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Amir Kassam, Francis Shaxson, and Theodor Friedrich	Technical Workshop held at FAO headquarters in Rome in July 2008, entitled: “Investing in Sustainable Crop Intensification: The Case for Improving Soil Health"	10/09/2008

At least in the semi-arid regions of Africa, if within-field soil variability is not taken into account, efforts to increase soil fertility will be less efficient and less likely to be adopted by farmers. Most of these farmers already practice ‘precision agriculture’ and take short distance variability into consideration in their management. One can safely assume that they do so for good reason, given that their management systems have developed over many centuries.

Precision agriculture is also relevant for the introduction of modern technologies. For example, the same principles are relevant to the efficient application of manure and the efficient application of compost and mineral fertiliser.

For the best solutions, farmer knowledge, extensionist knowledge and researcher knowledge of within-field soil variability need to be combined. This will lead to an increase in the knowledge of each group regarding the variability-related possibilities and constraints of the other groups. Increased farmer knowledge will lead to better and more efficient farmer management. Increased researcher knowledge of soil variability will lead to better-targeted and more efficient soil fertility research. If the minimum management area for farmers is part of a field, and researchers only analyse at the level of an entire field or experiment, then those researchers ignore information that is very relevant to the farmers. They should look for variables at the plot level that help explain why, in any one year as well as over the years, different plots with the same treatment react differently. They will find this useful for increasing their agro-ecological knowledge, for improving their scientific publications, and especially for more effective extension to the farmers. Farmers prefer well differentiated advice to blanket advice that turns out not to work part of the time, or in sections of their fields.

For further information, many telling images and additional soil variability literature references, see the final reference in the background document to this internet discussion. In this downloadable reference there is also information on how better knowledge of within-field soil variability can lead to increased yield security in times of unpredictable climate change.

[Also see publication in Resources]

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Your think piece on "Policy frameworks for increasing soil fertility in Africa: debating the alternatives" is really interesting.

Certainly, in many situations external input of plant nutrients is needed to increase the yields and the soil fertility and this is well demonstrated by your list of "models", where all, except the last one, explicitly aims at increasing the productivity through the increased use of chemical fertilizers.

There is however on large and free supply of plant nutrients available even to the most poor and which you do not mention, namely the plant nutrients in the human excreta. Due to the mass balance over the adult human body, the excreta contain all the macro nutrients and the micro nutrients in essentially the same proportions as supplied by the food (even though small amounts are lost with hair, nails, sweat, etc.). Calculations by Arno Rosemarin and Ian Caldwell in the SEI Report "Sustainable Pathways to Attain the Millennium Development Goals: Assessing the Key Role of Water, Energy and Sanitation" (Figure 4-21, relevant chapters attached) show that in the Sub-Saharan region the amounts nitrogen and phosphorus in the human excreta are of the same order as that used in 2002 in the form of chemical fertilizers. Yet, this option for providing locally available plant nutrients is not mentioned in your document.

As we see it, the excreta plant nutrients have several advantages:

- Available also to the most poor, at least in small amounts - from the own family
- No import and thus no impact on the trade balance
- Two complete and complementing fertilizers, urine and treated faeces (see the attached "Guidelines on use of urine and faeces in crop production")

*Urine has the largest flows of nitrogen, phosphorus, potassium and sulphur, and after degradation of the urea nitrogen, essentially of of these nutrients are in the ionic form, i.e. they are easily available. The hygiene risk of non-contaminated urine is low.

*While the flow of macro nutrients in faeces is smaller, its flows of many micro nutrients are larger and it also provides valuable organic matter. However, the pathogen risk associated with faeces is large and they must always be handled, treated and reused in such a way that this reuse chain is considered safe, i.e. its risks are considered acceptable.

- The complementing types of the excreta fertilisers means that the fertilizing schemes can be optimized, e.g. using the urine mainly on nitrogen demanding crops i.e. maize and the faeces on e.g. legumes.

- A further advantage is that the plant nutrient factories consists of toilets, i.e. programs to increase the excreta plant nutrient availability to crop production simultaneously improves the sanitation situation and decreases the pollution and degradation of the environment (MDG no 7).

Sanitation systems aimed at reuse of the excreta plant nutrients are often called ecological sanitation (ecosan), but a very good term for this used by FAO and IFAD is productive sanitation.

We believe in great synergies, especially for small holder farmers in dry regions, when productive sanitation (better plant nutrient supply) is combined with rain water harvesting and water conserving practices and sustainable agricultural practices (improving the soil organics) and are organizing a seminar (attached) August 17th on this "triple green revolution" approach at the World Water Week in Stockholm. Together with IFAD and CREPA, which is experienced in ecological sanitation in West Africa, we are also staring a project on this triple green revolution approach.

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I commend Ian Scoones for his excellent brief historic account of African soil fertility-related research over the last 10-20 years.

I share a kind of 'cross-roads' feeling on Africa, now that food price rises have caused turmoil and protectionist reflexes by rice-exporting countries. The Indian Trade Minister, at the failed WTO talks last week in Geneva put it right: 'every country should be allowed to strive at food self-sufficiency'. There are limits to market liberalization for agriculture. Next, protagonists of free markets have first sealed off their markets in order to develop their agricultural markets. EU and US still do this to a large extent. If Africa does not step up its own production, it will face a worsening terms of trade on agriculture year after year. The sale of natural resources to China will not change this. Development has taken off everywhere in the world with a strong agriculture sector.

Africa should be allowed to develop agriculture following a model such as the Common Agricultural Policy. As a certain size is needed in terms of area and inhabitants, the economic regions such as ECOWAS and COMESA may be suitable units. EU, AfDB and BMGatesFound can be instrumental in helping the areas to develop their agriculture. Actually, it would fit nicely in the European Development Fund. A demand-supply analysis is needed, and the selection of regions where intensification stands the best chance of success. Fertilizer needs and distribution networks should ideally also be organized for the economic regions as a whole to benefit from economies of scale. Microdosing efforts should be promoted at a large scale to access resource-poor farmers, and subsidies on fertilizers should be allowed (using the Malawi case as an example). The abolishment of fertilizer subsidies and the virtual ban on parastatals in the 1980s/1990s was a big mistake, somehow admitted by the World Bank in their latest World Development Report. CIMMYT for example was doing a good job with NARS in developing maize hybrids, only to find their effors frustrated by structural adjustment policies.

There is momentum now to really act: but the question Ian rightly poses is: how to act? In my view, the following investment pays off best, taking a region such as ECOWAS as an example:

- SECTOR ANALYSIS: analyse food demand and supply for the region, map current and future population distribution; and link that to current and future agriculture areas; analyse necessary price levels to make increased production profitable
- PRODUCERS: invest strongly in organizing producer organizations/cooperatives: get farmers trained, organized, connected (mobile phones, market information); what motivates them to increase production? are remittances important, making them less anxious to produce more?

- PRODUCTS: focus on crops with a high response to fertilizers and manure; high-value crops and crops that see demand grow rapidly (e.g. soybean, oilpalm); particular attention for livestock (small ruminants)
- POPULATION: partition the region into areas of higher and lower potential, proximity to consumers, and infrastructure density and development needs
- FERTILIZERS: produce N fertilizer in the region, exploit natural P reserves, and do tests on micronutrient needs and deficiencies; recycle town wastes for compost in the peri-urban area
- POVERTY: for some harsh areas, safety nets may be needed

Less specific for soil fertility, but important as well:

- The region should be able to protect its market, at least for a number of strategic commodities
- The region should work on lowering, streamlining, and even abolishing tariffs between member states
- The countries should work harder on tax collection.

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Major recent studies about the problems of African soils and consequently the low agricultural production have all recognised two generalised, yet paramount, problems:

- Low to very low soil fertility levels as compared with the other major agricultural production areas in the world, caused by low *active-clay* and soil organic matter contents, resulting into low nutrient retention / buffering capacities, often in combination with multiple nutrient deficiencies and nutrient imbalances that are readily induced and aggravated by prolonged use of mineral fertilizers of standardised nutrient compositions.
- A large variability / diversity in soils over short distances (i.e. within farms and individual fields).

These two major problems cannot possibly be handled through standardised type technological solutions like *seeds* of so called improved varieties, *agricultural chemicals* (mineral fertilizers in particular) and increased availability of *water*. And yet these are the major aspects, that have been highlighted albeit unsuccessfully in the past through ambitious projects like T&V, SG 2000 and currently again through the "Millennium Villages Project" and "Alliance for a Green Revolution in Africa".

Currently the issue of *soil health* is being emphasized increasingly as a component of technological approaches like "conservation agriculture / no-till systems", "integrated soil fertility management", "the system of rice intensification (SRI)" among others. These are laudable developments, that contribute to viewing soils as *dynamic* and *living* systems in which the combination of organic matter and *soil (micro)biology* are crucial (at a par with the conventional physical and chemical soils' parameters) in ensuring the long term sustainability of soil productivity and of agricultural production processes that rely upon it.

However, in spite of the scientific rational / logic of the various integrated approaches, these remain surrounded by combinations of (scientific) controversies, originating from differing ideas about what types of paradigms to promote, unresolved research questions, including effectiveness and efficiency issues, as well as by practical constraints associated with field implementation of such approaches under diverse farming conditions. Therefore long term support for research (national and international), conducted by well-trained, and adequate numbers of scientists pursuing the soil fertility issues holistically instead of through short term *silver bullet* type responses, still remains a basic requirement for achieving progress.

Within the context of the major development campaigns / projects referred to above, also the introduction of integrated approaches as blueprints, are bound to encounter a mixed response from farmers, simply because the practical implications of points 1 and 2 above have not been thought through adequately.

Obviously, any farmer and professional field agronomist / extension agent will be aware of these two problems and consequently of the limitations of the large scale approaches / technologies proposed by academics, (international) development experts and policymakers who are not exposed regularly to the practical field realities of farming. In short the ever increasing gap between “theory” and “reality”, and the corresponding “intertwining of scientific, commercial and political interests”, is likely to remain a serious stumbling block for improving African soils and their agricultural productivity.

Where do the preceding observations lead us in terms of policy frameworks in support of agricultural production by African nations? Firstly one has to face the fact that nearly all African governments have seriously neglected their respective agricultural sectors up to the point that it is unattractive for the average farmer to make any investment in his/her farm beyond what is required for the immediate survival of his/her family. Consequently there are no or highly inadequate emergency food buffers build up at national level to counter natural and other calamities. Secondly this situation is compounded by unfavourable international trade conditions (e.g. heavily subsidized production and dumping of excess production from the North; until recently, cheap rice imports from Asia and; etc.) which in the absence of adequate government trade / economic policies have undermined the domestic production capacity in most African countries.

Rectifying the situation will depend first and foremost on national governments getting their policies “right” in support for their respective agricultural sectors with regard to trade, infrastructural investments and adequate support for building and maintaining a stable agricultural technology R&D capacity based on a socially appropriate vision for rural development and agricultural production. In the absence of such national vision and policies, it is unlikely that external assistance programs and short term ad-hoc projects can contribute to sustainable improvements in soil systems and agriculture productivity, apart from providing poor “emergency aid”.

For national and international agricultural development interventions to be effective (i.e. to deal with the introductory points 1 and 2) they should be soundly and solidly anchored at local levels, in other words “bottom-up” and “participatory” approaches are a pre-condition. In addition, the implementing parties (i.e. farmers, research and development personnel) should be provided with considerable *flexibility* to test, adjust and adapt various practices and innovations to local conditions and needs, instead of being supervised strictly for achieving predetermined implementation targets for a standard recipe, and for writing meaningless journal articles. These conditions are, however, not self-evident since the average scientist and politician (irrespective of nationality) tends to operate in top-down, authoritarian fashions, often having been trained academically to believe that they know what is *best*.

In conclusion the points made by Prof. William Easterly1. become highly relevant in this debate, in particular that external (technical and financial) support to African countries should be piece-meal and should be built on / reinforce national capacities and initiatives that meet the dual requirements of being anchored at local levels, while being enhanced (rather than blocked) by national government policies.

1. Easterly, W., 2006. The White Men’s Burden. Penguin Publications, London.

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1. The Soil Fertility Initiative. I think it failed for several reasons. First, it was top down led largely from the World Bank. 2. It was even marginalized within the bank with really only one champion trying to move it forward, 3. As far as I know there was never any new money for this – it became an approved use of World Bank country funds, but countries would have had to cut other programs, which as we know, is difficult to do in any country. The new momentum is much broader based (institutionally) and has new money.

2. Promoting wider adoption of soil fertility management practices. What is written on the variability of soil constraints, even at micro scales, is very true. It is further true that the uptake of any individual option or practice is very low with two possible exceptions: (1) in some countries and for some higher value crops (mainly export crops) there has been high use of inputs including soil fertility management and (2) incorporation of animal manure or crop residues which are locally available by-products from other enterprises.

The overall lack of investment results from a combination of lack of incentives to invest in agriculture as a whole, lack of payoffs to the particular soil practices, or failing that, lack of credit or other resources to implement the practices. All soil fertility management practices face some constraint in their implementation, be it cash/capital, labor, land area, irrigation/water, equipment, or other. Because of that, their suitability to certain community and household conditions varies across the landscape, as do the soil constraints. There is certainly no uniform technical solution, the there may be some consistent principles and approaches to follow.

So what to do?

1. We do need better diagnoses of soil constraints because farmers truly can't afford to be wrong about how to address their soils. They face high risks even when they are right. Africa can't afford too much sophistication in this, but it needs to advance from the current state of knowledge.

2. Because of the general lack of profitability of smallholder agriculture, I just can't see wide adoption of soil fertility practices unless there is significant public investment in the sector. This needs to be in some of the areas mentioned – to help improve input markets, and to improve credit access by smallholder farmers. The private sector cannot do these in Africa. A real question is whether this is enough. Well, it isn't in the short run, for sure. So I believe that smart subsidies are needed, not only for fertilizer, but to encourage the use of complementary soil fertility practices (e.g. to help support information dissemination or leguminous seed multiplication). It seems clear from the examples we have had in recent years, that these types of investments can be very beneficial. If they are not implemented, and agriculture production remains poor, many other costs emerge that do not enter into analysts' equations (rising health needs, food aid, transactions costs associated with dual residence families, etc.…).

3. How to do that, what frameworks, investment strategies, partnerships, policies, institutions, etc, are needed? Well that is not simple for sure and we do need some good ideas on that. I am familiar with CAADP, TerrAfrica, AGRA, but haven't really given thought to the bigger picture. Thus, I will hold off on commenting for now.

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The debate about policy frameworks for increasing soil fertility is timely given the current food crisis. Now seems an appropriate time for revisiting some of the issues.

First of all I think we need to revisit the concept of soil fertility. When resource poor farmers speak about soil fertility they mean something different to us. They refer to a 'context' in which the crop grows rather than a 'content' which the soil contains. For example in *isiZulu* the word **umnotho** has a dual meeting – it can mean either 'wealth' or 'fertility'. When farmers refer to a fertile soil they say the 'soil is with fertility or wealth'. Thus fertility provides the context for a successful harvest and the wealth that ensues.

So we might just have something to learn from resource poor farmers. Rather than asking how much N, P or K a soil might need, we might ask how do we ensure the correct context for the crop to grow? Asking the question in this way ensures that we move beyond a polemical argument around the use or non-use of fertilisers to ask how do we make the soil fertile or wealthy.

We have in Malawi started a number of on-farm maize trials and demonstrations to compare the use of fertiliser and compost manures on 'traditional' OPV and hybrid maize varieties. Though the results, thus far, are variable and still inconclusive, it appears that compost manures – dependent obviously on their quality - provide a viable alternative to inorganic fertilisers. However one of the main benefits of compost use are attributable to good soil moisture holding capacity but, over the past few seasons, rainfall has been excellent and so we await drier season before drawing final conclusions. Farmers have claimed that, in drier seasons, their best maize harvest occurred where they had applied compost, but we would like to verify this for ourselves.

Given that water, rather than nutrients, is the limiting factor in African agriculture, an infertile soil may still produce a reasonable harvest. As one farmer once said to me 'our fertiliser is the rain'. Viewed from this perspective, and in the light of the aforegoing, we can question whether soil health and wealth can be secured by the ever increasing use of fertilisers. If nothing else, it leads us to the conclusion that farmers, and those who advise farmers, should be more cautious custodians of the land and soil.

To get back to Malawi, the growing reliance of farmers on state subsidies for otherwise unaffordable farming inputs – read fertiliser - does little to convince us that this is the way forward for Malawian - or African - agriculture given current predictions of climate change. Likewise the dependence on a single crop, maize, for food security, to the detriment of a range of other well-adapted crops appears to us foolhardy in the extreme given unpredictable weather patterns. Our work on soil fertility accompanies a crop diversification strategy which is designed both to promote the conservation of agricultural biodiversity and offer farmers real and lasting alternatives.

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Addressing Africa's soil problems would demand that a critical attention be paid to the fundamentals of the African soil peculiarity itself. Although inevitable, inorganic mineralisation/fertilisation cannot and will never be an ideal entry point for an integrated soil fertility management (ISFM) in sub-Saharan Africa. The reasons are not far-fetched. One, Africa's soil, as variously argued, is said to be low in *cation* exchange capacity (CEC). In other words, soils with low CEC tie up essential nutrients making them unavailable for plant use, even in situations where the soil has been adequately and inorganically fertilised. Studies have shown, too, that releasing these essential nutrients are made possible through the application of organic matter. For me, that is the foundation for resolving the Africa's soil constraints. Two, majority of small farmers in Africa, as widely claimed, cannot afford the cost of inorganic fertilisers. Getting the products to buy is also a daunting problem for the few who are willing to adopt the technology! Three, some farmers in certain locality (e.g. some community people in North-central Nigeria) do not even see reasons why they should use imported or foreign products to boost the fertility of their farmland. Using such foreign materials would, according to them, spell doom for bumper harvest! This is factual, albeit strange and hard to believe. This brings me to the fundamental issue of culture in the whole debate on soil improvement in Africa.

ISFM, as it were, has not been conceived to ensure the proper incorporation of the cultural dimension of soil management. Harping on other factors ranging from political to social to environmental to economic, no adequate emphasis has been placed on cultural factors of the small farmer. Regardless of any economic rewards brought about by any form of change amongst them, grassroots farmers respond more quickly to their values and cultural belief systems. Any policy framework that does not take cognisance of this all important aspect is almost destined for a stillbirth either in the short or long run.

That said, appropriate policies on soil revitalisation in Africa would start from good governance. A platform for synchronising resources, governance - as reflected in the political economy and ecology of soil management - will need to prioritise both farmers' and scientific knowledge in the policy formulation process. Rather than pay too much emphasis on science alone, the two bodies of knowledge need be made to work hand in hand without jeopardising the position of any of them. In other words, local or indigenous knowledge in soil conservation needs a voice as much as science does in policy formulation processes.

Now to the specifics. As organic mineralisation appears to answer the question, national governments need to pay attention to the development of local/indigenous plants [using local raw materials] for the manufacture of organic fertilisers in Africa. A typical example of this 'fledgling' initiative can be found in Ibadan, Nigeria. Public-private partnership seems to be the most ideal in the development of this industry as government may not be able to shoulder the responsibility alone. Doubtlessly, farmers are more likely to have access to this product than inorganic fertiliser in terms of costs and availability. As it is locally sourced, problems of adaptation and utilisation might not arise. Sourcing mineral fertilisers to compliment the organic ones would need a radical approach by Africa's national governments. Distributions and supply needs to be strongly and directly linked with farmer Cooperatives and organisations in order to circumvent the influence of the rent-seeking elite in the [political] corridor of power.

In addition to ISFM, soil recapitalisation may need some urgent attention at this time, too. Agreed that the use of rock phosphates may have its associated problems such as low reactivity, variability and the likes, addressing it through context-specific approach might be meaningful afterall. For instance, *Ogun* RockPhosphate in Nigeria has been found to be economically viable. It is said to compete favourably well with mineral fertilisers on acidic soils. Its solubility has been enhanced when tried with soil amendments (such as compost and mycorrhizae). It has, thus, been found to be a better source of phosphorus when applied in mixture with organic waste than using it alone (Adediran et al. 2006). This strategy would succeed where there is the 'political will' to make it work.

Going beyond the rhetoric of participatory methodologies in soil fertility research, scientists would need to allow farmers take the lead in the process. This is because farmers are good *Pedologists* and Soil micro-biologists in their own capacity. They know their farm terrain. They know the trends of their soils usage and how they have performed over the years. They could work with researchers to identify local materials for the production of soil amendments. Given a favourable platform, farmers could devise a more appropriate approach and context-specific strategies on soils sustainability. For me, these are some of the important issues for consideration in the development of a policy framework for a sustainable soil management in the 21st Century and beyond in sub-Saharan Africa.

Reference

Adediran, J. A., Adeniyan, J. A., Akande, M. O. and Taiwo, L. B. 2006. Effect of application of *Ogun* Rock Phosphate with organic waste on yield performance of maize and cassava. *Proceedings of the 30th Annual Conference of the Soil Science Society of Nigeria*. Markudi. 148 – 154.

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1. I'm afraid I don't understand the question, because you don't set out anywhere what you really mean by 'a policy framework'. Is it a framework for analysing policy, or for developing policy? The two are completely different: the former may have relevance from a research point of view, making it possible to test various solutions against a perceived framing of the problem. However I wonder whether policy makers will really be able to engage with the answers. I presume that you hope to engage them with the results of the dialogue but this also isn't very clear as I don't know which policy makers you are aiming for: in DFID, WB, politicians, or mid level civil servants in Malawi?

2. I think it's crucial that your analysis of the problem sets out what the current policy goals are in relation to soil use/productivity etc. If, as a policymaker, I am charged with delivering a set of goals, then having someone present evidence in a completely different framing is likely to make my life more, rather than less complicated. If I have to struggle to find the relevance of what is being said, I'll be more likely to misuse the evidence. (Not intentionally - but I'll probably cherry pick the bits that I understand, not have time to work through the challenging parts, and come to rely on (e.g.) chapter 3 as a bit of a 'crutch' because it's well written and seems to make sense.)

3. So I really think you need to consider the questions the presumed audience will be asking: and policy makers will be asking them in terms of the policy goals that they are working towards. Given that these change over time, often appear to conflict with one another, and are interpreted differently by different stakeholders, you can't rely on a single set of answers, no matter how nuanced they are. The answers must be conditional on the policy goals.

4. Thus, the 'design principles' for effective policy cannot be debated in the abstract: they must relate to specified policy goals and the outcomes that are sought. So *if* the specific policy goal we are working on is X *and* some related policy goals are Y and Z, *and if* the overarching policy goal for that Department is Q, *then* the evidence suggests that.... This makes it difficult to think about any of the issues raised in your bullet pointed section because I don't know what policy goals we are dealing with.

5. So I'd prefer to see your questions reframed somewhat, as in the italics below [your original questions in square brackets]...

- *Given that the national policy goal is X and the goal for that particular region is Y, how can we devise a national strategy which takes account of regional diversity? [*How can a strategy that operates at scale take account of the diversity of agro-ecological and socio-economic circumstances on the ground?]
- *Given that the policy goal is to increase agricultural incomes for the poorest quartile, by X% over the next Y years, and that we have evidence that an integrated soil fertility management approach is most appropriate, is inorganic fertiliser the most effective entry point?* [Is inorganic fertilizer the best initial 'entry point' for an integrated soil fertility management

approach? If so, what should a programme look like, bearing in mind past failures? If not, what should be done first?] *NB, if the policy goal is about improving crop productivity across the board, then the answer to the question would be completely different.*

- *Given the policy goal of reducing dependence on input subsidies by X% over Y years...[*How can efficient use of fertilizer use be ensured, avoiding the danger of benefits being captured more by fertilizer manufacturers and traders than small scale farmers?] *If it's the Treasury who 'own' this goal rather than the Dept of Agriculture, then you'll have some interesting discussions here. How might this goal conflict with a Dept of Ag goal on increasing crop productivity? What if there's also a Dept of Industry goal to improve the profitability of local businesses? What structures will be put in place to ensure that the three Depts talk to each other? (Not sure you can look to the UK for advice there...)*
- *If the goal is to help the poorest X% increase productivity on rainfed soils, what is the best mix of incentives? How can we monitor that mix to ensure it's delivering against the goal? If the evidence shows that we're not reaching our target, can we change the mix of incentives without doing too much damage? [*Do subsidies have a role in ensuring input provision and, if so, what is meant by a 'smart subsidy'? If not, what other incentives/investments make most sense?] *See above about who owns the policy goal for this.*
- What happens when there is no market – or when market mechanisms don't reach certain places or people? *I can't work with this one at all: it needs to be far more specific - e.g. if the goal is income growth in region X, is it worth focusing on improving crop productivity because the roads are lousy and transport costs are too high to effectively market the surplus? Given that the delivery mechanisms in place look like this....... what is the most appropriate sequence of interventions (roads, water catchment systems, crop productivity...)?*
- What is the role for the state – in managing, supporting, coordinating, regulating, financing – and which parts of the state need support to make this happen? *You can't answer this one unless you have a clear idea of what the policy goal is.*
- What type of policy processes are required to ensure pro-poor outcomes and avoid capture by elites, commercial interests and others? *What exactly do you mean by policy processes? At what level?*
- What enabling conditions need to be in place (e.g. trade policy, infrastructure, investment)? *For what?*
- How should 'success' and 'impact' defined? *Again, for what? It's about working through the individual policy goals, using existing and emerging evidence which is interpreted in light of what policy is trying to achieve for that particular issue at that particular time.*

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I was very surprised to find the comment that "biological soil fertility options" are problematic because they "require considerable labour and skill inputs, as well as large volumes of biomass," and no mention whatsoever of "green manure/cover crops (gm/cc)." The disconnect between people talking at the international level, and what is going on in the fields of resource-poor farmers in Latin America, Africa and Asia continues to be...well, frightening.

Green manure/cover crop systems do vary greatly around the world and around Africa, depending on climate, basic cropping systems, land tenure and dietary preferences, among other things. Yet they are already widely practiced by resource-poor farmers, in Africa as well as the other continents. I have personally stumbled across some 85 such systems spread across over 40 nations. In one case I researched a single system that is practiced among perhaps 50,000 farmers from Honduras through Guatemala and Belize to Mexico. Hundreds of thousands of farmers, if not millions, use similar systems in South America and Southeast Asia, and other hundreds of thousands in each of a dozen nations of Africa, at least.

Many gm/cc systems <u>reduce</u> farmers' labour, because when the gm/cc is intercropped with cash or subsistence crops, they often control the weeds, thereby eliminating one or more of the farmers' (usually women's) weeding operations. Thus, the assumption that these systems necessarily require added labour is just plain wrong. It is true that improving soils dramatically (ie doubling or tripling low traditional levels of productivity) requires large amounts of biomass, but that this factor is listed as a problem of biological options is wrong because the gm/cc species produce that biomass in the field (often 40 to 70 t/ha, green weight), at very little cost. In fact, in many, if not most, of the adopted gm/cc systems around the world, the beans, peas or other food or fodder produced by the gm/cc is much more valuable than the labour and costs occasioned by the practice. That is, the net cost/value of the biomass produced for soil improvement (that biomass not going to either the market or the family table) is negative.

The skill inputs needed by the top agronomists in a country may be fairly large, but for any single farmer or village of farmers they are rarely much more than those required to use inorganic fertilizers efficiently.

To respond, then, to your question about inorganics being the best entry, my response is that, in the vast majority of cases, they are <u>not</u> the best. If the soil still has enough natural fertility to grow weeds, farmers can grow green manure/cover crops along with their regular crops, as improved fallows, on "wastelands," or in other niches that don't have any opportunity cost. Such a technology requires an investment of a few pennies to buy the original gm/cc seed, and within a year (or sometimes two) can make a major improvement in the farmers' productivity, soil water retention, infiltration of water, crop root growth, resistance to termite damage, resistance to erosion, soil organic matter content, nitrogen content, etc. Inorganic fertilizers may supplement the gm/cc (especially to provide replacement phosphorus, plus nitrogen when there are problems of synchronisation), but these applications would usually be in much smaller quantities than conventional agronomists would recommend.

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The overall debate question is: "…. What are the policy frameworks that really will increase soil fertility [in Africa] in ways that will boost production in a sustainable fashion, where the benefits of the interventions are widely distributed, meeting broader aims of equitable, board-based development?"

We suggest the following design principles as a basis for effective policy.

1. Distinguish between increasing national food production and achieving full household level food security.

- Raising national food output does not necessarily lead to improved household and individual food security and nutrition: it may, however, contribute to lower food prices and hence increase the amount and possibly quality of food that poor families can afford to buy
- If very small-scale farmers, who themselves are food insecure, increase their output, this is likely to improve *their* food security and nutrition
- If increased food production comes mainly from small-scale farmers rather than large-scale farmers, this is likely to contribute indirectly to greater food security in rural communities, because production systems are more labour-intensive and hence more people receive earnings (or, in some cases, payments in food) from food production related activities.
- In most situations, higher levels of productivity are attained on small-scale rather than large-scale farms, and hence, where land is scarce, strategies for expanding food output mainly by small-scale farmers are not only more equitable but also likely to be more successful in raising output.

2. There are very few situations in which full household food security can be attained simply by raising national food production: income redistribution measures, especially targeted cash transfers (or other social security programmes) must be part of the solution, even in rural areas.

3. In many areas of Africa, there is unused land with reasonable agricultural potential. As long as labour is amply available and there is easy access to land, growth in production by small farmers in these areas can continue to come from expanding the agricultural frontier, with limited use of external inputs.

4. In other regions, where rural population density is high, intensification offers the only route for expanding food output.

5. In most agricultural land use situations in Africa, avoiding reductions in soil organic matter (OM) content is essential if soils are to be cropped intensively on a sustainable basis. If OM levels are allowed to fall, there will be a progressive decline in soil fertility.

6. Where soils are not already seriously depleted in organic matter, using inorganic fertilizers and soil amendments (including lime) can help to increase vegetative material production and build up soil OM content, provided that crop residues are retained on the land and soils are not disturbed by tillage.

7. Inversion soil tillage, whether by hoe or plough, accelerates the decline in soil OM content and the biotic activity it supports, and destroys soil porosity, and is best avoided or restricted to crop “planting stations”.

8. Use of *Conservation Agriculture* (CA) principles and practices (minimal or no-till, soil cover with mulch and residues, and crop rotations, especially with legumes) results in an increase in soil OM and nitrogen levels and hence can do much to maintain soil health and fertility.

9. CA is the foundation for a greener revolution that can make intensive farming sustainable, cut energy use (whether human or fuel-derived energy) in food production, decrease agro-chemical contamination in the environment, reduce greenhouse gas emissions, minimize run-off and soil erosion, make a higher proportion of rainfall available for crop growth, and improve the quality and dependability of fresh water supplies.

10. But the CA requirement for retention of crop residues and use of cover crops is difficult to reconcile, especially in low-rainfall areas, with other demands for crop residues – livestock feed, fuel, brick-making. In these situations, CA systems need to incorporate components that provide for animal feed and fuel while at the same time enabling adequate soil surface residue cover.

11. Moreover, where no-till systems have to use herbicides for weed control, this will usually decrease their attractiveness to small-scale farmers who do not have access to herbicides or the equipment to apply them, or want to engage in organic farming. Manual or non-chemical weed control can be difficult and time-consuming in the first years of practicing a CA system but, after a few years of good weed control and use of cover crops weed populations decline and become more manageable.

12. Best approaches to sustainable soil fertility improvement are likely to be location specific due to diverse agro-ecological and socioeconomic situations: “wholesaling” of standard solutions is unlikely to be feasible. However, mainstreaming of CA principles adapted to these diverse situations over time should form a policy goal for increasing soil fertility and enabling sustainable crop intensification.

13. In most situations, a shift to sustainable practices based on Conservation Agriculture principles requires fundamental changes in the ways in which farming is currently practiced and cannot be induced by top-down “message delivery” type extension services, though these may succeed in promoting greater use of fertilizers.

14. Instead, it is necessary to enable farmers to raise their level of understanding of the underlying causes of declining soil fertility and to engage them in testing CA-based options for improvement. The experiential learning methods practiced in Farmer Field Schools are very relevant to creating local capacities for moving towards more sustainable intensive farming systems with CA, adapted to local situations.

15. To the extent that farmer-facilitated and self-financing field school models are taken up, they have the advantage of imposing only limited demands on highly skilled staff and on recurrent budgets and hence can be scaled up rapidly without running into serious institutional, manpower and funding constraints.

16. Policies (e.g. subsidies) that promote fertilizer uptake or ploughing without linking these to the more complex changes in farming systems that may be needed to mainstream CA practices in Africa will undermine a shift towards sustainable soil fertility management and should therefore be avoided. In contrast, policies that compensate farmers for the enhanced provision of environmental services associated with the application of CA principles could accelerate a move towards more sustainable land use systems.

There is growing evidence of successful management of soil fertility for crop

intensification on both large and small-scale farms using Conservation Agriculture practices in Africa from countries as diverse as Ghana, Kenya, Madagascar, Morocco, Swaziland, South Africa, Tanzania, Tunisia, Zambia and Zimbabwe, covering a range of agro-ecological and socioeconomic conditions. The fact that Conservation Agriculture is now practised on almost 100 million hectares worldwide implies that the principles on which it is based are recognised by farmers as one major potential alternative for enhancing soil fertility and for sustainable agricultural intensification in Africa and internationally.

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Maybe declining soil fertility is a symptom rather than a disease.

Many African governments and donors are trying to treat the symptom without analyzing the causes of the disease: providing technology packages, tinkering with subsidy options, seeing what the private sector can do, and looking for innovative farmers who have figured out how to manage the symptoms.

The Future Agricultures paper is very helpful in reviewing all of these efforts -- but it does not get down to highlighting some of the *causes* of the disease:
-- land tenure policies that reduce farmers' incentives to invest in maintaining land quality;
-- population growth rates that outstrip productivity growth rates;
-- commodity markets that make investing in soil maintenance uneconomic;
-- transport systems that are so inefficient that fertilizer costs are outrageous when compared to the value of output produced;
-- inconsistent government policy -- just when one course of treatment is beginning to show promise, the diagnosis is changed and a new antibiotic is ordered; and
-- lack of technical knowledge/analytical capacity on the part of many producers.

More attention to causal factors would set off a whole new and more policy-oriented discussion that might actually make a difference over the next 20 years. Otherwise I fear we will be supplying band-aids here, iodine there, vitamins tomorrow, and antibiotics the next day. Let's make it worthwhile for farmers to invest in the quality of their soil (tenure, remunerative markets for products), give them the training/information they need to adapt generic recommendations (whether through demonstrations, farmer field schools, or whatever), and cut the costs as much as possible by investing in efficient importing/transport/competitive sales systems.

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A few thoughts on potential livestock dimensions of the soil fertility policy debate. These are not intended to be comprehensive in any way, but to simply raise the issue that in taking an equitable broad based approach to the topic, including consideration of a livestock dimension, whilst in no way a panacea, could be one useful aspect.

Livestock interact with soil in many ways, all of which have the potential to impact soil fertility:

- through consumption of material (forage, range, crop residues, in some cases crop grains) that removes these nutrients, vegetation or organic matter from the soil
- through the manure and urine that may contribute nutrients, and for the former, organic matter to the soil - in some instances providing a "redistribution" function for nutrients from rangeland to cropland, or (eg where feed is imported) on a wider scale
- through providing soil tillage that affects the soil physical structure and impacts crop (and forage) production
- through trampling soil that affects soil structure – such as water holding properties

In much of the developing world, especially for the poorest, inputs to soil fertility from livestock are highly valued. Many farmers keep livestock for manure even before the milk or meat they may produce. In the majority of cases however the nutrient inputs from livestock manure are probably only about 10% of those needed to support crop production. Many studies have shown that combining organic and inorganic inputs gives the best returns on both and helps to maintain soil structure/in a healthy condition.

Policies related to soil fertility directly can be influenced by and have an influence on livestock

- policies that make fertilizer easily and cheaply available if promoted in isolation, could mean farmers do not use manure – this would both jeopardize long term soil health (because of a reduction on soil organic matter) and potentially present a problem of manure use/disposal
- such policies could also favour the expansion of crop production which may impinge upon livestock grazing and trekking routes leading to conflicts as well as overuse of a restricted land area by livestock

Policies related to livestock production can influence soil fertility

- policies that influence the location of intensive livestock production can affect soil fertility. If policies encourage location of intensive livestock production in localities where crops are produced, along with appropriate manure management guidelines, there can be some win-win opportunities. If on the other hand, policies favour the separation of livestock production from the land where crops are grown, the soil suffers and the environment suffers

- policies that impact livestock movement may impact soil fertility – influencing where livestock deposit manure, or where the soil is adversely affected by over grazing/trampling or vegetation changes because of restricted livestock movement
- conversely policies that influence the ability of livestock keepers to be paid for environmental management can positively impact on the soil condition

Policies influencing land use and management impact both livestock and soil fertility

- incentives to manage soil in a sustainable way are likely to be higher if there is secure land tenure
- pricing of land as an input into livestock and crop production can influence the management of soil
- policies influencing the use of conservation agriculture may impact livestock – access to equipment; cover crops (some of which may also be forages); use of crop residues

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Ian has provided an excellent summary of the issues: how do we chart a way forward?

Picking up on some of the points Ian has made, I would like to put forward five starting points which I suggest have wide but of course not universal validity:

- In most situations complementary use of both inorganic and organic fertilisers will be needed to promote soil health and fertility
- The critical issues for both organic and inorganic investments are ***profitability*** and ***affordability***. Profitability involves soil fertility investments (of labour and working capital) yielding a return greater than their cost (allowing for seasonal interest rates and opportunity costs). Profitability depends upon farmgate input and output prices, input effectiveness (in terms of crop response), and risks (of price changes and low yields). Affordability depends upon farmgate input prices, opportunity costs of seasonal labour, working capital, and access to and costs of seasonal credit. Problems of both profitability and affordability of soil fertility investments are often compounded by inequity and insecurity in land tenure and in gender roles, rights and responsibilities.
- Soil fertility for the production of staple foods is of critical importance but also very challenging. Around 50% of African farmers are poor net buyers of food. Investments in soil fertility may be more profitable for these farmers than for surplus producers, as they value staple production at consumer purchase prices – but their soil fertility investments are critically constrained by major affordability constraints. Surplus producers may face lower affordability constraints than poor deficit producers, but since they earn lower farmgate sales prices, the profitability of soil fertility investments is lower, particularly in good years. Risks of low yields and bad years with high prices encourage low input subsistence production, but risks of low prices in good years discourage investments in high input surplus production. The result is large amounts of land and labour locked into low productivity staple cultivation. This reduces farm incomes, and this constrains demand for local non-staple products (livestock products, horticultural products) and for local non-farm goods and services.
- The need for large scale solutions to diverse problems suggests market mechanisms for matching supply to diverse demand. However affordability and profitability problems in staple food production lead to (and are maintained by) low level traps inhibiting the development of inorganic input markets (with low volumes and small transactions raising delivery costs, risks and margins), while supply of and demand for higher value local horticultural and animal products (which could otherwise boost agricultural productivity, input market development, and organic systems) is itself constrained by low staple productivity. Credit market failures are a critical feature of this, but microfinance initiatives are markedly absent from poor, low staple productivity rural areas.

- High food and fertiliser prices exacerbate these problems. Although high food prices should stimulate profitability of staple production, they also increase the affordability problems of the 50% of African farmers who are poor net food buyers, and depress demand by these people for non staple products and non-farm goods and services. High fertiliser prices lead to increased affordability problems for surplus producers as well.

Given these very difficult starting points, how can soil fertility investments, agricultural productivity, rural incomes and poverty reduction advance?

Historically large scale credit and input subsidies with output price stabilisation and heavy extension emphasis on high input packages underpinned both the Asian Green Revolution with its subsequent pro-poor growth and dramatic increases in fertiliser use and maize yields in various countries in Africa in the 1970s and 80s. These gains were achieved at very significant cost and in Africa could not be sustained without continued donor support, which was not forthcoming. There has been widespread recent interest in the use of smart input subsidies, most notably in Malawi from 2005/6. Much can and must be learnt from the Malawi experience, which demonstrates both the potential for such subsidy programmes and their weaknesses – potential and weaknesses as regards both the technical aspects of soil, market and subsidy management and inherent political economy paradoxes.

Recent growth in fertiliser use on maize in Kenya has followed a very different path. Lack of government intervention in a dynamic fertiliser market supplying large and small scale cash crop producers and large scale maize producers (in a protected and relatively stable maize market) has attracted private sector investment (by both national and international firms) and fostered competition and economies of scale. This, with reduced road haulage costs, has both pushed down importer and distributor margins and (with judicious donor support) stimulated a network of small agrodealers selling small fertiliser packs in rural areas – to both cash crop and maize producers.

There are major questions about the wider applicability, strengths and weaknesses of different aspects of both these models: how can their complementary strengths be exploited, and what are the necessary and sufficient conditions for their different elements' success? The common challenge is how to foster stable conditions that promote increasing profitability and affordability for both farmer and private input supplier investments promoting soil fertility in both staple and cash crop production. This has to be linked to the need for rapid improvements in food security and incomes of poor rural people, and for more emphasis on complementary organic soil fertility investments.

Unfortunately high global food and fertiliser prices undermine both these models. In the first case they increase the costs of subsidies while at the same time reducing subsidies' ability to drive wider growth and investment through lower food prices. In the second case lower cash crop profitability (from lower price increases in traditional export crops as compared with food and fertiliser prices) and higher fertiliser prices will increase affordability problems and depress growth in input demand – and hence depress input supplier investment incentives. How much is the increased relative attractiveness of complementary organic soil fertility investments and hence greater incentives for such investments a silver lining in these challenging conditions? These of course also face market, technical and political economy challenges.

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Ian Scoone's Paper makes interesting reading, but there are a number of open questions and issues – to be posed at the beginning of any campaign, and before starting Africa-wide (as the title suggests) such a large program.

The very first point is the (somewhat underlying ?) assumption for lay-persons that in every respect Africa has uniform or at least comparable (human and natural) conditions: – soils – soils' nutrient content and (water) keeping capacity (large areas of very sandy soils) - climatic – rainfall – agricultural practices, preferred food and cash crops, human population and their food preferences, etc, etc. In effect there will (and must) be hundreds of different approaches and programs for the continent. (One important question relates to the importance of the soil "quality" in the national and international breeding programs).

My second – but most important point covers suitable national professionals, (made) available for or attracted to such rather long term agricultural research and development work in poor rural areas, and with uncertain results.

My third point relates to an issue whether the policy makers and other interested parties, especially in Africa, will not misinterpret research questions, issues, expected results and general adoption uncertainties with promises. Unfortunately many have been made before – few with lasting results.

What is (are) the major aim(s) of increasing soil fertility in Africa?

- Higher and steadily increasing productivity (most likely land), but how about rural labour productivity (female above all) or both?
- To overcome - or at least to acknowledge and take appropriate action – of differences in soil and water quality requirements – but also of all other production factors of different food crops (which), and cash crops (which), annuals as well as perennials.
- To improve year-round nutrition and better nutritional standards for all population groups, also and especially in the rural areas, and for women and children.
- To provide higher agriculture based incomes for the rural population.
- To reduce imports of agricultural produce through better local supplies for the urban population.
- To guarantee improving long term soil fertility levels for steadily increasing (and not decreasing) agricultural production, raising the productivity of all inputs. The problem of increasing soil fertility under comparable natural conditions needs new approaches, and much more preparation of and with all involved, than still widely assumed. Furthermore any program needs at the beginning a first class selection of likely successes, keeping in mind (among others) soils, rainfall (total and distribution), temperature, the potential of different food and cash crops, their growing periods and length, water as well as plant nutrient requirements, in addition rural labour requirements, especially at peak

times (women and/or men) in quality and quantity, etc. etc. In many cases (not only between countries, but between rural areas) the importance and timely availability of each factor differs.

Therefore: is there sufficient comparability of issues for all of Africa to start an Africa wide program? Does such program include sufficiently the human factor and involved people's preferences and likely choices?

The question is: Can we afford sizeable failures with a very large and necessarily very long term project, where many results will hardly be comparable between regions, countries?

The present situation in Africa and approaches for improvement

There are a very large number of food and cash crops with their own dependence and requirements on soil fertility, and other production factors, including traditional or improved or even new farming practices. Are we sure about the specific bottlenecks? So far machinery has not replaced human labour for most crops.

There are different demands for agricultural produce, keeping in mind traditions as well changing urban and rural preferences for food – as well as for cash and export crops.

How to start with improving such often tradition based situations? Select national leaders and professionals at all levels – people who are knowledgeable of and interested in solving many of the short term, but also some of the longer-term rural problems: (poor) often undernourished people in the rural areas, especially women, lack of education, little income – very often only seasonal -, but also problems with respect to soil fertility (specific nutrients), specific food crops, certain market crops, but also crop losses and crop waste..

For such a large and important attempt on any national basis the program planning, the management, the responsibility for success but also failures must rest first and foremost with nationals.

Start with many small programs, developed by nationals, including rural partners, exchange experiences, failures and results. Set timetables (don't be open ended) – identify early-on potential and expected results. Exchange positive as well as negative experiences.

Conclusions and Recommendations

- Do not start with an Africa-wide Program – start with this Program IN Africa. Learn and improve while implementing. There will be many, many years for widely acceptable results - and at the same time too many disappointments;
- Select areas where success is most likely: because of natural conditions, farmers and their traditions, Government policies, and general interest;

- For the rural areas and the poor farmers provide rural storage facilities to protect their produce and ensure food self-sufficiency all year long;
- For cash crops assist in programs “cash for delivery”, and introduce more cash crops. (The rapid expansion of “khat” production in Eastern Africa and its possible effects on other cash and food crops is worth studying - for comparable application to other crops.

Remember: Nothing succeeds like success

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First, the authors of the document should be congratulated for providing such a thoughtful and comprehensive summary of the issues.

The document describes a number of “models”, many of which have made some contribution, and it correctly points out that virtually all are being promoted to some extent at the present time. In the face of limited success from past efforts we are asked, “Are things different now?” The document answers in the affirmative, but this can be debated. One thing that hasn’t changed is that a number of well-meaning development agencies, institutes, researchers, etc are still hoping to see a comprehensive plan fashioned from disparate interests and initiatives. Although some of the vocabulary inevitably changes, we are still lining up to march behind our chosen banner, be it “integrated soil fertility”, “innovation systems”, “smart subsidies” ,or whatever. And the fact that donors have large amounts of money they want (or in some cases are obliged) to spend may be a mixed blessing.

Surely part of the explanation for only modest success in the past is precisely that these have largely been special initiatives, introduced from outside. They usually pay little attention to the long-term capacities of the people meant to manage them or to the abilities of farming populations to have any influence over what their governments (or external agencies) provide. In addition, they usually bypass any examination of exactly what proportion of the African rural population has enough interest in, or income from, farming to elicit realistic commitment. Thus it might be argued that the specifics of a soil fertility plan should be postponed until there are coherent investments in developing more general policy capacity, political responsiveness, and rural organization. But donors are generally not set up to address these more basic issues, and the development industry has difficulty reaping rewards from long-term capacity building.

It is difficult to see how effective soil fertility policies will arise in the midst of more general inefficiencies in African agricultural economies. This is not meant to dismiss the questions asked at the end of the document about specific design principles related to soil fertility management. They are certainly relevant, but it is a challenge to see how they can be debated in the abstract. If we wish to avoid the disappointments of other failed programs and plans addressing African soil fertility management, it may be best for us to turn our attention inward, and to ask if our own development profession (as currently structured) can offer solutions, or is part of the problem. An integrated approach to soil fertility certainly makes sense, but is unlikely to be achieved as long as donors are not capable of an integrated approach to the development of basic national capacities. Without this, we may simply be entering another round of competition to collect rents from pilot projects and fruitless discussions about scaling up.

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My few comments are based largely on my observation of agricultural practice in the developing world over the past 39 years , not on any great expertise in soil fertility. I refer particularly to the viable farming practices of NR dependent subsistence and subsistence-plus farmers as well as those who are more market oriented. I will not deal with land tenure issues although these certainly need to be addressed by policy makers as there is clearly a major influence on soil fertility emanating from the consequences of unfair land access; nor will I emphasise on the need for policy makers to address tree felling/forest clearing and its influence on soil degradation. Rather I wish to deal with the lot of the literally hundreds of millions of farmers with access to 0.1 – 2 acres of land - those who still practice slash and burn shifting cultivation to the more fortunate ones who own land that is 'farmed'.

The first point I wish to emphasise is the need for policy makers to be reminded that the most effective and resilient use of small parcels of land (and soil) is achieved through MIXED farming practices. Unfortunately, policy makers in the developing world have been over-influenced by land-use policies of large scale agriculture in the North/West where the whole marketing , economic and social structures are totally different to those in the South.

Unfortunately, there are a myriad examples where well-meaning but badly conceived approaches to land use in the South have created havoc among rural poor communities. For instance, in the 1970s, enticed by the lure of financial gain, the Kenya Govt convinced mixed (crop/livestock) farmers in the Machakos region to transform their small plots into maize-only farms in an attempt to create a maize bank for the country. Initially the 'project' was deemed to be successful judging by financial rewards for the farmers - but ultimately the repeated mono-culture approach denuded the soil of tilth and fertility and the productivity declined precipitously . Furthermore, the incidence of kwashiorkor increased significantly during this time as the extra cash earned did not go to purchase the balanced diet required (milk/meat, cabbage, beans etc) by growing children and which the mixed farm structure would have originally provided. There are many Machakos-like experiments around the world; one only has to visit India to see the vast amount of land denuded by the mono-culture approach promoted by the Indian Govt of the past. The Green Revolution approach too has had its impact on soil fertility as it has made too many demands of friable land.

My second point is related to the first - but is regularly ignored. Successful small-scale farming is as much about social engagement with the community as it is a means of sustenance and cash rewards. These social networks provide security, confidence to take risk and other forms of social capital that are often the drivers in poor societies. The terms efficiency and financial returns so appreciated in the North do not resonate so loudly in the small-farmer community. And, getting to the point, tradition and culture in the rural community has always been based on a mixed farming approach – the consequences of which has maintained and enriched soils for eons.

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Biological approaches such as crop residues and biomass as surface mulch; integrating annual crops perennial trees and animals, strategic production of plant biomass and local botanicals for crop protection are feasible. These approaches have potential to meet crop nutrients and crop-protection needs in place of chemical fertilizers and pesticides and need to be explored widely.

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What are the design principles for effective policy?

- How can a strategy that operates at scale take account of the diversity of agro-ecological and socio-economic circumstances on the ground?

In southern Africa we were working actively through the SoilFertNet during the 1990s on targeting technologies, and came up with the term 'best bet' technologies to try to escape the idea of silver bullets that would work everywhere (see e.g. Waddington *et al.*, 1998). When sitting in a discussion for the Africa Challenge Programme in Blantyre, Malawi, with Paul Mapfumo (UZ-SOFECSA) and John Pender (IFPRI) the suggestion came we should be thinking of 'best-fit' technologies (Giller *et al.*, 2009). This was based on work through our NUANCES framework (Giller *et al.*, 2006) that has extended this the idea of targeting to a (hierarchical) systematic analysis of fields, farmers and farming systems in terms of agroecologies, market access and infrastructure, education, resource endowments, local field variability etc to recognise the "socioecological niches" for technologies (Ojiem *et al.*, 2006). John Pender referred to an IFPRI report that called for best fit approaches to information delivery services (Birner *et al.*, 2006).

I think the idea of one policy or one approach is what we have to escape from – we need to move towards a 'best fit' policy approach – that can be tailored to the needs and opportunities of different regions. I believe our NUANCES methodology gives us a structured way of revealing the diversity and heterogeneity within farming systems and allows us to analyse trade-offs for technologies, and likely effects of policies in terms of their impact (e.g. Tittonell *et al.*, 2008a; Tittonell *et al.*, 2008b).

BUT – when we start to discuss these ideas, people at the policy end tend to be frightened off – they seem to want to treat Africa as a homogeneous 'flat earth' rather than the hugely diverse continent that it is… For me the most important design principle for effective policy is to recognise that – in the same way there is no 'one-size-fits-all' technology, there is no 'one-size-fits-all' policy!

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[See additional contributions in Resources]

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Increasing Soil Fertility in Africa: *Indispensable but Insufficient*

Solving soil fertility management via increased fertilizer and organic inputs is an *indispensable but insufficient* element of agricultural and rural development in sub-Saharan Africa (SSA). From my recent research findings I find that suggest that biophysical factors, significantly affects the economic returns to fertilizer inputs. Some farmers cultivating more degraded soils may find it unprofitable to invest in soil nutrient inputs, not necessarily because the fertilizer/crop price ratio is too high or due to credit, information or risk constraints, or because of supply-side impediments, but because marginal yield response to fertilizer application is low on soils that have already undergone serious degradation, suggesting soil fertility mediated poverty traps. Thus using the *'indispensable but insufficient'* as a key principle, it is possible to outline why taking a broader focus on the soil fertility problem stands a better chance of success. This broader approach will provide complementary (and sufficient) conditions to buttress these programs as part of a broader rural economy.

In this debate I am most interested in the bullet point that asks: *What happens when there is no market – or when market mechanisms don't reach certain places or people?.* In my experience, I find that people involved in Agricultural development often look at the process of agricultural development as that of transforming low-productivity subsistence farms into 'small-scale business firms' producing and selling some agricultural product for own consumption, sale or both and at the end of the day generating incomes and profit. I use the term 'business firm' because to achieve the kind of increases in the use of fertilizers and other labor intensive soil fertility investments these investments must provide adequate profit or financial returns for individual farmers and for society these investments must also be economically sensible especially where public resources are to be expended. How realistic is it to aim at turning millions of subsistence farmers into businesswomen and men?

The conditions which have made investments in soil fertility inputs (SFI) to become both financially and economically unremunerative (and hence the preponderance of subsistence modes of production) have well been documented which I broadly summarize as follows:

- Lack of physical and market infrastructure which has stifled the development of commercial fertilizer supply networks.
- The preponderance of low value agricultural enterprises creates high input-output price ratios making their use infeasible.
- Lack of requisite financial capital (associated by missing credit markets) to invest in SFI even if such investments offer decent returns.

Therefore, the outcome in many parts of sub-Saharan Africa (SSA) are exactly as predicted by basic tenets of microeconomic theory. These conditions reflect rational responses of economic players in SSA's agricultural sectors to unfavorable input-output prices for farmers and for potential fertilizer dealers, the resulting thin input markets make fertilizer merchandizing an unprofitable proposition at various levels, hence the low supply of fertilizers.

In order to develop key policy principles for soil fertility recapitalization we need therefore to look more keenly at rural household goals and incentives. This is because incentives should be at the heart of efforts to increase investments in SFI:

- Is food self sufficiency an overriding incentive for all or just some households? Does food self sufficiency translate into adequate household incomes?
- Are there *rural* households in SSA who can solely rely on agricultural markets for their food supply through earning income in rural and peri-urban labor markets or through production of non-staple commodities including livestock products?
- What might the optimal balance between partly supplying own food and partly relying on agricultural markets for food look like?

Below I sketch three scenarios with attendant policy foci in a way that I believe will broaden the approach to solving soil fertility problems and rural development.

- **Households in areas with little or no reach to markets**

In simple terms, these places are cut off from national markets by reason of lack of transport and communication infrastructure or their economic bases have no link to the broader national or regional economies. In the former case, neither state nor non-government actors can do anything about low supply of fertilizers until there is infrastructure in place to enable commercial or publicly supported delivery. Self provision of food in these environments may be high on the household's agenda and should therefore be a legitimate concern for public policy.

In the latter case it is apparent that there is no realistic way of increasing food production without opening up these areas and linking them to the wider world. Will that require increased food production with attendant increases in the use of SFI? Will other natural resource based economic activities such as forestry, livestock production or fishing (which may require more natural resource management than external fertilizers) develop?

Key Policy Principle: If there are realistic chances of *increasing the use of SFI excluding fertilizers* (and that is a big 'if') then these may offer the best chance in the short term for improving soil fertility and food production. Focus on the natural resource management (NRM) aspects of SFI to promote local production of food and inter-household trade within the region may be the most feasible in the immediate term. The most important adjunct is to *integrate these areas to* *national economies* by bringing in infrastructure investments in order to allow the *importation of food and exportation of niche products from these areas*.

The process may lead to these areas joining category number 2 and eventually category 3 below with attendant policy focus.

- **Households in areas with some (moderate) market access**.

Households in these regions have some rudimentary access to local labor and agricultural markets. These markets provide some employment opportunities but not sufficient to make them rely solely on labor incomes and agricultural markets for their food consumption. For these households, the greatest benefit will be adequate self-provision of (and perhaps even self sufficiency in) basic foodstuffs. If this can happen and these households are able to spare some labor for off-farm income generation there will be a significant dent on poverty.

Key Policy Principle: Focus on *infrastructure investment and 'Smart Subsidies'* until such a time that these areas are fully integrated into the national and global economies leading to expansion of economic opportunities and less reliance on subsistence economic activities and more on employment in high-productivity agricultural production as well as in alternative sectors.

- **Households in areas with good (adequate) access to markets**

These areas are on average likely to be situated in high potential agro-ecozones which is why infrastructure and markets have developed in these areas. These are also the same areas where input use are likely to be above national average even if not necessarily at par with international averages in similar areas outside SSA. Households in these regions may have greater off-farm employment opportunities and therefore can reasonably rely on local agricultural markets for their food supply. These areas also offer the greatest opportunity for expanding agro-dealer networks. These regions should receive as much attention in terms of fertilizer programs and policies as the low potential areas. Some may worry that such an approach may stretch public resources too much leading to perhaps 'anti-poor' outcomes. I disagree. If national policies lead to increased commercial food production in high potential areas and hence lower food prices, the greatest beneficiaries will be the poor households who rely on markets for their food production. There will always be households for whom own production will be a better alternative. For these I have outlined key principles in category 1 and 2 above.

Key Policy Principle: The chief policy principle in these zones should be *increased use of fertilizer to achieve productivity levels at par with international levels while ensuring environmental sustainability.* Any macroeconomic policy lever which can be used to reduce fertilizer costs and increase its supply should be fully exploited.

Summary
A generic focus on soil fertility management will fail to generate the needed response from farmers or even achieve economic and equity goals unless there is adequate compartmentalization of the problem. It is apparent that there are households and regions where the most economical approach is to enable households use just enough fertilizers and other SFI to achieve a degree of household food self sufficiency and to sustain the soils for continued household food supply. These households generate extra incomes from labor markets. In these areas, public resources in the form of smart subsidies and other approaches may dominate fertilizer and SFI programming. On the other end of the spectrum is a situation where households will need to increase the use of fertilizers and other SFI considerably for commercialized food and cash crop production. It will be easier to develop market based mechanisms for increased fertilizer supply in these areas.

In this contribution, I have tried to provide an archetypal scheme that can be used for separating out policy approaches suitable for different market circumstances. **The key principle that should permeate the whole discussion is that the problem of soil fertility depletion is both a cause and a consequence of underdevelopment.** It is possible that progress in non-agricultural sectors *within* rural areas can stimulate enough economic growth and linkages to agriculture and improve incentives for SFI use without resorting to subsidies to encourage increased use of SFI.

It has been recognized in the background document to this debate that increased use of SFI will not provide the same level of incentives for all households. It may be desirable heighten policy focus on market-based fertilizer (SFI) programs in areas with the greatest financial and economic returns. Other areas may require greater publicly-supported investments in NRM to accompany fertilizer programs. This is especially so if investments in NRM have been hampered by high labor and financial costs.

Agricultural development will require more than increased use of SFI, rather it will require investments in public goods needed for broad rural development. These investments will benefit all sectors of the rural economy providing the best incentives for investing in SFI and reversing soil fertility depletion because these SFI investments will now yield adequate returns by reason of increased and diversified demand for agricultural products. This in my view will provide the best chance for soil fertility recapitalization and agricultural development as part of the rural and national economies.

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Policy Framework for Increase and Effective Use of Fertilizer in Ethiopia: Evidence from Recent Experiences and Debating the Problems

1. Background The Ethiopian government has worked hard to reverse the country's terrible history associated with a series of famines that ashamed of Ethiopians periodically since the 1970s. Hunger, however, has once again re-visited Ethiopia this year, threatened the live of millions of Ethiopians and become the major news headline across the globe. Why Ethiopia unable to feed its population and thus continuing to depend on foreign donations of food to sustain millions of its citizens? Why a minor shocks as the 2008 failure of belg rain brought a significant impact on national food availability and hunger.

Despite some recent rapid growth of higher-value export crops such as coffee, livestock, and horticulture products, agricultural growth in Ethiopia remains unsatisfactory especially measured in terms of improving productivity in the cereal sector. The poor performance of the agricultural sector is unparalleled with its old history of institutionalized agricultural research and extension system in Africa. The formal beginnings of public agricultural research and extension in Ethiopia can be traced to the establishment of agricultural education establishments in the late 1940s and 1950s. The Institute of Agricultural Research (IAR) was established in 1966 with the formal mandate to formulate national agricultural research policy guidelines and undertake crops and livestock research. A major agricultural extension work began with the initiation of several package projects in the late 1960s and 1970s. It was thought that concentrating resources on the most promising regions would yield better results than spreading resources thinly over a larger area. The package consisted of mainly improved seeds, fertilizer and chemicals (Mulat, 1999). Since then, with the support of a variety of international institutions and donors a variety of agricultural development policies were experimented and several agricultural development programs and countless projects were implemented.

Most of recent agricultural development strategies and programs in Ethiopia are centred on fertilizer promotion, along with the provision of improved seeds, credit and farm management practices. Does these fertilizer-centred strategies worked? What is Ethiopia's recent experience and challenges for increased and effective use of fertilizers? This paper will try to highlight some critical issues and debates the problems the country faced in its effort of enhancing the use of fertilizer in the smallholder sector.

2. Ethiopia's recent experience with its fertilizer promotion strategy

Some 62 percent of the Ethiopian population is estimated to live in the moisture-reliant highlands . A core goal of the Ethiopian government agricultural strategy (ADLI) in recent years (since mid 1990s) was to raise cereal yields especially in moisture-reliant areas through a centralized and aggressive extension-based push focusing on technological packages that combined credit, fertilizers, improved seeds and better management practices. Following this strategy, fertilizer use has increased significantly (Byerlee et al, 2007).

Along with the new strategy, with support from the World Bank, the Ethiopian government formed a project to support for fertilizer market development in Ethiopia (Ethiopia National Fertilizer Project, ENFP) in 1992/93 with the aim of increasing agricultural production and productivity with an emphasis on fertilizer demand and supply, soil fertility management, and fertilizer policy reform. Since then, national fertilizer consumption increased almost three-times.

National fertilizer consumption at the beginning of the 1970s (when it was first introduced) and 1980s was about 950 and 43,200 tons, respectively (Tenkir et al, 2002). It increased to 250,000 tons (21 kg/ha) in 1995 and then to 323,000 tons (32 kg/ha) of product in 2004/05 . This growth of total fertilizer consumption was more rapid (i.e. it has been positive) than the average for Sub-Saharan Africa (SSA) over the same period, and the average use of fertilizer per hectare was almost double the average for Sub-Saharan Africa (Crawford, Jayne, and Kelly 2006, see Byerlee et al, 2007) . This rapid improvement is partly due to the decision of the Ethiopian government allowing farmers to buy fertilizer with 100 percent credit in 19995 (Alemenh, 2003).

Although the strong push for intensification has resulted in higher use of fertilizer, the figures for Ethiopia are still low when compared to those in other countries that have successfully intensified cereal production in the past, particularly in Asia. On average, fertilizer application rate was 110 and 101 Kilogram per hectare of arable and permanent cropland in South Asia in 1999 and 2002, respectively; and 251 kg/ha and 257 kg/ha in China and only 16 kg/ha and 14 kg/ha in Ethiopia during the same years (Byerlee et al, 2007).This leads to low level of land productivity. Despite the availability of proven technologies , a recent study reported that cereal yields in Ethiopia are less than a quarter of the yields achieved in Asia during the green revolution (MoFED and UNDP, 2007).

The state-led policy formulated to push seed-fertilizer technologies has helped to improve fertilizer use per hectare . Fertilizer consumption per hectare, albeit encouraging growth in recent years associated partly to the extremely low use in base year and partly to improved policy support, however, has increased only marginally and remains much below the level recommended by agricultural researchers or to the international standard especially to those Asian countries that have successfully experienced the green revolution.

Given the precarious food situation and acute land scarcity in the country, fertilizer, modern seed and improved water and farm management, are critically important for intensifying grain production and boosting food production in Ethiopia. Based on extensive data collected from millions of demonstrations carried out through PADETES (3.6 million in 1999 alone), Howard et al. (2003) indicated that the adoption of seed-fertilizer technologies could more than double cereal yields and would be profitable to farmers in moisture-reliant areas.

A study by Mulat et al (1997) also indicates that one ton of fertilizer can yield 3-7 tons of additional grain in high potential areas. In general, the role of fertilizer in improving the declining nutritional status and productivity of Ethiopia's soil is widely recognized. Then what are the challenges to strengthen smallholder access to fertilizer in general and its wide, effective, profitable and sustainable use in particular. Why the massive, state-led policy and program formulated to boost the use of fertilizer (seed-fertilizer) has only brought a marginal improvement in its use (especially in terms of use per hectare of farm land) and unnoticed impact in terms of improving cereal productivity and food security.

A number of factors seem to account for the low level use of fertilizer, low technical efficiency in fertilizer use and poor performance of agricultural productivity in the face of significant efforts at intensification and use of modern inputs. A lot of studies (e.g. Byerlee et al, 2007, Habtemariam, 2004, Mulat, 1999) have identified a number of contributing factors. Below is a major points emerged from review of these studies.

2.1 Technical factors

One major factor appears to be low technical efficiency in the use of the principle modern input, fertilizer. A recent analysis indicated that farmers are only achieving on average 60 percent of their potential production, given current levels of input use (World Bank 2006a, see Byerlee et al, 2007). As a result, fertilizer use may be yielding negative returns to many farmers, thereby resulting in stagnation of further intensification and significant rates of dis-adoption. This may be associated to farmers' suboptimal use of fertilizer and lack of complementary inputs. Farmers don't often go along with the recommended practices (100 kg DAPS and 100 kg Urea for most crops except for teff and Urea which requires 50 kg of DAP and 200 kg of Urea) but follows practices they can afford (often half the recommended rate). As a highly specialized input, the efficient use of fertilizer generally requires complementary inputs (e.g. improved varieties), as well as higher levels of management. Farmers might not optimally mix the required ingredients.

As soil erosion and land degradation are major causes for low productivity and vulnerability of smallholders, chemical fertilizer should be augmented with soil conservation practices and use of organic fertilizers. This is especially important in view of increasing fertilizer price and need for foreign currency the country needs to import it (Ethiopia imports all of its fertilizer). It is widely recognized among experts and policy makers that the increasing application of fertilizer at the current price will not be affordable to many farmers and possibly the Government (Ethiopia struggles to get the foreign exchange required to import fertilizer), extension and research should accord a high priority to find an economically viable option that uses fertilizer in combination with other local available organic sources (Alemenh, 2003).

2.2 Policy related factors

Distortions in the land market, lack of effective policy on population and low level of non-farm employment

Sub-economic holdings operated by poverty-stricken farmers are not favorable for widespread dissemination of new agricultural technology. Apart from the population pressure, the land policy has significantly contributed to subeconomic holdings and tenure insecurity. The average farm size in Ethiopia has declined to just one ha due to the rapidly growing population. Over one-third (46%) of the rural holdings are less than 0.5 ha. Given the low level of productivity, nearly all produce is devoted to home consumption for households with smaller plots. There is little surplus for investment and for input purchase. Empirical studies have also shown that the probability of adopting fertilizer and improved seeds decreases with decline in farm size (Croppenstedt, et al., 1998; Mulat et al., 1998; Wolday, 1998, see Mulat, 1999).

Since the 1975 land reform which made all rural land public property, the possession of land plots has been conditional upon residence in the village. The transfer of land through long-term lease or sales as well as the possibility to use land as collateral that will help to generate money for investment on land has been forbidden. This coupled with lack of effective policy on population and low level of non-farm employment has overcrowded the rural sector. Increasing population in the rural areas was thus absorbed in agriculture through leveling down of holdings, rather than through alternative forms of employment.

Fertilizer trade – government policy, undeveloped market and lack of private sector participation

According Byerlee et al (2007), Ethiopian fertilizer market lacks the participation of the private sector especially in recent years. When fertilizer market was liberalized in early 1990s, the initial response of the private sector to market liberalization was rapid. By 1996, several private firms were importing fertilizer, and 67 private wholesalers and 2,300 retailers made up a significant share of the domestic market. However, since 1999 the private sector that had initially responded to the reforms has largely exited the fertilizer market. In the case of imports, the share of private firms operating in the market went from 33 percent in 1995 to zero in 1999.

The decline of the private sector in the retail market was more dramatic. While private sector retailers held a majority share of the market in the early 1990s, the public sector and cooperatives have become almost the sole distributors of fertilizer since early 2000. As of 2004, the public sector accounted for over 70 percent of distribution, with private dealers accounting for only 7 percent of sales nationwide (DSA, 2006, EEA/EEPRI 2006, see Byerlee et al, 2007). The public sector supply channels have also changed; whereas extension agents initially managed distribution, the responsibility was shifted to local input supply offices in more recent years.

Byerlee et al (2007) indicates that the current government policy is to target at least 80 percent of fertilizer sales through cooperatives, which are eventually intended to replace the public sector involvement in retail distribution of fertilizers. This process, as with the importation process, tends to favor those firms or organizations with access to capital markets and experience in navigating the regulatory and administrative systems at both the federal and regional levels.

Despite some positive effect of the public-cooperative monopoly in the fertilizer trade especially from short-term perspective; in sum, the current system in Ethiopia is inefficient and unsustainable in the long run, and that it severely hinders the development of sound input markets and financial institutions in rural areas. Byerlee et al (2007) assess the overall performance of the current system in terms of price competitiveness, services provided, and fiscal and other costs to the public sector.

Price competitiveness

At first glance, fertilizer prices in Ethiopia are competitive. The margin between domestic and international prices is higher in Ethiopia than in Asian and Latin American countries, but comparable to the margin in other African countries, including South Africa. A comparison of the price build-up of fertilizer from port to farm gate indicates that marketing margins in Ethiopia are somewhat lower than those in comparable African countries, and that costs may have decreased over time with improvements in transportation.

Another way to measure this is to compare prices in Ethiopia with prices in comparable countries that are deemed to have a relatively dynamic fertilizer industry. By this measure, prices in Ethiopia do not seem to be out of line, and are in fact often lower than those in Kenya, a country where fertilizer use by smallholders is growing rapidly (Ariga, Jayne, and Nyoro 2006, Heisey and Norton 2006, see Byerlee et al, 2007). In reality, however, these apparently low prices reflect the peculiarities of the Ethiopian fertilizer markets. For example, a part of the cost-build up in fertilizer delivery does not show up in retail prices because the bottom end of the supply chain is essentially subsidized, with extension agents and cooperatives assuming the retailing functions.

Despite sustainability and effectiveness of the public/cooperative dominance in fertilizer market, a reasonably high price associated to private sector might not hinder improved use of fertilizer. A review of the situation in Kenya where fertilizer use by smallholders growing much rapidly, for instance, reveals that a dynamic private sector can promote smallholder use of fertilizer even when prices are relatively high (Ariga, Jayne, and Nyoro 2006). Moreover, there are no solid evidence on the competitiveness of fertilizer price between the public and private sector in Ethiopia .

Quality and dependability of services

Fertilizer prices represent only one dimension of market performance. The ability to provide the right type of input of good quality to farmers in a timely manner is equally important. Based on a study by Byerlee et al, 2007, some problems that might affect the use of fertilizer or its profitability in Ethiopia are listed below.

- Unlike neighboring countries, Ethiopia does not offer fertilizer in smaller packages or different formulations needed for non-cereal crops. The distribution system in Ethiopia is inflexible, providing only two types of fertilizer, both in 50 kg bags.

- Moreover, numerous farmers in recent years (as many as half in some regions) have consistently reported late delivery of fertilizer. About 12 to 46 percent of farmers received fertilizer late, depending on the region. Many farmers also complained that bags were underweight, and 30 percent of farmers in two regions registered a negative response on quality.

  A study conducted in 2004 (Bonger et al, 2004) also reinforced these findings, reporting that half of farmers noted that the fertilizer arrived after planting, 32 percent reported underweight bags, 25 percent indicated poor quality, and almost 40 percent reported that their planting was delayed by fertilizer problems. Most recently, fertilizer quality problems had been reduced but delays in delivery were still common—25 percent or more of farmers complained of late delivery. Timely availability of fertilizer is critical in rainfed agriculture; fertilizer applied late causes it to be unprofitable, while delayed planting can incur even higher costs.

- Beyond fiscal costs, there are also considerable but non-quantifiable implicit costs in the system, many of which are borne by the government through its input supply parastatal and administrative offices. These include the costs resulting from the “central planning” system of estimation of demand by extension agents at the local level and then aggregation at the national level as the basis for allocation import permits. This understandably results in substantial inefficiencies due to the lack of a market clearing mechanism. The indirect costs also include the storage costs and quality deterioration incurred because closing stocks have comprised 50 percent or more of total consumption in most years except in 2004 and 2005. Kenya, which has a fully private sector supply, has an inter-annual carryover average of less than 10 percent. Finally, the implicit costs include those resulting from damage done to extension-farmer relationships when and if extension agents participated to ensure fertilizer loan repayment.

- Furthermore, fertilizer is tied to credit programs and fed by government targets for fertilizer consumption at the local, regional and national levels.
    - This may result in the promotion of fertilizer where it is not profitable, and could explain the negative returns to fertilizer noted above. It may also tend to create moral hazards among farmers with respect to careful use of credit, and may discourage the development of their skills in independent financial management.

- In addition, input distribution tied to credit tends to limit the space available for the emergence of private sector retailers. Thus, those farmers with sufficient resources to purchase fertilizer for cash, often on more favorable terms than on credit, are unable to do so since there are very few private traders. This problem is compounded by the exit of private firms and the rise of party-affiliated companies and cooperatives—a situation that is widely perceived as reflecting the lack of a level playing field in the agricultural input sector.
- Similarly, the guaranteed loan program with below-market interest rates creates an un-level playing field in the rural finance sector by undermining efforts to set up alternative institutions such as MFIs, branches of commercial banks, or independent financial cooperatives.
- There are also high fiscal costs and fiscal risks associated with the guaranteed loan program. The write-off to loan guarantees amounted to Ethiopian birr (ETB) 84 million in 2001, but by 2005 liabilities had again accumulated to ETB 183 million (DSA 2006). Also in 2005, the Oromiya Region was obliged to pay out approximately ETB 84 million to the Commercial Bank of Ethiopia to honor its guarantees for the previous three-year time period. The guarantee thus becomes a subsidy that is not accounted for in government budgeting.

2.3 Institutional factors

The aforementioned problems that could hinder the extensive and efficient of fertilizer might be reflection of institutional weakness. Institutions working to improve the use and profitability of fertilizer use might face various problems like lack required financial and manpower resources. Weakness of these institutions in their internal administration and coordination among various institutions (extension, research and government) might also contribute. Following is a variety of problems related to institutional weaknesses that have hindered wide and more effective use of modern inputs in general and fertilizer in particular in the Ethiopian smallholder sector.

- Adoption of conventional, top-down approach in agricultural extension that established a bureaucratic structure for the regular transmission of pre-determined technical messages from subject matter specialists to farmers. The hierarchical “culture” underlying the extension system does little to encourage and exploit the inherent resourcefulness of those who work closely with farmers and rural communities. Farming communities do not participate in extension planning, and the extension agents remain largely conveyors of technical messages, rather than active facilitators of community capacity building and providers of relevant information.

- Low and unbalanced public investment between agricultural research and extension. Unlike many other developing countries, Ethiopia continues to invest heavily in its public sector-led agricultural extension system in order to implement the recent intensification program. But it drains resources that could be used else where more productively. Byerlee et al, 2007, for instance, reported that the public investment to the recent extension program, excluding the much larger expenditure on food security programs, amounted to over $50 million dollars annually or almost 2 percent of agricultural GDP in recent years. This was four to five times the investment in agricultural research.
- Frequent restructuring of MoA - Since mid 1970s, MoA has undergone through at least ten major restructuring processes. It is worth mentioning here that evidences are difficult to find that would indicate that such restructuring measures were made based on commissioned studies evaluating previous organizational structures nor are there any measurable performance indicators suggested to monitor that the new structures would perform better. One could say that the organization of extension kept on changing because of leaders own intuitions, and not based on evaluation and assessment. This negatively affects continuity of programs and increases instability of staff which, in turn, affects the provision and sustainable use of modern inputs like fertilizer (Habtemariam, 2004).

In addition to institutional instability, weak financial and administrative capacity that lead to poor extension planning and monitoring system might have weaken the effectiveness of the extension system and indirectly, extensive, effective and sustainable use of fertilizer and other modern inputs among the small farmers (Habtemariam, 2004).

Conclusion

There is widely held view that poverty reduction in Ethiopia is impossible without significant growth in crop yields for major staples. Recent developments , however, depicts the enormous challenge the agricultural sector faced to satisfy national food requirement and help in reducing poverty. A recent study by Diao and Pratt (2007) shows that significant poverty reductions in Ethiopia could be achieved by prioritizing investment in improving cereals and other food staples productivity relative to both traditional and non-traditional export crops (see Byerlee et al, 2007).

The recent rapid growth of higher-value export crops especially cut flower (but to lesser degree other crops like coffee, livestock, and horticulture products) indicate the central role of government policy to improve agricultural production and productivity. Cheap and guaranteed access to farm land, financial resources and other incentives including duty free import of agricultural technologies and tax-holiday for investors help for rapid growth of the horticulture sector. To boost cereal production among other through extensive, effective and sustainable use of fertilizer, improved seeds and farm management practices, Ethiopian policy makers to reconsider their policy. The food sector needs a comparable but different kind of policy attention.

Any intervention to improve sustainable and effective use of fertilizer and other modern technologies should be holistic; systematic that could address a range factors discussed earlier. At the final analysis, productivity is a technical/technological problem but the intervention required to improve smallholders' access to farm technologies and their efficient and sustainable use should not necessarily be implementing a technology-led extension program. If that is the case, Ethiopia's over 4 decades experience should have made Ethiopian smallholders' major users of modern farm technologies and alleviate the widespread structural food deficits and a chronic dependence on food aid.

Of course, technology required for enhancing productivity could be internationally available or generate domestically. Government policy and donors financial assistance to widely diffuse existing or new technologies (e.g. fertilizers and improved seeds) to areas with low productivity is only one aspect of the problem in a complex institutional, social and political environment. The exclusive concentration given to technology as a determinant of productivity in theory and the effectiveness of such a concentration in increasing productivity in practice in countries such as Ethiopia should be revisited. While technology is important, the whole social structure of the growth process needs to be considered to effect durable productivity enhancement and sustainable use of modern farm technologies like fertilizers and improved seeds.

It would be better, therefore, for Ethiopian policy makers and donors, to change their approach in dealing with the problem the country faced in promoting the use of fertilizer and its effective and sustainable use. Among others, they should refrain from making any specific recommendation (to improve farmers access to modern inputs such as fertilizer (e.g. subsidy)) before identifying and studying the whole gamut of factors that affect decisions by farmers, including the incentive structure, institutional configuration, governance and risk behaviour patterns.

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_In my view, any policy for improved soil fertility management must have the below ingredients to ensure efficiency and reliable learning.

- A systematic programme to properly diagnose soil fertility constraints and their associated risk factors spatially at different scales, using statistically valid sampling schemes. We have the technology to do this cost-effectively now. Participatory diagnosis by land users/communities is important but not a substitute for scientifically sound objective assessments. There is need for interaction among both types of systems.
- A systematic programme for testing soil fertility management options using standardized protocols and linked to the baseline above (no. 1) to provide evidence-based recommendations. Again this is required to complement and inform farmers testing strategies.
- Baselines and monitoring of soil fertility in soil management/development projects so impacts of interventions can be reliably assessed. Again no.1 above provides a method for doing this.

This evidence base is needed to inform decision making at all levels: individual farmers, communities, stockists, fertilizer/seed companies, land resource managers, national research and extension, government planning and finance ministries, donors, development agencies, etc. We have the technology to do this - we just need good design and systematic application. The types of systems I am describing are surveillance systems similar to those used in the public health sector - which indeed primarily guide public policy and practice.

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Increasing agricultural productivity and achieving caloric food security is a first-year goal in most of the Millennium Villages (MV) sites. Soon after the first harvest, communities in MVP areas should diversify crops both for nutritional diversity, with vegetables, fruits and livestock, and for income generation, with high-value products. In the short term, a *package of technologies*, including superior germplasm, agronomic practices, and postharvest handling, must be determined in consultation with the communities and agricultural expertise in each site. In the medium and longer term, a *package of services* is crucial to the economic viability of agriculture. These services include: timely supply to improved seeds of staple and cash crops as well as improved livestock and vegetables; fertilizers, water, and credit; training; and the establishment and strengthening of village farmer organizations. Initially some of these services must be provided through the project, but a transition to private sector agricultural input dealers and public sector extension agents is essential. This vision will also require putting into place a *package of public policies*, which include input and output markets, building up grain reserves, and strengthening rural infrastructure.

Broadly, agriculture interventions aim at more robust and diversified agriculture, including nitrogen-fixing trees and cover crops, organic manures, crop rotations, soil conservation practices, livestock, aquaculture, small-scale water management, improved crop storage, and crop insurance. More specifically, soil rehabilitation techniques, which comprise a significant aspect of agriculture interventions, include:

- Fertilizers and hybrid maize subsidies by the government
- Joint use of mineral and organic fertilizers, the latter of which include green manures and leguminous tree fallows
- Financial incentives for N-fixing legumes

The MVP has already seen successes with these interventions, specifically in Mwandama, Malawi, which is in the southern region of Malawi's Zomba district. Nearly 90% of people in the Mwandama Millennium Village cluster live in extreme poverty, a much higher proportion than the 65% national level. Prior to the MVP interventions, the average maize yield without fertilizer was 0.5 tons per hectare. Most households produced enough food to last through August, meaning that families experience a six-month period of food shortage. Mwandama suffered a drought in the year preceding the start of MVP operations. But even in good rainy seasons, the shortage of nitrogen in the soil resulted in low maize yields. After MVP initiated agriculture interventions, including those described above, maize yields increased from .8 to 6.5 t-ha-1 in 2005/06. In addition, the area planted almost doubled, and the total maize production increased nearly 15-fold. Maize yields from farms not using improved seeds and fertilizers averaged 2.2 t-ha-1, illustrating that improved rains were only responsible for half of the yield increases.

Malawi is also seeing improvements in agricultural productivity on a national scale. Decades of intensive cultivation in the absence of significant fertilizer use has resulted in a depletion of nutrients, particularly nitrogen, from smallholder fields. National yields of smallholder maize have averaged 1.2 MT/ ha during the last 20 years, and more than half of the farming households operate below subsistence. A dry spell in 2004 had devastating impacts on maize yields. Total maize production in 2004/5 declined nearly a quarter from the previous year, providing just 57% of the national maize requirement. In response, in June 2005, the Government of Malawi began to import fertilizer and procure improved maize seed for distribution to farmers through a national subsidy scheme.

For the 2005/6 season, the Government allocated 2 million coupons sufficient fertilizer to grow maize in 1 acre (0.4 ha), at the recommended rates (86 kg N ha-1 and 11.5 kg P ha-1). An additional 740,000 coupons were allocated for growing tobacco. For maize, the recommended nutrients were provided by one 50-kg bag of 23-21-0 fertilizer and one 50-kg bag of urea. Coupons enabled farmers to purchase fertilizer at MK 950 per bag ($7.60) compared to the market prices ranging from MK 2,500 ($20) – MK 3,500 ($28).

The 2005/6 season was characterized by good rains. The total maize production more than doubled from the previous year, producing a surplus of 510,000 MT above the national maize requirement. Maize yields averaged 1.59 MT/ha, almost doubling the 0.81 MT/ha of the drought-affected 2004/5 season. Estimates for the 2006/7 harvest illustrate a 32% increase over the 2005/6, an all-time national record for Malawi, generating a surplus of about 1.34 million MT of maize grain above national requirements.

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The African soil fertility ‘problem’ (I am thinking of dryland soils) is of course a *management* problem, as after many decades of expanding cultivation and grazing, the basic characteristics of virgin soils have been significantly altered nearly everywhere, or stand to be altered soon. Management is based on *knowledge,* which is fragmented. At least three levels can be discerned:

- Science-based knowledge, drawing on soil science and related natural science disciplines, which has enjoyed dominance since the beginning of the colonial period and has therefore led policy makers to search for technology-driven solutions
- Policy-makers’ and donors’ perceptions, linked to that of field professionals, which has been marked by top-down and generalist tendencies that result from attitudes obtained from educational institutions, the influence of influential stakeholder groups, and donors’ home constituencies
- Local peoples’ knowledge, which consists not merely in picturesque representations of the properties and potentials of local soils, inherited from the past (‘indigenous’ knowledge) but also in experiential and adaptive knowledge from project successes or failures as found relevant to their livelihood circumstances

Each of these crude categories has its own social ambiance. The first flourishes in universities and research stations, entangled with institutional structures and priorities and often lacking adequate ‘off-station’ inputs, often for want of resources rather than inclination. The second is driven by political targets and prejudiced in favour of grand scale interventions that attract publicity and funds. The third – insufficiently recognised – positions soil management as one component in a complex livelihood system where natural resources compete with wide-ranging livelihood objectives for the limited labour, skills and finance available.

It is only at the third level that knowledge properly confronts the complexity of local ecosystems, which have recently been characterised as ‘co-evolving human and ecological systems’ in the ‘Drylands Development Paradigm’. This level is also the only level at which the diversity issue is confronted on an everyday basis. It is at this level that well-known ‘success stories’ characterised as ‘area development’ (rather than project successes) have been worked out. There is a great gulf fixed between scientific knowledge patiently acquired from research at this level and the sweeping generalities promoted by the continental surveys and projections, and ruthlessly repeated in support of politically acceptable grand programmes in the soil fertility debate. Divergences between understanding obtained from macro- and micro-scale research should be a cause of concern. And such micro-scale research as has been undertaken is far too limited.

What is ‘success’? Given the current trends in food prices, fuel and other inputs, demographically-driven demand, urbanization, and climate change (or increasing variability), sustainable soil productivity is surely the only acceptable indicator of successful management. As such, it comes quite close to the perspective of a great many small farmers, who only ‘mine’ nutrients when their resources are constrained, and who are acutely aware of their need to pass on a productive asset to their heirs. Provided that the inheritance is assured, they invest – often with labour rather than with finance – in small-scale, intermittent, incremental inputs over time.

In this context, the search for the ‘right’ policies continues, each with its own proponents. A question worth raising is whether the difficulties faced (so far) in hitting on demonstrably ‘successful’ strategies reflects a failure to come to terms with the fragmented and under-developed state of understanding of African soils management. Beyond the commendable use of participatory methods in projects (which pursue an external agenda) and a new emphasis on knowledge partnerships between farmers (or livestock herders), researchers, professionals and policy makers, two awkward concerns are:

- The near-universal popularity of a diagnostic-prescriptive framework for designing intervention and promoting change. This mode, inherited from colonial forbears and an unequal exchange between scientific and local knowledge, suggests that every intervention begins afresh, as if no-one had been there before. This cannot be so, after many decades of agricultural policies and interventions affecting most of Africa. It is a consequence of the nature of development projects – nothing yesterday, funded today, impact (and withdrawal) tomorrow. Is this shallowness acceptable, or does the diagnosis need to be positioned beyond expert opinion in a more sophisticated analysis of project precursors, policy impacts, and long-term trends (for example, in rural population densities, markets, technology transformation, ecological or landscape evolution)? This is how local people see it. Their memories are often longer than those of the institutions that seek to turn their lives upside down! Projects should be positioned through long-term understanding of transition in the countryside, not only in environmental management but also in livelihood circumstances.
- Livelihoods approaches, although widely acknowledged to be relevant to soil management, are quite difficult to implement. How can development policy or project design deal with the possibility that investment in a bag of fertilizer may have to compete with the cost of taking a sick person to hospital? Agriculture is traditionally managed at national and donor level as a sector, but at the local level, no sector division is made. Investment decisions reflect such variables as education, attitudes, state of health, access to labour and knowledge, markets, social priorities, as well as

> financial resources. All these are embedded in a slow process of change that may influence how local people evaluate the prospects of technologies being promoted.

This may be a caricature of issues already familiar. But they are not always reflected, it seems, in policy debates leading up to grand programmes. Beyond the local scale, and the inspired action-research project agenda, there are methodological difficulties in scaling up temporal depth and systemic breadth, which remain as outliers in the policy debate, if recognised at all.

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"Is inorganic fertilizer the best initial 'entry point' for an integrated soil fertility mgmt approach? If so what should a programme look like bearing in mind past failures? If not, what should be done first?"

First comment:

The best entry point is fertiliser (organic/inorganic) COUPLED with improved water mgmt at field scale. Multiple approaches (technologies) are available, and no single solution can be used as blanket for the wide variety of farmers ..... The COUPLING of fertiliser with water is more essential the drier the agro-climatic conditions. Water mgmt alone will not diminish the current yield gaps on in-fertile soils with low input/low re-circulation of organic matter. Equally, the full benefit of fertiliser (organic/in organic) inputs will not be realised without addressing water limitations by recurring dry spells and possibly droughts in semiarid and sub humid climatic zones.

Multiple benefits of increased re-circulation of OM in a crop system will not be sequestered if C/N quota isn't favourable: Thus, the input of (inorganic) N may be a essential component to increase yields, as it enables a favourable C/N, increase overall biomass, and enables re-circulation of OM back to soils putting a cropping system on positive soil health trajectory.

It is not a matter of doing water or fertiliser 'first': With current available knowledge, the important issue is how to effectively provide knowledge input linking at first water and nutrient management packages, but also soon the use of improved varieties. Only the coupling can achieve substantial yield increases over relatively short time (possibly 5-10 years with effective knowledge/awareness spread??).

To my mind (not with any solid evidence that it works of course)

- subsidised fertiliser, specifically targeting macro as well as micro nutrients in the area of distribution: subsidising fertiliser have had fast & positive response in Malawi , partly due to favourable rains enabling the positive response of fertiliser input (*any other evidence at national scale in recent times in SSA?)*
- strong emphasis on fertiliser distribution coupled with water management small and large scale investments
- development and distribution of improved seeds to further boost investment gains in water & fertilizer (*evidence??)*
- the current trend of privatising extension service will most likely not help promote technological sound packages in soil-water-crop mgmt that are

diverse enough to address smallholder farmers knowledge gaps. Privatising rural extension service may be more beneficial to specific farmers, and more promote specific use of crops and agro-inputs not necessarily managing negative environmental (and social) externalities very well... It will also only be affordable to certain income strata (*evidence?)*

'How should success and impact be defined?'
Second comment:

Raising the yields, i.e. realising the potential with better water and nutrient management will have environmental impacts as well as social. There are no longer any space that are not utilised or provides produce and services necessary for humans and society. Any agricultural development, whether intensifying existing systems through nutrients and water, seeds etc, or expansion will have effects on surrounding landscape. Some of these are positive, and some can be negative. The 'next' /first? / 'triple/ green revolution in Africa must be continuously evaluated for social as well as environmental impact. It cannot be acceptable that the negative environmental (and perhaps social??) impacts of the green revolution in Asia are reproduced. It would create extremely costly avenues to re-tract such negative effects of agricultural development, which can be ill-afforded both from economic (Africa by and large strapped for cash) as well as climate adaptation perspectives (measures in agriculture development needs to be climate change 'proofed' to avoid future costs & livelihood losses).

There is globally, and occasionally regional and nationally, awareness, and willingness to consider pro-active measures to avoid negative externalities. However, such measures usually tend to add cost without adding visible (economic) value in short term...

Example: when smallholder farmers in a given area adopted conservation tillage (as desirable), there was a tendency to put more land into production, i.e. area expansion of agriculture, which globally can be ill afforded, although feasible locally.

Example: the use of treadle pumps have at local spots been popular & provided users with much needed cash income, further investment in agriculture production and development opportunities as well as achieved absolute poverty alleviation. However, non-monitored water level has tended to decrease altering downstream seasonality of flows and user opportunities...

Clearly, success and impact are not solely about short term yield increases, not even about poverty alleviation per se. Both these obvious criteria need to be integrated with long term measures of environmental and social sustainability: negotiating tradeoffs, building resilient systems which can cope better with change/stress, whether climatic, economic or other,. It is crucial in agro-development that the resource base (of which we have comparatively good basic knowledge) is maintained and not 'mined' whether it refers to land area, soil nutrient, or water management...Thus it is necessary that agro-development is environmentally and socially monitored and evaluated to ensure development takes a desired route, and avoid undermining negative externalities (social and environmental) in the near and far future

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We are deeply interested in improving and assisting address the serious mining of nutrients and carbon in Sub-Saharan Africa. We are just concluding some research into providing ways to address the extremely tenuous supply of nutrients, especially in the Sahel of West Africa where the majority of the inhabitants are living on the brink of famine.

Two types of interventions are needed in our view: one that addresses the inherent problems with the loss of the meagre, irregular rainfall and the other that improves soil properties so that capture and harvesting of water is improved.

A recent paper describing the increased crop yields can be found at:
- Gigou, J., Kalifa Traoré, François Giraudy, Harouna Coulibaly, Bougouna Sogoba, Mamadou Doumbia. 2006. Aménagement paysan des terres et réduction du ruissellement dans les savanes africaines. Cahiers Agricultures vol. 15, n° 1, janvier-février 2006 Vol. 15.

A subsequent paper describing the water-harvesting properties of the technology - the water capture and increased retention of surface water for crops, subsoil water for trees, and deep drainage for groundwater restoration can be found at:
- Kablan, R., R.S. Yost, K. Brannan, M. Doumbia, K. Traore, A. Yorote, Y. Toloba, S. Sissoo, O. Samake, M. Vaksman, L. Dioni, and M. Sissoko. 2008. “Amenagement en courbes de niveau”, increasing rainfall capture, storage, and drainage in soils of Mali. Arid Lands Research and Management 22:62-80.

A third paper is soon to appear in Agronomy for Sustainable Development reports on the C sequestration and build up potential of the ACN technology and the increased fertilizer efficiency is announced at:
http://www.agronomy-journal.org/index.php?option=forthcoming&Itemid=18&lang=en

In the broadest sense, SFI arguably includes inorganic fertilizers, organic amendments and natural resource management practices.

When I was a student in Agricultural Economics at the University of Nairobi a fellow graduate student from another department once asked me in puzzlement the following question in response to my assertion that many poor farmers lack incentives for fertilizer use: ‘’What other incentive is anyone looking for than the ability to grow enough food for one’s family without having to buy it?’’ The answer that readily came to my mind was: ‘’Yes that is a powerful incentive but at what cost?’’

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