discourse provides a simple and powerful framing device, it is most often used without the discipline or caveats associated with the best examples of its use in production ecology and microeconomics. Despite an association with science and systematic analysis, yield gaps are often purposively and loosely constructed by policy advocates to support particular narratives and policy options. In general, the link between the yield gap and issues addressed by the favoured policy options is lacking or at best poorly specified.

The paper proceeds as follows. The next section is a short discussion of the importance and role of framing within contemporary policy processes. Following this, the history and use of the notion of yield gap within the agricultural sciences is explored. The fourth section looks at how yield gap is used in contemporary policy discourse. The final section considers the implications of this analysis.

Framing matters

Policy advocates use a variety of ways to reinforce or change attitudes to problems or particular policy options held by decision makers, other policy advocates, opinion formers or the general public. One of these “weapon[s] of advocacy and consensus” (Weiss 1989, p.117) is framing, defined as “the process of selecting, emphasizing, and organizing aspects of complex issues, according to overriding evaluative or analytical criterion” (Daviter 2007, p.654). The basic observation that underpins the interest in framing is that small changes “in the presentation of an issue or an event produce (sometimes large) changes of opinion” (Chong and Druckman 2007, p.104). This is referred to as the “framing effect”. While much of the research literature focuses on the effects of framing by politicians and other elites on public opinion, the same dynamic is at play *among* elites and *within* policy communities. Chong and Druckman (2007, p.111) suggest that framing can work at three levels:

“making new beliefs available about an issue, making certain available beliefs accessible, or making beliefs applicable or ‘strong’ in people’s evaluations”.

Framing is a political act which, if successful, allows a policy advocate or coalition “to influence ensuing policy dynamics over the long run to the extent that the specific representation and delineation of policy issues shapes the formation of substantive interests and at times restructures constituencies” (Daviter 2007, p.655). Framing is best conceptualised as a process that evolves over time (Chong and Druckman 2007); rather than being an antecedent of action, it is “at the heart of the action itself” (Weiss 1989, p.98).

Of particular relevance to the renewed interest in African agriculture is Chong and Druckman’s (2007) suggestion that by reframing, “traditional issues” can potentially be transformed into “new” issues, and the idea that framing “exerts most leverage when it coincides with a parallel shift of institutional venues” (Baumgartner and Jones 1991, p.1044).

It would be wrong to conclude that because of the existence of the framing effect people—whether policy elites or the general public—are passive targets or hapless victims of efforts to frame or re-frame issues. On the contrary, evidence suggests that “citizens deal with elite frames in a relatively competent and well-reasoned manner” (Druckman 2001, p.246); and in any case, strong resistance to framing should also be seen as problematic if it means that people are unable to recognise or accept good arguments (Chong and Druckman 2007). Nevertheless, framing “reveals the enormous latitude for inadvertent, tacit (or deliberate, covert) influence of power” (Stirling 2008, p.275).

The argument in this paper is that within debates about the future of agriculture in Africa the notion of yield gap is being widely used as a framing device: a significant recurrent element that frames and anchors a narrative, and that helps justify particular technical and policy options.

A yield gap primer

Economists have long been interested in explaining observed differences in agricultural productivity over time and space. Clark (1954) for example, compared productivity of the whole agricultural sector both across countries and over extended time periods within the UK and USA. Clark’s focus was on labour productivity, as was later work by Hayami (1969) who estimated aggregate production functions to explain national gaps in agricultural “output per male worker”. Working at the level of individual fields, Herdt and Mandac (1981) also estimated production functions in an effort to explain what they thought would be large gaps between the yield achieved by a sample of Philippine rice farmers who were using modern technology, and the yields that could be achieved if the technology was

exploited to the fullest. In fact, their analysis showed these gaps to be “rather modest”, and they concluded that “the largest potential for closing the yield gap among the study farmers is through increasing their technical efficiency, not by convincing them to apply more inputs” (p.399).

Crop production ecology is the other disciplinary home of the yield gap and it is here that the theory and methodology of yield gap analysis (*agronomic diagnosis* in French) was developed. In the remainder of this paper we focus solely on yield gap as conceived and used within crop production ecology. In the most general sense a crop yield gap can be thought of as the difference between two yield estimates. Most commonly, one is an estimate of “potential” yield while the other is of “actual” yield, with the former being larger than the latter, and the gap defined as the difference between them. In yield gap analysis “the relative importance of growth factors and inputs is investigated to explain actual yield levels and resource-use efficiencies and to analyze differences between potential and actual yield levels to open ways for improvement” (Van Ittersum and Rabbinge 1997). According to Prost et al. (2008) “yield gap analysis is used to identify and rank the factors that can explain the low yields observed in a range of farmers’ fields”.

In their widely cited paper Van Ittersum and Rabbinge (1997) suggest that crop growth can be understood in terms of “growth-defining” factors (plant characteristics, temperature and solar radiation), “growth-limiting” factors (water and nutrients) and “growth-reducing” factors (including weeds, pests, diseases and pollutants). From a “crop’s point of view” potential yield is an estimate of performance when the crop is optimally supplied with growth-defining and growth-limiting factors and completely protected against growth-reducing factors. Actual yield refers to performance when water or nutrients levels are sub-optimal or protection against growth-reducing effects is less than 100 % effective. In this scheme the role of management by farmers is to use “yield-increasing” measures (relating to the supply of water and nutrients) and “yield-protecting” measures (relating to control of pests, diseases and weeds) to move from actual to attainable yield (with attainable yields always being less than potential yields). These authors stress the location specificity of this framework and the fact that it favours long-term explorations that look “beyond current, often temporary, limitations and constraints regarding farmer’s skills, socio-economic factors or available techniques”. Thinking along these lines is further developed by Van Ittersum et al. (in press).

It is in the operationalisation of theoretical schemes such as this—what is in effect a shift in perspective from a “crop’s point of view” to an “analyst’s point of view”—that the yield gap story becomes problematic. It should already be clear that the meaning of an identified yield gap and the interpretation of a yield gap analysis are both dependent on the estimates of potential and actual yields that are used. Lobell et al. (2009) identify a number of “traditional”

approaches to the estimation of potential yield—including model simulations, field experiments, yield contests and maximum farmer yields—each having advantages and disadvantages (also see Van Ittersum et al. in press). Equally, many different methods for the estimation of actual yield have been suggested and used. As a result, even within the rather constrained fields of crop ecology and agronomy, there is a “lack of consistency in yield gap analysis in the literature” (Lobell et al. 2009), which is duly illustrated in the following definitions of yield gap:

- “the difference between actual farmers’ yield and calculated average potential yield” (Becker et al. 2003); using similar language Cassman et al. (2003) defined the “exploitable yield gap” as “the difference between yield potential and the actual yield achieved by farmers”
- the difference between simulated yields and observed yields (Audebert and Fofana 2009)
- “the difference of the average production situation with the anticipated best one” (de Bie 2004)
- the “gap between the actual crop yield and the expected yield” (Zinck et al. 2004)
- “the difference between average and maximum yields” (Lobell et al. 2007)
- the “gap between farmers’ and experimental yields” (Ortiz-Ferrara et al. 2006)
- “best versus average” (de Bie 2004; also see Waddington et al. 2010)

Fresco et al. (1994) attempted to bring some order to this by identifying four gaps between five yield estimates: calculated potential yield, maximum station yield, technical ceiling yield, economic ceiling yield and actual farmer yield (Fig. 1). In introducing “economic ceiling yield”, the maximum yield that makes economic sense under a specific set of conditions (input and output prices, market access etc.), and defining Gap 4 as the difference between it and actual

Calculated potential yield	Gap 1			
	Maximum station yield	Gap 2		
		Technical ceiling yield	Gap 3	
			Economic ceiling yield	Gap 4
		Actual farmer yield		
Research		Farmers' fields		

Fig. 1 Four yield gaps (adapted from (Zinck et al. 2004) based on (Fresco et al. 1994))

farmer yield, Fresco et al. have clearly departed from “the crop’s point of view” and in so doing brought yield gaps squarely into the realms of both applied agronomy and policy. An agronomist’s interest is drawn to the variable levels of actual yield achieved by farmers growing the same crop under broadly similar agro-ecological conditions. In principle this variability can be accounted for by micro soil and climate effects, differential input use, skill and management—including timeliness or “logistical efficiency”, pests and diseases pressure, and luck. Some producers may consistently achieve higher yields than others, use available resources more efficiently and/or be more profitable. The implication of this is that conceiving of “actual” yield simply as a mean without a variance immediately confounds the calculation of a yield gap. The difference between the “potential” yield and the “average” yield of the top quartile of producers might be considerably smaller than that between the “potential” yield and the “average” yield of the bottom quartile. As the spatial scale of the analysis increases, and with it agro-ecological variability, the variance around mean producer yield would be expected to increase.

Yield gap remains an important concept in applied crop ecology and agronomy: the last few years have seen the publication of yield gap studies relating to cassava in East Africa (Fermont et al. (2009), maize in Western Kenya (Tittonnell et al. (2008), rice in West Africa (Audebert and Fofana 2009), (Waddington et al. (2010) and Sahelian irrigated rice (Van Asten et al. 2003).

Apart from the field and farm level, there is interest in what Van Ittersum et al. (in press) refer to as “global” yield gap studies that seek worldwide coverage using consistent methods. The recently initiated project to develop a Global Yield Gap Atlas¹ seeks specifically to make these global approaches relevant at local level.

Before turning to how the notion of yield gap is used as a framing device in policy discourse it is important to return to Van Ittersum and Rabbinge’s (1997) insistence upon the context-specificity of yield gaps and yield gap analysis, because, in general, context-specificity does not play well within policy discourse and processes. Importantly, relaxing this context specificity constraint opens the way to a much more creative approach to the “potential” element of yield gap calculation. This is a critical part of what makes yield gap such an attractive and versatile framing device for agricultural policy advocates.

Arguing agricultural policy through the yield gap

In this section I will argue that yield gap is a particularly effective framing device because it neatly and clearly

¹ See: <http://yieldgap.org/>

indicates the magnitude of the problem to be addressed and, as highlighted in the previous section, the many options available for constructing the gap provide the farmer with considerable scope for creativity. Because reference to the existence of a yield gap—no matter how it is defined—comes with no self-evident explanation for its causal factors or the ways it might most effectively be addressed, it provides an ideal platform for policy advocacy.

The remainder of this section looks at the use of yield gap as a framing device in four recent high profile documents touching on African agriculture: the InterAcademy Council report *Realizing the Promise and Potential of African Agriculture* (InterAcademy Council 2004); the 2008 World Development report *Agriculture for Development* (The World Bank 2007); the International Assessment of Agricultural Science and Technology (IAAST) report *Agriculture at a Crossroads* (McIntyre et al. 2009); and the UK Foresight report *The Future of Food and Farming* (Foresight 2011).

InterAcademy Council: realizing the promise and potential of African agriculture

Realizing the Promise and Potential of African Agriculture originated in a request from the UN Secretary General to the InterAcademy Council for a study and strategic plan by which “the best of science and technology could be harnessed to help Africa substantially increase its agricultural productivity, thereby contributing to improved food security” (InterAcademy Council 2004, p.1). The InterAcademy Council, a grouping of the world’s science academies, appointed an 18 member study panel: a process involving panel meetings, consultative regional workshops and commissioned papers culminated in the publication of *Realizing the Promise and Potential of African Agriculture*. The launch of this report was widely covered in the press. African smallholder farmers, yield gaps and yield gap analysis are central to *Realizing the Promise and Potential of African Agriculture*. This emphasis on yield gaps should not be surprising as the study panel was co-chaired by Professor Rudy Rabbinge, a widely respected Dutch crop ecologist who played a critical role in the formalisation of yield gap analysis.

Highlighting the many different types of farming systems and institutions found in SSA the report argues for multiple “rainbow evolutions” as opposed to a single Green Revolution. To support this it calls for the adoption of a “production ecology approach”, “integrated sustainable intensification” and “market-led productivity improvement”. A host of other recommendations are made addressing science and technology strategies, institution building, investments in human capital and market development.

The report’s Box 3.4 (Chapter 3) introduces yield gaps and yield gap analysis. Two types of yield gaps are identified: those based on production ecological principles and those

based on “actual farm conditions”. The former use as the upper limit “theoretically calculated yields that can be obtained under potential or attainable production conditions” and compares these to actual farmers’ yields. In contrast, yield gaps based on actual farm conditions compare yields obtained on experimental fields with those of “the best” or “average” farmers. Also falling into this category are yield gaps that contrast “differences between countries, and so on”. While *Realizing the Promise and Potential of African Agriculture* is clearly partial to the production ecology approach, it concludes that “while experimental yields may be seen as the highest yields feasible, still unidentified factors may suppress the performance of the crop. These factors cannot be identified without thorough, in-depth analyses based on eco-physiological principles. The two methods are therefore complementary” (p.41).

As is fitting given the report’s emphasis on the diversity of production environments, farming systems and institutional contexts in SSA, a very wide range of recommended responses are identified to enable the identified yield gaps to be bridged (Box 1). Some of these responses are broad (i.e. “create incentives”) some are narrow (“encourage and promote farmer organizations”); some are strategic, while others are methodological (e.g. use agro-ecological and participatory approaches). While all are reasonable and plausible, they have all been seen before. There is little indication in the report how these recommendations actually link to or arose from yield gap analysis. In other words, despite the high profile of production ecology and yield gap analysis in the report, the logical, context-specific links between these and the policy recommendations appear quite weak.

Box 1. Solutions identified in *Realizing the Promise and Potential of African Agriculture* for bridging yield gaps.

- Use agro-ecological approaches; use production ecological approach; focus on growth- & yield-limiting and growth- & yield-reducing factors
- Strategic research on pervasive priority problems of a regional or continental character, where spillovers are possible
- Address both technical & economic aspects; work on technical, institutional and policy measurements [sic]
- Place premium on farmer participatory approaches; use “participatory knowledge quadrangle”
- Create incentives
- Identify new niche value-added marketing opportunities
- Market-led productivity improvement strategy
- Information & communications technology (ITS); use ICTs to provide speedy & timely market & price information
- Develop new options for the future
- Varieties with properties such as salt tolerance & resistance to the prevailing pests & diseases
- Development of low-cost water management, weed-competitive & nutrient-responsive rice varieties
- Improve soil fertility; site-specific soil fertility management
- Direct research at understanding and resolving factors that limit access to fertilizers, that make fertilizers use more efficient & that make irrigation more appropriate & less costly for small farmers
- An integrated package of appropriate technology options, services & public policies, particularly in the field of input and output pricing & information
- Systematic fine-tuning of technology options to improve adoption; adapt & fine tune technology options
- Scale up examples of successful productivity-enhancing innovations
- Strengthen national, regional & continental strategic research capacities
- Research on technology exchange & delivery systems
- Encourage & promote farmer organizations, including co-operatives

Agriculture for development

The 2008 edition of the World Bank's World Development Report—*Agriculture for Development*—argues the case for an increased policy focus on, and support for, agriculture. Underlying the report's very detailed analyses are four propositions:

- Agriculture is a fundamental “instrument” for achieving sustainable development and poverty reduction.
- A “productivity revolution” in smallholder farming within agriculture-based countries is necessary.
- A “comprehensive approach” for addressing income inequality will include “shifting to high value agriculture, decentralizing nonfarm economic activity to rural areas, and providing assistance to help move people out of agriculture”.
- It is possible to simultaneously reduce agriculture's environmental footprint, make it less vulnerable to climate change and enhance its ability to deliver environmental services.
- Governance of agriculture at local, national and global levels must be improved.

Agriculture for Development was both celebrated for bringing agriculture in from the cold and critiqued for its

ideology, naiveté, inconsistencies and reliance on “myths” (e.g. Amanor 2009; Devereux et al. 2009; McMichael 2009; Veltmeyer 2009; Woodhouse 2009; Hetherington 2009; Murray Li 2009; Oya 2009). Nevertheless it stands as a seminal document in relation to the current cycle of heightened policy interest in agriculture.

The need to increase crop productivity and the image of a smallholder “productivity revolution” are central to *Agriculture for Development* and it is in this context that the notion of yield gap is deployed. Table 1 shows all direct references to yield gap in the report. It is immediately evident that yield gap is used in a very flexible way, to include gaps in productivity between:

- Average farm yields and experimental yield potential
- Current yields and “what can be economically achieved with better support services”
- SSA and the rest of the world
- Favoured and less favoured regions
- Large and small farms

All of the categories used to construct these gaps are problematic. Gap A comes closest to the sense in which yield gap is used in the crop ecology literature, but in using experimental yield potential as opposed to estimated

Table 1 References to yield gap in *Agriculture for Development*

Page	Yield/productivity gap	Cause(s)	Proposed solution(s)
14	For cereals, between SSA & the rest of the world	<ul style="list-style-type: none"> • Low investments in R&D • Low international transfers of technology 	<ul style="list-style-type: none"> • Sharply increased investment in R&D • Regional cooperation in R&D
15	Between favoured & less-favoured regions		<ul style="list-style-type: none"> • Better technologies • Approaches that exploit biological & ecological processes
66–67	Between average farm yields & experimental yield potential [some rice producing areas of Asia where average farm yields are less than 80 % of experimental yield potential]	<ul style="list-style-type: none"> • Deteriorating soil & water quality • Imbalanced nutrient use 	
67	Exploitable yield gap [presumable between average farm yields & experimental yield potential] [for maize in SSA]		<ul style="list-style-type: none"> • Transfer of “best bet” technologies • Establish institutional structures “that farmers need to adopt the technologies”
91	Between large & small farms	<ul style="list-style-type: none"> • Large farms tend to apply more fertiliser & other inputs 	
91	Between large & small farms	<ul style="list-style-type: none"> • Imperfections in credit & insurance markets prevent adoption of more productive capital-intensive techniques or higher-value products 	<ul style="list-style-type: none"> • Jointly consider policies targeting land, capital & risk for smallholders
232	Between current yields & what can be economically achieved with better support services, especially in high-potential areas		<ul style="list-style-type: none"> • Improved incentives • Investments in agricultural research & extension systems • Access to financial services • “Market smart” subsidies to stimulate input markets • Better mechanisms for risk management

maximum yield potential it is closer to Fresco et al.'s Gaps 2+3+4. Gap B is similar to Fresco et al.'s Gap 4 (economic ceiling yield minus actual farmer yield). It is more difficult to see the relevance of Gaps C, D and E as they blatantly violate the proposition by Van Ittersum and Rabbinge (1997) that it is only through context-specificity that yield gaps become meaningful. What does the “fact” that the gap between cereal yields in SSA and those in “the rest of the world” is large and increasing really say about African agriculture? What conclusions can be drawn from a cereal yield gap of 5 tons/ha between SSA and “Developed countries”?

Turning now to the rest of the table, we see first that the logical links between the gaps, the causes and the solutions proposed to address them, are neither complete nor compelling. The same solutions are proposed to address different gaps, which would seem to indicate a certain lack of specificity. In any case, it is only right that the credence given to specific solutions should be directly proportional to the relevance of the gap used to justify them: as noted above a number of the gaps used in *Agriculture for Development* might be considered far-fetched. Finally it is important to note that taken together the proposed solutions are nothing more than the now orthodox prescription of better technology, better institutions, greater incentives and smarter subsidies. As with the InterAcademy Council's report, the question is whether the use of yield gaps brought anything new or unique to this analysis. Alternatively, are yield gaps used simply to help frame and justify a pre-existing agenda?

IAAST: agriculture at a crossroads

Agriculture at a Crossroads (McIntyre et al. 2009) is the main output of a global assessment process initiated by the World Bank and the FAO in 2002. The goal of the IAAST was to assess “the role of agricultural knowledge, science and technology (AKST) in reducing hunger and poverty, improving rural livelihoods and facilitating environmentally, socially and economically sustainable development” (p.ix). The IAAST was designed “in order to ensure ownership of the process and findings by a range of stakeholders” including governments, civil society organisations and the private sector. Around 400 “experts” worldwide contributed to *Agriculture at a Crossroads* and five accompanying “sub-global” assessments.

In the event the politics amongst the various stakeholders involved in the process were intense—focusing specifically around a biotechnology vs. agroecology fault line—and resulted in the withdrawal of some private sector stakeholders from the process (Scoones 2009; Feldman and Biggs 2012). Nevertheless, *Agriculture at a Crossroads* has been widely endorsed and, with its acknowledgment of the importance of agroecology and food sovereignty, is actively promoted by some as the basis for a radical reformulation of global agriculture (cf. Ishii-Eiteman 2009).

There are five specific references to yield gap in the main text of *Agriculture at a Crossroads* (Table 2). Three of these provide a definition, and these definitions are all different: one defines yield gap as the difference between high and low income countries; one as the gap between yield potential and yield achieved; and one as the gap between the biological potential of Green Revolution crops and what the poor farmers in developing countries typically manage to produce in the field.

A section of the report's Table 6.2 identifies “AKST [agricultural knowledge, science and technology] gaps and needs” required for “closing yield gaps in low productivity systems”. A number of “challenges” are identified including

- Improve practices for root health management
- Conventional Breeding/rDNA assisted (breeding)
- Transgenics (GM)
- Improve the performance of livestock in pastoral and semi-pastoral subsistence communities
- Rain water harvesting, supplemental and small scale irrigation for rainfed systems
- Integrate soil water and soil fertility management
- Multiple water use systems, domestic and productive uses, crops/livestock/fisheries

However, there is no clear link between these challenges and the yield gaps referred to in the text, and consequently the actions proposed to address the challenges are very broad (e.g. “enhance nutrient cycling”).

Foresight: the future of food and farming

The Future of Food and Farming (Foresight 2011) is a product of the UK government's Foresight Programme which seeks to improve how science and technology are used within government and society. The Global Food and Farming Futures project set out to “to explore the pressures on the global food system between now and 2050 and identify the decisions that policy makers need to take today, and in the years ahead, to ensure that a global population rising to nine billion or more can be fed sustainably and equitably” (p.9). To achieve this, the project commissioned: 13 synthesis reports; 22 driver reviews; case studies of success in sustainable intensification in SSA; 7 regional reviews; 41 state-of-science reviews; plus a number of additional reviews and working papers. While SSA was not the sole focus of Global Food and Farming Futures project, it nevertheless features quite prominently in the report.

The Future of Food and Farming was launched with much fanfare in January 2011. Project outputs have entered the scientific literature through articles in *Science* (Godfray et al. 2010) and special issues of *Philosophical Transactions of the Royal Society B* (Vol 365, 2010)² and *Food Policy* (Vol. 36,S1, 2011).

² Jaggard et al. (2010) deal most directly with yield gaps but there is relatively little in the paper on SSA.

Table 2 References to yield or productivity gaps in *Agriculture at a Crossroads*

Page	Yield/productivity gap	Cause(s)	Proposed solution(s)
20	Between high- and low-income countries	• Differences in context	
147	Between crop yield potential and yield achieved	• Poor farmers cannot afford to buy fertiliser	• Agroforestry (“a partial solution”)—biological nitrogen-fixation by leguminous trees/shrubs
223	Between the biological potential of Green Revolution crops & what the poor farmers in developing countries typically manage to produce in the field		• Overcoming the constraints to innovation & improving farming systems • Farm products to be fairly & appropriately priced so that farmers can spend money on the necessary inputs.
378	“filling the yield gap”		• Smarter & more targeted application of existing agricultural knowledge, science & technology (AKST) • New science & innovation
418	Productivity gap [in semiarid agriculture]	• High rainfall variability • Poor quality seed	• Technologies & practices that reduce the exposure of sensitive crop growth stages to seasonal climate variability (access to quality seed, seed priming, transplanting)

The report makes six references to yield or productivity gaps (Table 3) and provides two definitions:

- “Both within and between countries there are differences in productivity that are not explained by local physical conditions” (p.80)

- “The difference between realised productivity and the best that can be achieved using current genetic material and available technologies and management” (p.204)

Once again the explanations for the existence of yield gaps are broad: “poorly developed infrastructure, whether in

Table 3 References to yield gap in *The Future of Food and Farming*

Page	Yield/productivity gap	Cause(s)	Proposed solution(s)
80	Differences in productivity—both within & between countries—that are not explained by local physical conditions	• Poorly developed infrastructure (roads, storage, inputs and services).	• Application of existing knowledge and technology • Better access to insurance; better outreach or farmer exchanges (to stimulate greater innovation & risk-taking amongst producers)
80	“yield gaps”	• Conflict & political turmoil • Political or economic mismanagement • Lack of human, physical & financial capital	• Increasing prices • Decisions by policy-makers that enable production systems to respond efficiently to increasing demand
83–85	To bridge “yield gaps” sustainably		• Extension services • Improving the functioning of markets & providing market access • Natural resource & land rights • Infrastructure
85	Some governments (e.g. China) aspire to bridge “the yield gap”		• By strengthen the agricultural sector, including... restructuring the agricultural markets; promoting agricultural infrastructure; raising rural incomes; and alleviating poverty through development
86	“The yield gap” can be bridged...		• Sound investment by governments in a range of support measures
204	Difference between realised productivity & the best that can be achieved using current genetic material & available technologies & management		

roads, storage and markets, or in input and services” (p.80), and in some situations “conflict and political turmoil”, “political or economic mismanagement”, low prices, and “lack of human, physical and financial capital [that] restricts the application of existing knowledge” (p.80). It should not be surprising that the links between the identified yield gaps and the proposed responses are weak and non-specific.

Some members of the Foresight team published a review paper in *Science* that put the notion of yield gap at centre stage (Godfray et al. 2010). According to these authors “The difference between realized productivity and the best that can be achieved using current genetic material and available technologies and management is termed the ‘yield gap’” (p.813). If we assume the “realised productivity” refers to actual farmer yield, this gap would appear to be equivalent to either Fresco et al.’s Gap 3+4 or their Gap 2+3+4, depending on whether the “best that can be achieved” relates to farmers’ fields or to maximum yields in an experimental context. Subsequently they acknowledge Fresco et al.’s Gap 3 (the gap between “technical ceiling yield” and “economic ceiling yield”) (p.813).

Two things are important here. First, yield gap—or rather “the” yield gap—is presented as a straightforward notion that is, at least in principle, relatively unproblematic to estimate. No reference is made to the fact that this particular version of yield gap is one amongst a number of possible alternatives, or that the generation of meaningful estimates of any of these gaps can be extremely challenging. Second, while a number of factors associated with the yield gap are identified, no indication is given how to move systematically from the identification of a gap to the development of specific policy prescriptions.

Conclusions

Yield gap is an example of a concept taken from one field (in this case crop production ecology) and applied in another (agricultural policy analysis and advocacy). As is often the case, in the process of a transfer like this a good deal of the subtlety and nuance of the concept appears to have been lost, as has any recognition of its limitations.

As illustrated through the examples examined in the previous section, yield gap is commonly used to frame the “problem” of agriculture in SSA and to justify particular policy responses. Any number of alternative yield gaps can be and are constructed. While the immediate meaning and relevance of some of these may be difficult to discern (e.g. the 5 ton/ha gap in average cereal yields between “SSA” and “developed countries” referred to earlier), for those wanting to draw attention to the need for further investment in African agriculture, the motivation is to construct the largest gap possible.

Yield gap is an excellent policy framing device: it brings an aura of scientific analysis and quantification and appears to be technically rooted. A large gap focuses the mind: surely

something must and can be done! But as is evident, yield gaps can be constructed in many ways, and the size of the resulting gaps vary accordingly. Further, there is no direct or logical line between a yield gap—no matter how it is constructed—and appropriate policy responses. Rather, in the cases we have examined it would appear that yield gap is used predominantly to support a set of broad responses around which there is already general agreement. Finally, the yield gaps used to frame agricultural policy debates seldom approach the level of context specificity that is assumed in most crop production ecology analyses—which, if they did, would perhaps allow the identification of more appropriate policy options

Policy advocates concerned with agriculture in SSA will continue to use “all the tools in the toolbox”—including framing and yield gaps—to argue and promote their favoured policy options. One would hope, however, that policy researchers would cast a more critical eye on and be more circumspect in their reference to yield gaps. In any case, the message for policy makers and others is clear: “mind the (yield) gap(s)”, for they are seldom what they appear.

References

- Amanor, K. S. (2009). Global food chains, African smallholders and world bank governance. *Journal of Agrarian Change*, 9(2), 247–262.
- Audebert, A., & Fofana, M. (2009). Rice yield gap due to iron toxicity in West Africa. *Journal of Agronomy and Crop Science*, 195(1), 66–76.
- Baumgartner, E. R., & Jones, B. D. (1991). Agenda dynamics and policy sub-systems. *Journal of Politics*, 53(4), 1044–1074.
- Becker, M., Johnson, D. E., Wopereis, M. C. S., & Sow, A. (2003). Rice yield gaps in irrigated systems along an agro-ecological gradient in West Africa. *Journal of Plant Nutrition and Soil Science-Zeitschrift für Pflanzenernährung und Bodenkunde*, 166(1), 61–67.
- Borras, S. M. (2010). The politics of transnational agrarian movements. *Development and Change*, 41(5), 771–803.
- Cassman, K. G., Dobermann, A., Walters, D. T., & Yang. (2003). Meeting cereal demand while protecting natural resources and improving environmental quality. *Annual Review of Environmental Resources*, 28, 315–358.
- Chong, D., & Druckman, J. N. (2007). Framing theory. *Annual Review of Political Science*, 10, 103–126.
- Clark, C. (1954). World supply and requirements of farm products. *Journal of the Royal Statistical Society. Series A (General)*, 117(3), 263–296.
- Daviter, F. (2007). Policy framing in the European Union. *Journal of European Public Policy*, 14(4), 654–666. doi:10.1080/13501760701314474.
- de Bie, C. (2004). The yield gap of mango in Phrao, Thailand, as investigated through comparative performance evaluation. *Scientia Horticulturae*, 102(1), 37–52. doi:10.1016/j.scienta.2003.11.017.
- de Janvry, A., & Sadoulet, E. (2010). Agriculture for development in Africa: business-as-usual or new departures? *Journal of African Economies*, 19(suppl_2), ii7–ii39.
- Desmarais, A. A. (2007). *La Via Campesina: Globalization and the power of peasants*. London: Pluto Press.
- Devereux, S., Scoones, I., & Thompson, J. (2009). Critical responses to the World Bank’s World development report 2008: agriculture for development. *Journal of Peasant Studies*, 36(2), 468–474.
- Druckman, J. N. (2001). The implications of framing effects for citizen competence. *Political Behavior*, 23(3), 225–256.

- Feldman, S., & Biggs, S. (2012). The politics of international assessments: the IAASTD process, reception and significance. *Journal of Agrarian Change*, 12(1), 144–169.
- Fermont, A. M., van Asten, P. J. A., Tittonell, P., van Wijk, M. T., & Giller, K. E. (2009). Closing the cassava yield gap: an analysis from smallholder farms in East Africa. *Field Crops Research*, 112(1), 24–36.
- Foresight. (2011). *The future of food and farming: Challenges and choices for global sustainability. Final project report*. London: The Government Office for Science.
- Fresco, L. O., Huizing, H., Van Keulen, H., Luning, H., & Schipper, R. (1994). *Land evaluation and farming systems analysis for land Use planning*. Rome: FAO.
- Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., et al. (2010). Food security: the challenge of feeding 9 billion people. *Science*, 327(5967), 812–818.
- Hayami, Y. (1969). Sources of agricultural productivity gap among selected countries. *American Journal of Agricultural Economics*, 51(3), 564–575. doi:10.2307/1237909.
- Herdt, R. W., & Mandac, A. M. (1981). Modern technology and economic efficiency of Philippine rice farmers. *Economic Development and Cultural Change*, 29(2), 375–399.
- Hetherington, K. (2009). The strategic incoherence of development: marketing expertise in the World Development Report. *Journal of Peasant Studies*, 36(3), 653–661.
- InterAcademy Council. (2004). *Realizing the promise and potential of African agriculture*. Amsterdam: InterAcademy Council.
- Ishii-Eiteman, M. (2009). Food sovereignty and the International Assessment of Agricultural Knowledge, Science and Technology for Development. *Journal of Peasant Studies*, 36(3), 689–700.
- Jaggard, K. W., Qi, A., & Ober, E. S. (2010). Possible changes to arable crop yields by 2050. *Philosophical Transactions of the Royal Society B*, 365, 2835–2851.
- Kretzmann, J., & McKnight, J. (1993). *Building communities from the inside-out*. Chicago: ACTA Publications.
- Lobell, D. B., Ortiz-Monasterio, J. I., & Falcon, W. P. (2007). Yield uncertainty at the field scale evaluated with multi-year satellite data. *Agricultural Systems*, 92(1–3), 76–90. doi:10.1016/j.agsy.2006.02.010.
- Lobell, D. B., Cassman, K. G., & Field, C. B. (2009). Crop yield gaps: their importance, magnitudes, and causes. *Annual Review of Environmental Resources*, 34, 179–204.
- Mathie, A., & Cunningham, G. (2003). From clients to citizens: asset-based community development as a strategy for community-driven development. *Development in Practice*, 13(5), 474–486.
- McIntyre, B. D., Herren, H. R., Wakhungu, J., & Watson, R. T. (2009). *Agriculture at a crossroads: International Assessment of Agricultural Knowledge, Science and Technology for Development, Global Report*. Washington, DC: Island Press.
- McMichael, P. (2009). Banking on agriculture: a review of the World Development Report 2008. *Journal of Agrarian Change*, 9(2), 235–246.
- Murray Li, T. (2009). Exit from agriculture: a step forward or a step backward for the rural poor? *Journal of Peasant Studies*, 36(3), 629–636.
- Ortiz-Ferrara, G., Joshi, A. K., Chand, R., Bhatta, M. R., Mudwari, A., Thapa, D. B., et al. (2006). Partnering with farmers to accelerate adoption of new technologies in South Asia to improve wheat productivity. In *Symposium on Challenges to International Wheat Improvement, Obregon, MEXICO*, (pp. 399–407).
- Oya, C. (2009). The World Development Report 2008: inconsistencies, silences, and the myth of ‘win-win’ scenarios. *Journal of Peasant Studies*, 36(3), 593–601.
- Prost, L., Makowski, D., & Jeuffroy, M. H. (2008). Comparison of stepwise selection and Bayesian model averaging for yield gap analysis. *Ecological Modelling*, 219(1–2), 66–76.
- Scoones, I. (2009). The politics of global assessments: the case of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). *Journal of Peasant Studies*, 36(3), 547–571.
- Seck, P. A., Tollens, E., Wopereis, M. C. S., Diagne, A., & Bamba, I. (2010). Rising trends and variability of rice prices: threats and opportunities for sub-Saharan Africa. *Food Policy*, 35(5), 403–411.
- Stirling, A. (2008). “Opening up” and “Closing down”—power, participation, and pluralism in the social appraisal of technology. *Science Technology & Human Values*, 33(2), 262–294.
- The World Bank. (2007). *Agriculture for development: World Development Report 2008*. Washington DC: The World Bank.
- Tittonell, P., Vanlauwe, B., Corbeels, M., & Giller, K. E. (2008). Yield gaps, nutrient use efficiencies and response to fertilisers by maize across heterogeneous smallholder farms of Western Kenya. *Plant and Soil*, 313(1–2), 19–37.
- Van Asten, P., Wopereis, M., Haefele, S., Isselmou, M. O., & Kropff, M. (2003). Explaining yield gaps on farmer-identified degraded and non-degraded soils in a Sahelian irrigated rice scheme. *NJAS-Wageningen Journal of Life Sciences*, 50, 277–296.
- Van Ittersum, M. K., & Rabbinge, R. (1997). Concepts in production ecology for analysis and quantification of agricultural input–output combinations. *Field Crops Research*, 52(3), 197–208.
- Van Ittersum, M. K., Cassman, K. G., Grassini, P., Wolf, J., Tittonell, P., & Hochman, Z. (in press). Yield gap analysis with local to global relevance—a review. *Field Crops Research*.
- Veltmeyer, H. (2009). The World Bank on ‘agriculture for development’: a failure of imagination or the power of ideology? *Journal of Peasant Studies*, 36(2), 393–410.
- Waddington, S., Li, X., Dixon, J., Hyman, G., & de Vicente, M. (2010). Getting the focus right: production constraints for six major food crops in Asian and African farming systems. *Food Security*, 2, 27–48.
- Weiss, J. A. (1989). The powers of problem definition: the case of government paperwork. *Policy Sciences*, 22(2), 97–121.
- Woodhouse, P. (2009). Technology, environment and the productivity problem in african agriculture: comment on the World Development Report 2008. *Journal of Agrarian Change*, 9(2), 263–276. doi:10.1111/j.1471-0366.2009.00205.x.
- Zinck, J. A., Berroteran, J. L., Farshad, A., Moameni, A., Wokabi, S., & Van Ranst, E. (2004). Approaches to assessing sustainable agriculture. *Journal of Sustainable Agriculture*, 23(4), 87–109.



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