Is Fertilizer a Public or Private Good in Africa? An Opinion Piece

CHRISTINA H. GLADWIN, ALAN RANDALL, ANDREW SCHMITZ, AND G. EDWARD SCHUH

Traditionally, fertilizer has been treated by economists as a private, not public, good. [1] Soil scientist Pedro Sanchez and researchers associated with the International Center for Research on Agroforestry (ICRAF), however, claim that ICRAF's agroforestry innovations should be adopted by African farmers as an inexpensive way to replenish their depleted soils. "Replenishing soil fertility" is important because it is the number-one natural resource in Africa currently being depleted: the nutrient capital of African countries is being mined, just like mineral deposits of metals or fossil fuels. [2] Soil fertility depletion on smallholder farms is the fundamental biophysical root cause of declining per-capita food production in Africa. Society as well as farmers must invest in soil fertility as a form of natural capital.

Soil fertility depletion in Africa has both private, on-farm costs (e.g., decreased crop production, increased soil erosion) and public, national, even global costs. These include: decreased national food security, exacerbated rural poverty, increased migration to urban areas, increased urban unemployment and social unrest. Public costs also include: increased stream sedimentation, decreased water quality, loss of soil carbon to the atmosphere, loss of adjacent forests, and decreasing biodiversity (as land extensification occurs).

Replenishing Africa's soils is possible, however, on the high phosphorous fixing soils of Africa. For an estimated 530 million hectares, phosphorus-fixation is now considered as an asset and not a liability as previously thought. [3] Inorganic fertilizers are absolutely necessary to overcome phosphorus (P) depletion on these soils. Large applications of phosphorus fertilizer can become 'P capital' as sorbed or fixed P, almost like a savings account, because most P sorbed is slowly *desorbed* back into the soil solution over 5-10 years. The larger the application rate, the longer the residual effect. If phosphorus is applied as a one time application of phosphate rock, the decomposition of organic inputs that produce organic acids which acidify the phosphate rock (e.g., the organic acids in *Tithonia diversifolia*, a common shrub in W. Kenya) can assist in desorbing P.

To reverse nutrient depletion of nitrogen, however, Africa needs a combination of inorganic fertilizer, biological nitrogen fixation technologies, biomass transfers of organic matter into the field, animal manure/compost, and/or trees whose deep roots capture nutrients from subsoil depths beyond the reach of crop roots (nutrients are transferred to the topsoil via decomposition of tree litter). Subsoil nitrate accumulation is not significant in all soil types, but it is in Nitisols and similar soils, which comprise 260 million hectares in Africa.

http://www.africa.ufl.edu/asq/v6/v6i1-2a13.pdf

ISSN: 2152-2448

Can nitrogen demands be met biologically? Yes, to produce *mid-range* yields of 4 tons/ha of food crops such as maize. But to produce higher yields of food crops of 6 tons/ha, combinations of organic and inorganic fertilizers are needed (recovery by crop of nitrogen from leaves of leguminous plants is lower, 10-30%, than recovery from nitrogen fertilizers, 20-40%). ICRAF's solution to soil fertility depletion involves replacing phosphorus lost over the last 20 years on these Nitisols by importing Minjingu phosphate rock from Tanzania. Nitrogen lost over the last 20 years will be replaced with nitrogen from agroforestry innovations (such as hedgerow intercropping with *Leucaena*, biomass transfer with *Tithonia*, manures improved with *Calliandra*, and improved fallow systems using N_2-fixing shrubs like *Sesbania sesban, Tephrosia vogelii, Gliricidia sepium,* and *Cajanus cajan*). How to pay for this one-time application of phosphate rock? Because there are national and global benefits to farmers' use of fertilizer in Africa, national and global institutions should also share the costs.

OPINIONS ABOUT SOIL FERTILITY REPLENISHMENT

What do agricultural economists have to say about this issue of the public benefits to private fertilizer use? To show both the diversity and consensus in their thinking, I first present my own opinions about this possible solution to the soil fertility depletion problem in Africa, given the results of our five-year "Gender and Soil Fertility in Africa" project. The reactions of three esteemed fellows of the American Association of Agricultural Economists (AAEA) given at the 1997 AAEA meetings in Toronto, Canada, follow.

Comments by Christina Gladwin

In 1987 I was part of a Robert Nathan team sent to Malawi to consult on the removal of fertilizer subsidies. I have not been the same since. As the two-month mission unfolded and I interviewed many farmers in three districts of Malawi about what they would do if fertilizer subsidies were removed, it became clear that fertilizer prices would increase, the quantity of fertilizer used would decrease (in line with micro-economic theory), and the quantity of maize produced per hectare -- by individual farmers and in the aggregate -- would also decrease. Farmers would use more land-extensification strategies rather than land-intensification strategies, switching from hybrid maize to local maize production because local maize did not require as much fertilizer to produce.The risk of hunger for individual households would also increase, because farmers in Malawi, accustomed to applying chemical fertilizers since the 1960s, did not operate enough land to be food self-sufficient. Furthermore, they could no longer apply animal manures as a substitute for chemical fertilizers, due to lack of grazing land and child labor to care for the animals. Hence with the removal of fertilizer subsidies, there was a need for a national safety net program in Malawi. At that time, however, safety net programs were nonexistent. I imagined dire consequences.

For a few years, no such dire events occurred, partly due to government's delaying the final removal of fertilizer subsidies and partly due to droughts in 1991 and 1993, which led to donor-supported free input grants programs. In 1994/95, however, the price of fertilizer increased 200 to 300 percent without corresponding increases in maize prices in 1995/96 and 1996/97. As Uttaro's paper in this edition shows, by 1997 farmers dropped their land-

intensification strategies, with both men and women farmers shifting back from hybrid maize varieties to non-fertilizer-responsive local maize varieties. Aggregate maize production fell. This was followed by a massive devaluation of the Kwacha in August, 1998, and subsequent increase in maize prices (as shown by Anderson's paper in this edition). Many food-insecure households were threatened by the growing length of the hunger season, and the Malawi government responded in 1998/99 with a safety net program – called the starter pack program. But as demonstrated in Gough's paper here, because the starter pack was universally applied to all rural households, its benefits were too small to significantly increase cash incomes of the food insecure households who comprise the poorer 40% of the rural population.

How to reach the bottom two quintiles of the population in a poor African country remains a tough problem, and one that forces government to examine its funding trade-offs when designing a soil fertility replenishment strategy. If government allocates its scarce funds by importing Minjingu phosphate rock from Tanzania and distributing it free over a wide geographical area (relying on agroforestry innovations to replace nitrogen lost over the last 20 years), as Sanchez suggests, it might increase aggregate food production in the country. But would it address food insecurity in the country? No, the truly food-insecure can only be addressed via a safety net program targeted *directly* at them, not at all the households in a given area. Neither should government be persuaded by OECD donor countries with oversupplies of cereals to provide a maize safety net to farmers who know how to grow their own maize and can do it more cheaply with a fertilizer safety net. A maize safety net would only increase their dependency. A government concerned with improving food security but strapped for funds might spend them more wisely on a productivity-enhancing safety net program (PES-net) that would provide nitrogen-fixing seedlings or seeds to only the food-insecure households.

Findings from all the micro-level studies undertaken as part of the "Gender and Soil Fertility" project seem to agree. During the five years of the project, we analyzed several policy options with respect to whether they work for women farmers in Africa: fertilizer vouchers, small bags of fertilizer sold in local markets, credit and microcredit for fertilizer, grants of fertilizer, and the organic options (agroforestry innovations, legumes, animal manures, and combinations). In all the sites, we found location-specific and historical conditions made it difficult to generalize results across all the micro climes. Yet our conclusions may be summarized as the following:

·Fertilizer voucher distribution is almost non-existent in Africa. We did not find a naturally-occurring experiment in which to assess fertilizer vouchers targeted at women food producers.

·Small bags of fertilizer are bought in local shops by both men and women in MHHs, but are usually used on men's cash crops rather than on women's food crops. Small bags are rarely bought by FHHs. Fertilizer in local markets, unlike cement, is rarely sold by the kg.

·Credit targeted directly at women is problematic. For women in MHHs, it leaks to men in locations where cash income is the man's domain. Women use informal credit more

than formal credit. Household composition also affects credit use, as FHHs are still considered bad credit risks.

·Grants of fertilizer targeted only at the poorest FHHs did not occur in Africa and where targeted universally at all rural households the impacts are not significant. Flexi vouchers for grants of fertilizer add more to household cash income while input grants add more to aggregate maize production.

·Women plant grain legumes for food and do not plow them under when green, so they do not serve as a soil fertility amendments in Africa.

·Lack of land, labor, awareness-knowledge, and technical-knowledge limit women's adoption of agroforestry innovations (e.g., hedgerow intercropping, biomass transfer, and improved fallows). But where land is available and extension efforts alleviate the lack of knowledge constraints, poor FHHs do test and adopt improved fallows, even more so than married women in MHHs.

·Combinations of small amounts of chemical and organic fertilizers may show promise, but again, we did not find a naturally-occurring experiment that was disseminating innovative new combinations of inorganic and organic fertilizers in a formal manner.

·Women's access to cash crops does not ensure their use of soil-fertility amendments, but does help relieve women's cash constraints, so that cash-allocation decisions may be made about fertilizer use. In locations where women receive credit for cash-crop inputs, they usually divert some of the fertilizer received from the cash crop to their food crops.

The conclusions reached by the individual papers in this issue, taken collectively, show that gender differences do affect the use of soil fertility amendments by African farmers.Results are hopeful for reaching women farmers in male headed households (i.e., married women) and men in MHHs. These two groups do have some good options for improving their soils in the form of small bags of inorganic fertilizers sold locally, microcredit programs for fertilizer use, safety-net programs, additional cash cropping, and organic options (including legumes and agroforestry innovations). But African women farmers are not all alike. For the poorer FHHs, the results do not paint a rosy picture. Their options are fewer because their resources of land, labor, and capital are less. In our opinion, their soil-fertility options boil down to cash cropping, nitrogen-fixation technologies (in the form of improved fallows or doubling-up legumes), and safety net programs. For these women, and thus 25 to 35 percent of African households, if improved fallow technologies do not diffuse or if markets for cash crops fail, soil fertility improvements will have to come in the form of safety net programs. The challenge for African governments and donor countries will be in designing and delivering safety net programs that can serve the dual goals of increasing agricultural productivity as well as helping food-insecure households survive the lengthening hungry seasons in Africa.

Comments by Alan Randall

Anybody who is comfortable with the notion of passive use values for environmental amenities might be able to find the public good in the problem under consideration here. When one thinks about public goods, several things come to mind: first, the notion of preferences, i.e., something has to be preferred by at least some people, and second, the notion of an isolation paradox, i.e., that there is something produced which is of some value to many people, but not enough value that anybody in particular can afford to pay the cost of it. But if a way were found to break the isolation and bring them all together, to share costs and as such generate benefits for each one that exceeded their own costs, that is, a private benefit that exceeds cost share individual by individual, then one clearly has an isolation paradox that is loosely called a public good.

What are some of the sort of things that might or might not be public goods? There is relatively little to guide us. There is the notion that extensification of land use for farming that would diminish biodiversity in Africa or elsewhere might represent a public bad, and there might be a public good in addressing this. The notion of soil as natural capital is not certain but should be kept as a possibility.Is poverty itself a public bad? Certainly lots of people prefer to live in a society where others are doing reasonably well -- although there are some reservations about this. What about social instability, such as occurs with urban migration? There might be a public good in keeping people productive and in place where they are.

Poverty and Social Instability as Public Bads

These concepts have to be formulated very carefully. The notion of defining other people as public goods is a little bit scary. Yet some of the impacts of loss of soil fertility in Africa -- demands on services, losses of biodiversity, etc. -- can be thought of as potential public bads.

It is clear that something ought to be done about replenishing Africa's soil fertility. The questions arises: why must it be addressed as some kind of extended micro economics? It perhaps might be sufficient to say in fact that it is a good thing, therefore go ahead and do it. Very few people see the world in quite the same way as welfare economists do, as utilitarian consequentialists. But there are lots of other people who do see the world that way: champions of various kinds and libertarians and contractarians and people who invent far fetched stories starting in the notion of natural rights. There are two ways to think about the sort of pluralism that emerges from that. One is that there is a stand-off between those who are consistently consequentialists about everything and those who are Kantian. Bernard Williams is writing eloquently at the moment for that notion of pluralism. But there is another view: that we are all ourselves pluralist in some kinds of ways, and we draw upon different traditions to answer different questions. There is a conversion process that turns us into consequentialists -- economists -- and makes us want to put everything in that framework. But the rest of the world does not necessarily do this. There is room for arguments in favor of allowing reasonably productive and prosperous farming in Africa at the expense of people beyond that sector. It does not necessarily need a contrived economic argument for justification, and the public good argument doesn't seem to hold water.

Finally, why does it seem important to make a welfare and efficiency argument for taking care of what seems to be a serious problem? In the United States, very poor economics was

done in the 1970s, officially in the name of the forest service, to redefine benefits. The reason for that was that the commitment to maximization of benefits was simply premature. The support for it really wasn't there. There is a similarity here, where we have donor agencies that are committed to imposing world prices right down to the local level of people who are substantially distanced from world markets. So in some ways, we might pragmatically be forced to contrive an efficiency-type argument to do something that very likely should be done for quite different and thoroughly honorable reasons.

Comments by Andrew Schmitz

At a recent annual "Farming for Profit" conference in Saskatchewan, Grant Devine (on the board of directors of a large fertilizer producer), argued that the fertilizer industry was totally competitive. There had supposedly been no money in the fertilizer business for years so many people went out of business. But we have learned something about predatory pricing. Some firms exit the industry because other firms drive them out and then they drive the prices right back up. What happens as a result? Share prices go up.

Second, if you take a look at the total demand for fertilizer worldwide, the large growth in demand is obviously from India and China. Third, with respect to fertilizer applications and prices, I still am totally confused about the use of fertilizer, whether it be in Africa or Saskatchewan or wherever. Even in Saskatchewan we are still trying to find out whether there are any benefits to precision farming with very specific applications of fertilizer to different subplots of a field.We have no idea what the fertilizer response functions are in any area of the world, let alone Africa. Production functions vary all over the map.

Something that is even more disturbing is that yields have actually gone down in a large part of the world, even with heavy applications of fertilizer. The uncertainty of fertilizer use is due not only to the impacts of variations in amounts of fertilizer applied, but also to the impacts of soil degradation and soil fertility loss with continuous cropping. As a result, we're going to have to add more and more fertilizer just to keep yields constant. So what does this mean to Africa? It appears those soils have been cultivated for hundreds of years. How can one maintain the quality of those soils? We have a very serious problem of soil degradation.

On this whole topic, until we solve these problems and understand the production function, the applicability of economics is questionable. How much do we really know about how soils respond to fertilizer?

We recently wrote a book on Bulgaria on the topic of privatization in Eastern Europe. What was really frightening was how could Bulgarian farmers fertilize at the world market price of fertilizer, when government capped the price of wheat at $2.00 a bushel? Government policy was charging farmers essentially the full price of fertilizer at the international market price and then placing a cap on what they could export and at what price. It essentially squeezed farmers right out of the fertilizer market. With respect to fertilizer use in Africa, this means one also has to know the pricing policy of the main commodities to get a feel for whether fertilizer can be applied at any profitable price.

One can easily justify subsidizing fertilizer use based on the theory of "the second best." [4] If one is in a world of "second best," which in Africa is the case, one can easily justify an

international cost sharing (i.e., subsidy applied to fertilizers). However, the issue of "second best" arguments is perhaps less contentious than how to effectively implement a subsidy so that it goes to the end user -- the farmer. What form should a subsidy take so that it doesn't end up being wasted by governments and/or the private sector? Often subsidies do not benefit those for whom they are intended because of the distribution system. If a subsidy program is designed poorly so that it ends up in the hands of middlemen, then it is of no use in helping local farmers out. Also, there are issues such as fertilizer price instability and relative prices of inputs versus outputs. Fertilizer prices are highly unstable. A major importer can gain from optimal fertilizer storage. One should examine subsidizing storage rather than placing direct subsidies on the input itself. Finally, what is the price of maize, for example, in Africa given that a large percentage of domestic food grown is consumed directly by the household? If this food is undervalued, then the case is weakened for increased use of fertilizer.

Comments by G. Edward Schuh

The Sasakawa Global 2000 project (SG 2000) in Africa combines the agronomic genius of Nobel Peace Prize laureate Norman Borlaug and the political skills of Jimmy Carter with the commitment to African development of the late Ryoshi Sasakawa and his son. In the 1980s, these three started a technology transfer project that is now operating in twelve African countries. In order to meet their policy advice needs they created a group called Agriculture Council of Experts (ACE), part of whose mandate is to put together policy papers. The first paper that was put together was called, "Fertilizer Policy in Africa: Recurring Issues and Recommendations". [5]

In order to increase fertilizer use, the issue of fertilizer profitability and a whole range of barriers or constraints to increased fertilizer use must be addressed. My comments detail these, and follow with a set of recommendations, which are presented here with little elaboration. The puzzlement about fertilizer use is that the low level of use is due to a large number of factors; and implementation of any fertilizer policy requires tradeoffs between some of these factors.

Barriers to increased fertilizer use

First, the lack of profitability in using fertilizer is due to unprofitable and unstable ratios between the prices of fertilizers and product prices, as has already been mentioned. If one looks at any of the current price ratios (of nitrogen fertilizer to maize, for example), it is clear why farmers do not use fertilizer. If one then looks at the instability in the price range, one can see why they do not spend a lot of time trying to learn how to use it unless it is highly subsidized.

Second, past dependence on heavy government intervention in the economy has led to unstable supplies, inappropriate fertilizer mixes, and lack of timeliness in delivery for profitable use. On the lack of relevance of fertilizer mixes, a lot of the fertilizer supplies have been the byproduct of aid programs. That doesn't necessarily mean that the market really isn't useful, it is often that some companies are trying to get rid of unwanted fertilizer blends and sell them to aid agencies at lower prices. The United States is not the only country guilty of doing this.

Third, there is uncertainty about the responses to fertilizer due to unstable weather patterns, lack of irrigation, and more importantly, unstable public policies.Fourth, there is lack of knowledge on the part of farmers about the use of fertilizers. African farmers implement all kinds of complex systems of multiple cropping and rotations of numerous crops. Decisions about how much fertilizer to use, and where and how to apply it, become a very complicated issue.

The fifth barrier to increased fertilizer use is lack of sufficient distribution systems for modern fertilizers that would facilitate delivery of input supplies to the farmers in a timely manner. The sixth barrier is lack of appropriate fertilizer mixes for local conditions. The seventh is lack of credit, from the small farmer to the retailer and the wholesaler in the entire fertilizer distribution system. The eighth barrier is lack of foreign exchange for importers to acquire adequate and appropriate supplies. The ninth barrier is lack of adequate research and extension systems to generate knowledge about fertilizer use and to diffuse that knowledge to the farm population.

The tenth and final barrier is an inadequate world transportation and communication infrastructure to reach distant areas and to ensure timely delivery. This issue is very neglected. The physical infrastructure that Americans take for granted is just not there. Consequently, when looking at the costs of getting fertilizer to the farms and getting the product back out, there are serious problems and escalating costs. Ultimately, the question boils down to whether government wants to use fertilizer subsidies to offset some of those kinds of costs.

Policy Recommendations

We suggest eleven policy recommendations for reducing and eliminating these ten barriers. [6] The first should not be surprising: trade and exchange rate policies are still wrong in most African countries, even though they underwent structural adjustment reforms and programs in the 1980s. Looking at their price, relative to product price at the port, fertilizers are still very unprofitable -- even at the port. Exchange rates are the most important price of the economy. If government doesn't get them right, it's not going to be able to do much about the profitability of fertilizer.

In addition, Africa still has rather large export taxes. Africa has specialized in export taxes that limit their own farmers' access to international markets. This drives domestic prices down to a very low level. Until governments begin to get some of these policies right, little other progress can be made. Trying to offset this with subsidies becomes a costly process, and leads to questions about obtainability. How long can we continue to provide those kinds of subsidies?

Second, present policy trends towards the privatization of the economy should be continued. It is imperative that a private distribution sector for fertilizer should be developed and that government withdraw from this activity. So much of the fertilizer industry in the public sector is filled with people who have no knowledge of agriculture or farming or fertilizer. In addition, the public sector has often been dull and slow and unresponsive.

Third, while little can be done about unstable weather, a great deal can be done about unstable policy. Out of unstable monetary and fiscal policies one gets unstable exchange rates. This leads to price uncertainty.

Fourth, expanded research efforts are needed to better understand semi-arid soils and to solve the very specific problems caused by lack of knowledge of local responses to the application of fertilizer. Similarly, expansion of extension efforts is needed in most semi-arid African countries, to help farmers learn new production practices and more economic use of their resources. Some international agricultural research centers (IARCs) are dominated by agronomists and physical scientists, but research on soils often ends up far down on the list of priorities. The truth of the matter is, very little is known about soils in most places in the world. We tend to think that increased agricultural output comes from the introduction of improved varieties. But underdevelopment can be caused by a soil problem and the solution can be a technological innovation produced by soil scientists who know the local soils. This is very applicable to large areas of Africa.

Fifth recommendation: An efficient distribution system for fertilizer will emerge only if the government withdraws from the sector and the use of fertilizer becomes profitable. Thus, government parastatals that occupy space in the fertilizer distribution system should be phased out quickly and macro-economic policies put in place to make agricultural production profitable. There is also a whole set of issues related to educating people in the private distribution sector, and setting up a strong extension program among fertilizer distributors so that they know something about fertilizer values. In the process they can learn about the risks and uncertainties involved in farming.

Sixth recommendation: It is difficult to generalize about fertilizer mixes. Proper mixtures vary enormously from country to country and from commodity to commodity. The only general recommendation would be that preference should be given to high concentration materials, largely because of the high transportation costs of fertilizer. Government can lower the transportation costs with high concentration materials. But fertilizer mixes still must reflect their local nutrition deficiencies and their commodities.

The seventh recommendation involves imperfectly performing credit markets, which are a major issue in Africa and other parts of the developing world. There is hardly any place in Africa with efficient financial intermediaries. Instead, state-controlled banks take money appropriated by the government and channel it into the financial system. Distribution is not always done equitably or appropriately. Major reforms in the banking system are needed, reforms that create financial intermediaries and institutions to mobilize savings and make it available to farmers. The best institutions are cooperatives and credit unions that mobilize savings from local farmers and then provide a mechanism for reinvesting it. To do something similar for the fertilizer distribution sector is more complicated. It requires examining the barriers and constraints that the fertilizer distributors face. They often cannot get access to credit either. So again, there is another whole set of institutional innovations badly needed.

The eighth recommendation focuses on how to get more realistic exchange rates. Government first needs to get trade policy right. It needs to get monetary and fiscal policy at least stabilized, so that they become neutral. With a flexible exchange rate, that is probably as good as it can be. Government is not going to eliminate all of the instability generated from the

foreign exchange markets. But if it neutralizes fiscal and monetary policy, and gets trade policy at least uniform across sectors, it can do a lot to eliminate exchange rate distortions. At the same time, it will stabilize this most important macro price.

The ninth recommendation concerns lack of infrastructure in Africa. One of the tragedies of the developing countries is that when the World Bank became heavily involved in stabilizing macro prices and policy reform, it turned away from longer term investments in physical infrastructure. Consequently, the highway, railroad, and communication sectors in Africa are really non-existent. Africa cannot get very far until it has more physical infrastructure. It has a long way to go.

Tenth, more long-term investment in agricultural research and extension systems is also recommended. The stock of location-specific knowledge about agriculture in African countries is very, very limited.

Finally, one can hardly talk about fertilizer or fertilizer policy in Africa without talking about subsidies and the enormous pressure on African governments to provide subsidies. Norman Borlaug feels that to diffuse various improvements, Africa has to have more fertilizer use and the only way to promote fertilizer use is to subsidize it. Part of the problem, however, is that fertilizer subsidies have not been supplemented by government investments in infrastructure, institutions, and policies that *permanently r*educe farm level fertilizer prices (e.g., reducing transportation costs and increasing efficiency in the input and output markets). It is both more equitable and efficient to use scarce development resources to reduce or eliminate these constraints to the wider use of fertilizer. Fertilizer subsidies should be conditioned on investments that reduce the structural impediments to increased fertilizer use in the future.

At the same time, there is a certain degree of ambivalence on the whole subsidy issue. Eventually the question comes up, "what are the tradeoffs"? If government uses its scarce development resources to subsidize fertilizer in the short run, it has to be at the expense of longer term investments that eventually would lower fertilizer costs. What we as economists can contribute to this debate is to look carefully at the tradeoffs and estimate just how much long-term physical infrastructure versus how much of the domestic fertilizer industry can and should government subsidize. How much agricultural research can government provide if it is also subsidizing short-term fertilizer benefits that nobody would pay for privately?

Notes

1. Tomich et al. 1995: pp 255-258.
2. Sanchez et al. 1997. Smaling (1993) has estimated the depletion rates of soil nutrients as 22 kg/ha/yr for nitrogen (N), 2.5 kg/ha/yr for phosphorus (P), and 15 kg/ha/yr for potassium (K).
3. These soils are concentrated in central Africa.
4. Just and Schmitz 1982.
5. Ndayisenga and Schuh 1997.
6. Ndayisenga and Schuh 1997.

References

Just, Richard, and Andrew Schmitz. 1982. *Applied Welfare Economics and Public Policy.* Englewood Cliffs, N.J.: Prentice-Hall.

Ndayisenga, Fidele, and G. Edward Schuh. 1997. Fertilizer Policy in sub-Saharan Africa: Recurring Issues and Recommendations. ACE Agricultural Policy Series 1. Minneapolis: Humphrey Institute of Public Affairs.

Sanchez, P., A.M. Izac, R. Buresh, K. Shepherd, M. Soule, U. Mokwunye, C. Palm, P. Woomer, and C. Nderitu. 1997. Soil Fertility Replenishment in Africa as an Investment in Natural Resource Capital. In *Replenishing Soil Fertility in Africa,* R. Buresh and P. Sanchez, eds. Madison, WI: Soil Science Society of America Special Publication Number 51.

Smaling, Eric. 1993. An agroecological framework for integrating nutrient management, with special reference to Kenya. PhD Thesis, Agricultural University, Wageningen, Netherlands.

Tomich, T.P., Kilby, P., Johnston, B.F. Transforming Agrarian Economies. Ithaca, NY: Cornell University Press, 1995.

Reference Style: The following is the suggested format for referencing this article: Gladwin, Christina H., Alan Randall, Andrew Schmitz, and G. Edward Schuh. "Is Fertilizer a Public or Private Good in Africa? An Opinion Piece." African Studies Quarterly 6, no.1: [online] URL: http://web.africa.ufl.edu/asq/v6/v6i1a13.htm