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OPERATIONAL FEASIBILITY OF SMALLHOLDER INNOVATIONS:

AN ADMINISTRATIVE VOID IN DEVELOPMENT

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Operational Feasibility of Smallholder Innovations: An Administrative Void in Development

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Professor Emeritus, Colorado State University.

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Introduction

Most of the agronomic "innovations" developed and promoted for the poverty alleviation of smallholder producers are based on standard small plot research technology. These small plot agronomic techniques do an excellent job of determining the physical potential of an area, but say nothing about what it will take for farmers to extend the small plot results across the rest of the field, farm or smallholder community, in a sufficiently timely manner to take full advantage of the innovation. Typically this would be two or three weeks, beyond this the viability of most agronomic information becomes progressively less appropriate. Often these innovations are more labor intensive than the current indigenous practices. With the high degree of mechanization in developed countries, this is normally not a serious problem, just a manner of bigger and more sophisticated equipment. However, in developing countries with the greater reliance on manual labor this can be major problem that is often overlooked by the development community. Unfortunately, the default assumption is that it is not a problem and research results can be quickly turn over to extension for demonstration and training of farmers in the "new" improved technology, as knowledge is considered the only limiting factor even for poorly educated smallholder producers. Once they understood the benefits smallholder farmers will readily adopt the "new technology". However, the limited education is often interpreted as limited intelligence instead of limited opportunity, thus the extension education process may have to be repeated multiple times before being fully understood and appreciated. The problem is no one is seriously reviewing innovations for their operational feasibility. This has simply fallen through an administrative void in the development process.

Operational Feasibility

The operational feasibility refers to the availability of the operational resources needed to extend research results beyond the small plots on which they were developed and for which all the operational requirements are minimal and easily accommodated. In addition, the operational feasibility would include any rational compromises farmers make in adjusting the technology to the limited operational resources available to them. For most smallholder communities, particularly in Africa, the primary operational resource is labor. However, it would also include access to labor substitutes such mechanization and possible animal traction. The underlying question here is how much of the operational requirements for extending research results in compliance with recommendations are fully discretionary to the smallholder farmers, and how often are they obligated to respond to events well beyond their control. Also, many of the operational resources are mobile resources that move through a community and have to be analyzed on a whole community basis instead of individual family farm basis, the normal economic analytical unit for smallholders.

The Administrative Void

The question is "who within any given agriculture development project for the poverty alleviation of smallholder producers is or should be responsible for evaluating the operational feasibility of an innovation"? Should it be agronomists, economists or sociologists? The first thought is often agronomists. However, they are applied biologists and operational resources such as labor and access to mechanization are more associated with the social sciences. Economists, as part of an overall cost benefit analysis, will often determine the operational needs, such as 300 person hours to manually cultivate a hectare of land, or 60 person days to transplant a hectare of rice. However, economists will normally not determine where all this labor will come from, just assuming if the farmers were serious

they could hire the extra labor, and it is readily available, if the price is right. Perhaps of greater importance is "what are the rational compromises farmers make when labor or other operational resources are limited"? Thus the question remains who is or should be responsible to determine the operational feasibility of innovations and the rational compromises farmers should make when the operational resources are limited.

Limitations of Labor

Family Labor: While the availability of labor within smallholder communities is often assumed to be limitless, it can be highly restricted. Usually smallholder labor is considered family labor, but at times it can also be casual day labor. As family labor this is often considered as husband, wife and possible some adolescents' children being kept out of school to assist with the farm work. However, labor isn't just free, it has to be supported with a reasonable diet over and above what is needed for basic metabolism. For a complete day of agronomic field work the daily diet needs to be in excess of 4000 kcal[i]. This can represent a substantial amount of calorie rich food independent of other dietary needs for a healthy balanced diet (Fig. 1). This 4000 kcal/day is rarely available to most smallholders. The limited data available on caloric intake for smallholders indicates smallholder farmers more typically have a daily caloric intake closer to 2000 kcal, marginally meeting basic metabolism (Table 1) with limited energy for diligent agronomic field work.



Fig. 1. 4000 Kcal for different staple foods produced & consumed by smallholders farmers.

Table 1. Kcal/Day Available to Smallholders

Location*	Kcals*	Working Hours**
Ghana	2,930	4.2
Bangladesh	2,480	2.1
Tanzania	2,140	0.5
Zambia	1,880	Not Able to Work
Kerala, India	2,010	0.0

*Source: http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8376.pdf

** (Kcal – 2000)/220



Fig. 2 Typical eight week spread in timing in smallholder community. Here you can see unplowed fields, plowed fields, rice nurseries, transplanting and post transplanting recovery.

This limited 2000 kcal/day diet is consistent with the subsistence stock farmers retain after harvest of approximately 150 kg/maize per adult or comparable amounts of other staples such as rice, wheat, plantains, cassava, etc. This limited caloric energy can severely restrict the work day to a few diligent hours, perhaps more when pacing their energy, but with reduced hourly output. Asking or expecting people to work in excess of their caloric intake can only be done to the determent of their health, and losing weight is not a healthy option for most smallholder farmers. Since domestic chores take priority over field work, this will also limit the time and caloric energy available for a spouse to assist a husband in the field. Thus, if it takes 300 person hours to manually cultivate a hectare of land and the farmer only has enough energy to work 3 or 4 hours a day, it will take over 70 days to do basic crop establishment. This is actually fairly typical of the observed time spread across smallholder communities[ii] (Fig 2). It also means considerable loss in potential yield with the delay, and opens the question in viewing an eight week spread in field work, does this represent (A) a few farmers getting all their field planted in a timely manner and other farmers lagging behind perhaps in need of some major extension education on technology. Or (B) does it represent most farmers getting a few of their field planted early, but being delayed with most fields, in which case the need is more to facilitate access to operational resources then additional education on technology, they fully understand and are practicing to the extend it is operationally feasible for them to do. In the first won't the lagging farmers be seriously risking their family food security? Isn't the second case the more reasonable to reduce food security risks?

Somehow the development community will readily acknowledge that smallholder farmers are poor and maybe hungry, but rarely factor that hunger as a major impediment to innovations they promote. This also raises the question if working only with hoes will it be possible for an entire smallholder community to dig itself out of poverty? With the limited work day, delays in basic crop establishment accompanied by declining potential yields, will the community ever be able to produce sufficient calories to meet food security demands? Perhaps a few members but only at the expense of other members as noted below. Also, with the current strong interest in improved nutrition mostly from promoting more diverse diets, is the caloric work requirements appropriately factored in? From the farmers perspective what has higher priority obtaining sufficient calories to undertake the day's work, or diversifying the diet for better overall health and nutrition? Unfortunately, producing more diverse nutrition crops normally result in producing less calories, resulting in less work energy, and increasing the overall food security at risk.

In addition, it must be recognized that most smallholders are involved in several farm enterprises including both crops and animals as well as the usually single enterprise promoted by development projects. Development projects typically concentrate on staple crops like rice or maize, or on specific cash crops like soybeans, and can be nearly oblivious of the other farm enterprises the farmers are involved with. Thus this limited labor needs to be rationalized over all the farm enterprises in what is an effort to ***"maximize the total return from all farm enterprises"*** rather than maximize the return to any individual enterprise. An example is the estimation of the daily activities for smallholder farmers in

Koffele, Ethiopia[iii]. This showed a full time involvement but nearly equally split between animal and crop husbandry. Since calories were limited, one has to consider the diligence of some of the effort, particularly the more energy intense crop husbandry. Thus when reviewing smallholder communities it might be best to consider that the farmers are maxed out with their limited operational capacity being a major drag on the physical potential as shown by both agronomic and animal production recommendations. Also, it might be good to review the stereo-typical view of the African male apparently loafing around the village in the afternoon, and consider that they are more likely in need for a hearty meal, having already exerted all the calories they had access to long before any visitors arrived in the village, than a motivational application to their posteriors. Their family's annual food security is at risk if they were truly loafing.

Casual Labor: One answer often considered is for the smallholder farmers to hire casual labor as needed. This is possible and one can often see gangs of laborers working together in a field well in excess of family labor, but this may need a more in-depth appraisal. The question is where, in a smallholder community, will the casual labor pool come from? Too often the casual labor pool is composed of other smallholder farmers who, for any of a variety reasons, are opting for a day of casual labor instead of working on their own land. Thus, while the hiring farmers will advance their crops, the hired farmers will degrade their crops, in what should be a zero sum effort for the total community. From a development perspective this needs to be discouraged and avoided. Since, while the development efforts tend to concentrate on a few cooperating farmers for demonstration purposes, it ultimately has to be concerned with poverty alleviation across the community, and thus increasing one farmers potential at the expense of another will be counter-productive.

Also it should be noted the casual work day is often limited to five hours. Nominally this is to allow the labors to have some time to return home and work their own land. However, it might allow for someone to work a double shift, but this is discouraging as someone who did a double shift would not be able to work the next day. Perhaps the dietary restrictions are impacting this.

Treadle Pump: An example of a labor intensive innovation that might have limited acceptance by smallholder producers would be the extensively promoted and distributed treadle pumps (Fig. 4). Treadle pumps are manually operated pumps that can typically lift water about two meter and irrigate about 1/6th ha adjacent to the source. But just how labor intensive are they? Don't they require in excess of 300 kcal/hr.? Thus how many hours can a person operate one with the limited diet mentioned above that only marginally meets basic metabolism needs. While thousands of treadle pump have been distributed through the developing world by various well intentioned NGOs, how many are actually in use compared to how many have been set aside or converted to small portable motorized pumps, perhaps the farmer selling a cow or two to pay for the pump. Would it be possible to make a spontaneous



Fig. 4. Treadle pump distributed by NGOs for local small scale irrigation. But requiring people with limited dietary calories to work hard, perhaps well in excess of available calories.

visit to farmers who have received a treadle pump and find them actively using them, or is it necessary for an advanced visit to let the farmers know to expect visitors interested in the treadle pump? It was noticed in Zambia, that while thousands of treadle pumps had been distributed by various NGOs, virtually none were being sold on the open market, which would reach communities not part of the NGO distribution. If this was a truly respected and appreciated technology the open market sales should be nearly equal to the NGO distributions[iv]. It is interesting to note that iDE (formerly IDE), one of the original proponents of treadle pumps and for which much of their original activity was exclusive working with treadle pumps, has back away from them in favor of more mechanized pumps, and is concentrating on other low cost irrigation ideas.

Rational Compromises

When farmers have limited operational resources for maximum production what are the rational compromises they should do in managing all their farm enterprises for maximum total returns? This very much depends on a careful look at the standard sigmoid production function of inputs vs. yield (Fig 4). This production function starts off slow, raises rapidly in the middle, and then slows down as input level approached the maximum yield as normally specified in the recommendations. Often this become a question of which gives the most total return, quality or extent. Thus, the need is to operate in the middle of the curve where you get the most output for the input. That is, with a finite amount of labor farmers can manage half hectare at full recommendations or a full hectare at half the recommendation. Maximizing total returns will usually mean emphasis on extend instead of quality, and provide the maximum return for the farmers' labor. Aren't farmers more interested in return to labor rather than return to land, which is in contrast to agronomists, who tend to be more interested to returns to land. Such compromises in practices often emphasized in farmer training program would include:

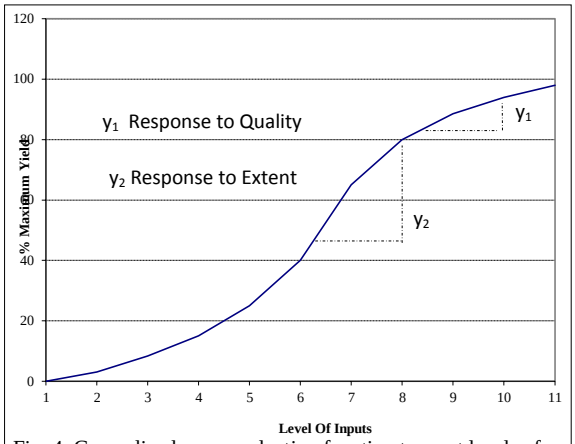


Fig. 4. Generalized crop production function to most levels of inputs.

1. First and foremost will be the time of planting (TOP). As labor becomes limited crop establishment will be delayed and this will be non-discretionary on the part of the farmer. As mentioned earlier, the usual expectation is for crop establishment to be spread over two or at most three weeks. The reality is that it will extend up to eight weeks, with declining yield potential with each day's delay (Fig. 1). Also, for rain fed areas with a typical six month rainy season, by the end of eight weeks the projected crop maturity would be beyond the projected end of the rains. Perhaps the typical 1.5 ha smallholder farm size is more determined by the limited family labor, than the availability of land for cultivation. Perhaps there is a need to take a closer look at the often repeated recommendation to plant earlier, and make certain it is within the discretionary control of the farmers and not a case of farmers following events beyond their control, or if completed with hired labor will be at the expense of neighbors' fields as mentioned above. Under such circumstances how valuable are all those TOP research studies that are an integral part of most national agronomic research programs?

Is it probable the farmers are already familiar with the importance of early planting and complying as best they can?

2. The second compromise would be in plant population particularly for any row or hill planted crops such as maize, beans, sunflowers, less so for broadcast crops like rice, wheat. This gets back to the sigmoid curve in which the best returns are to emphasis getting more land planted than maximizing the plant density when labor is short and full compliance not realistic.

3. Similar, row vs. random planting. Typically it takes 20% more time to layout and transplant rice in-line than to do it randomly. Thus it is hard to justify the row transplanting as planting is delayed, seedling are getting old, and potential yield declining. The greater need and total yield is to get as much area planted as soon as possible.

4. Perhaps less noticeable but equally important would be the quality of the weeding and other mid-season crop management practices. This will again come back to the maximizing returns from emphasis on extent instead of quality. But it will suppress the potential yields and quality and may explain why smallholders have difficulty meeting the international quality standards for cash crops like Cheetah Paprika Ltd. programs for smallholders in Zambia and Malawi.

5. On the animal side the emphasis on cut and carry fodder is basically a non-starter, as the extra time taken to cut and carry fodder comes directly from the labor needed for crop management, much easier to simple hobble the animals in the communal grazing area to eat what they can and recollect them at the end of the day.

Farmers' Knowledge

One can only image if the result of all these operationally imposed compromises is the farmers have actually optimized the recommendations they are being repeatedly trained in, to the limited operational resources available to them. How is it possible to separate "lack of knowledge" from "lack of operational resources"? This then leads to the question of how knowledgeable are smallholder farmers about the recommendations promoted for their benefit even when unable to adopt them. After all despite their most likely limited education they are experienced practitioners in the art of farming. The "art of farming" being adjusting the science of farming to their specific situation, including integrating their limited labor across all farm enterprises. The answer maybe that they are reasonably well informed and the failure to comply is a very rational decision on their part. The example come from a recent Farm-to-Farmer assignment to "teach" farmers the importance of row seeding wheat in Ethiopia[v]. However, interviews with groups of 20 farmers quickly indicated the farmer were very familiar with process of row seeding and could easily tell the yield benefit as well as the extra time required. Thus the decision to row seed or not would have to be considered as rational. Most likely the row seeding would be concentrated on the earlier planted fields, but as crop establishment became delayed the shift would go to broadcast sowing to allow more land be sown as potential yields declined. It would be interesting to see how other pre-training interviews would show how knowledgeable farmers already are about what they being trained for, and how rational the compromises made, as well as how much the farmer training ends up badgering the farmers on what they already have a reasonable good knowledge of.

Drudgery Relief - Mechanization

Asia Success: The net result of the need to look at the operational feasibility of innovations is to avoid labor intensive innovations and concentrate on drudgery relief. This quickly translates into facilitating smallholder access to mechanization that will diminish the drudgery of smallholder farming and expedites the basic crop establishment so they could take better advantage of the technology being developed and promoted for their benefit. In paddy rice Asia this was done some 40 years ago, concurrent with International Rice Research Institute's (IRRI) major advancement in rice technology when farmers, without the assistance of the development community, shifted from water buffalo to individually owed power tillers (Fig. 5). According to one farmer in NE Thailand the shift to power tillers more than halved his rice establishment time, and with his rice under control he spontaneously diversify into poultry suspended over a fish pond for a duel farm enterprise (Fig 6) with no outside assistance from the development community.



Fig. 5. Power tiller that replaced the water buffalo some 40 years ago and expedited the crop establishment contributing to the success of the green revolution in Asia.



Fig. 6. Rice farmer diversified into poultry suspended over a fish pond in NE Thailand. The result of shifting from water buffalo to power tiller for rice cultivation.

Unfortunately, since the development community was not involved in the shift to power tillers, it has tended to completely overlook its contribution to the success of the "green revolutions" in Asia and attributes the success solely to IRRI's technical advances. That leaves the question, if the farmers had not made the concurrent shift to power tillers and continue to rely on water buffalo, how much of the rice crop would have been planted in sufficiently timely manner to take full advantage of IRRI's technology advances. Unfortunately, since this shift is now 40 + years ago, representing one entire generation of adult rice farmers, few can recall the days of the water buffalo, it might be nearly impossible to retroactively do the analysis of the impact. While IRRI deserves full credit for the technical advancements in rice production, the farmers deserve equal credit for getting the crop planted in time to take full advantage of the technical advancements. Now which represents the greater contribution? Meanwhile, in irrigated rice production in Thailand rice mechanization has advanced to include small contract combining able to work in one rai ($1/6^{th}$ ha) fields (Fig. 7). This has further increased the intensity from two rice crops a year to five crops in two years,



Fig. 7. Small combine commonly used in irrigated rice in Thailand that allow for increased rice cropping intensity.

with good potential for increasing the recovered yield and grain quality from cleaner threshing and reduced foreign material contaminating the grain, both are normally possible with good mechanical harvesting, and usually more than cover the cost of contracted mechanization.



Fig. 8. Typical 60 to 80 hp tractors used by private service providers for contract land preparation slowly becoming available in many countries in Africa.

Africa Initiative: In Africa the power tillers are slowly coming into the paddy areas, but this is a very limited area. Most of African smallholder agriculture is upland for which the mechanization needs to emphasis access in contrast to ownership to 60 to 80 hp 4-wheel tractors pulling 3-bottom disc plows (Fig. 8). Such tractors are more than an individual smallholder can afford or justify. Thus the emphasis has to be on access to tractors for basic land preparation, and perhaps threshing after harvest. However, this has to be done with extreme care to avoid some of the historical problems. That is tractors, like all kinds of machinery, have to be individually owned and operated and not any form of communal ownership, such as a government mechanization unit or farmer cooperative ownership. Communal ownership of tractors was fully discredited over 40 years ago and need not be reconsidered, at least by the development effort. Under any form of communal ownership most tractors will be surveyed out of service with less than half the 10,000 designed operating hours. Just visit any Agriculture Development Project (ADP) for any state in Nigeria, examine the line-up of non-operational tractors, and look at the odometer, if in fact it has not been vandalized so the operators cannot be carefully monitored and are free to provide some off the books services in exchange for some cash gratuities (Fig 9). There is also the high probably of some irregular activity under communal ownership as appears to be the case in Ethiopia where farmers were complaining of having to make informal access fee payments in addition to established cost of the service. This occurred for both - land preparation and combining with high quality Class equipment from Europe[vi].



Fig. 9. The line-up of out of service tractors at ADP in Nigeria. Most have less than half the designed operation hours.

Such contract mechanization is slowly becoming available throughout Africa and in many countries the farmers can quickly quote the price of such services. The need for some innovative approach that will allow individual members of smallholder communities to obtain tractors, perhaps used and reconditioned ones[vii]. They could than drift out of direct farming to become private service providers for their community. This may require some major modification of micro-finance to allow first the capital cost of the tractor for which the tractor could serve as the collateral, and if a used reconditioned tractor provide most of the collateral. In addition an operational loan that would allow the owners/operators to provide some of their services on credit for an in-kind payment after harvest. The operational loan would have to be unsecured. Would this be possible? It should also be noted the through much of the Middle East from Egypt to Pakistan most of the land preparation is done through contract tillage with

private service providers, often working with tractors with considerable more operating hours than design specifications of 10,000 hrs.

As happened in Asia the development community is not getting involved, and perhaps missing a great opportunity to assist smallholder farmers. Instead the development community is taking note of the well-publicized success of the technology driven green revolutions in Asia overlooking the role of the shift to power tillers, and again emphasis that Africa's development will be technology driven. Will again overlooking the operational needs limit the rate of development in rural Africa.

A final note on contract mechanization with owner/operator private service providers, they will be free to undertake whatever demand is needed in a community even if not the promoted crop. However, this needs to be accepted and appreciated as the general expediting of crop establishment will ultimately favor all crops including the promoted crops.

Animal Traction: While thinking of mechanization a note of caution concerning animal traction (Fig. 10). While this may look like an appropriate progression between manual operations and contract mechanization, it must also be recognized that animal traction can be deceptively expensive. That is mostly in terms of the daily labor needed to maintain them rather used on not used. This can be easily seen in the earlier reference on the estimated work day for Ethiopia in which half the time was spent taking care of animals and this was at the expense of working in the field[viii]. Also, animals do require land be set aside for grazing and this is usually done as communal grazing lands for which the ***Tragedy of the Commons***[ix] will apply to the general determent of the animals. It also has to be noted that when possible and reliable mechanization is available, farmers very quickly opt for the contract mechanization, even under informal credit conditions of an estimate 100% seasonal interest rates and in-kind payment at harvest[x] or as mentioned by an Ethiopia farmer claiming he would sell some of his animals and convert land from pasture to crops[xi]. Also, note the animal powered sakia for low lifting irrigation water in Egypt have been completely replaced by Indian manufacture Lister/Petter single cylinder diesel pumps. Finally for development projects to promote animal traction, do the animals need to be in donor country acceptable physical condition to be used, and how often are the animals coming out of a weight losing dry season and surviving on communal grazing lands be in sufficiently good condition to work, or in home country would this be considered animal cruelty.



Fig. 10. Animal used for draft power in Ethiopia. Is this really appropriate or too expensive and are the animals in sufficiently good condition to be worked or without be cruelty to animals.

Summary & Conclusions

The ultimate question is until someone within the development community take a serious look at the operational feasibility of innovations for smallholder benefits, will the poverty alleviation effort continue doing exceptional research on the physical potential, with extension make beautiful demonstration, and excellent training programs for farmers, but with only limited acceptance by the farmer beneficiaries. Is this acceptable? It will generally appease the donors, who often rely on training numbers to evaluate program success, give them a good feeling of have accomplished something, but in reality there will be

little change at the farm level. After all the farmers are poorly education and thus have difficulty learning, or is poor education equated to poor intellect, rather than limited opportunity, so the farmers need to be trained or perhaps badgered again and again on material they are already reasonable aware of, but don't have the means to take full advantage of.

Once the operational feasibility of innovations is evaluated will that change development effort focus to concentrate on facilitating access to operational resources that will expedite all farming activity in a smallholder community and provide a better opportunity for farmers to take full advantage of the research results intended for their benefit. Will such a shift enhance the overall prospects for sustainable poverty alleviation of smallholder producers? Thus the question remain who within a development project is or should be responsible for evaluating the operational feasibility of innovations and the rational compromises the farmers make in applying any innovations to their specific situation. Please someone fill this administrative void!!

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[i] http://smallholderagriculture.agsci.colostate.edu/calorie-energy-balance-risk-averse-or-hunger-exhasution/
[ii] http://smallholderagriculture.agsci.colostate.edu/basic-premise-was-something-overlooked/
[iii] http://smallholderagriculture.agsci.colostate.edu/ethiopia-diet-analysis/
[iv] http://webdoc.agsci.colostate.edu/smallholderagriculture/SMC-RLT-Report.pdf
[v] http://webdoc.agsci.colostate.edu/smallholderagriculture/ET09Report.pdf
[vi] http://webdoc.agsci.colostate.edu/smallholderagriculture/ET09Report.pdf
[vii] http://smallholderagriculture.agsci.colostate.edu/most-effective-project-enhancing-access-to-contract-mechanization-via-reconditioned-used-tractors/
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[x] http://smallholderagriculture.agsci.colostate.edu/cost-of-credit-informal-vs-institutional-credit/
[xi] http://webdoc.agsci.colostate.edu/smallholderagriculture/ET09Report.pdf