Mid-term Report: Conditions and Processes Shaping Research and Technology Transfer for Agriculture in Mali

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SM-CRSP Project: *Decision Aids for Integrated Nutrient Management*

This report describes observations and data collected in Mali during the third year of the SM-CRSP project. It is based on work of a travel team who visited Mali in June 1999 and on the follow-up activities of colleagues in Mali who have developed additional information. The team traveled extensively through Southern Mali to observe the diversity of social context and landscape and to meet with leaders of research and extension field offices and farmer organizations. This paper provides a follow-up on themes of social and economic factors relevant to the design and use of decision support systems for soil management in Mali. It advances the socio-economic analysis begun with the baseline assessment (Doumbia, et.al., 1998) and supplements the team's trip report (Hoesner, Hons and Smith, 1999).

The objectives of the mid-term review were to:

1. follow-up on findings and questions raised in the baseline assessment,
2. search government reports and archives for information on nutrient management,
3. survey local prices for factor inputs and product outputs,
4. interview project participants and beneficiaries about processes and impacts, and
5. monitor progress of the project in the socio-economic context of rural Mali.

The social and economic factors affecting nutrient management

The baseline assessment (Doumbia, et.al., 1998) was successful in helping to reveal local practices of soil management and the perceived problems and needs of target beneficiaries. But the baseline assessment also exposed the gaps in existing information and raised questions about farmer practices and market mechanisms. In 1998, government, industry, and farmer organizations were doing the best they could without analytical tools or ready access to technical information. Basic market-making information (e.g. price series for factors and products) was not available to researchers or farmers. The conditions that were observed at the time of the baseline study remain substantially unchanged at the time of this two-year follow-up study. Because of limitations in the capacities of local institutions to reach out to farmers and provide timely technical assistance and clear market signals, farmers are slow to change their farming systems and they continue to rely on traditional practices which are low-input and low-yield. However, improved contacts with village leaders and small-scale, on-farm trials are helping to prepare the way for future change. The descriptive information contained in this paper will help project developers anticipate the range and magnitude of the uncertainties affecting farmers based on information from the farmers themselves. It is another contribution intended to facilitate the adoption and use of innovative decision support system (DSS) technology in Mali as a means to promote more productive and sustainable agricultural practices as a foundation for sustained economic and social development.

The baseline study produced a rather unexpected finding that nine of 55 farmers (16%) reported use of cereal complex fertilizer 15-15-15 and 5 of 55 farmers (9.1%) report use of urea (46% N) for millet production. These results were surprising because they were inconsistent with the experience of local researchers and because all economic analyses indicate unfavorable ratios of unit prices for millet per unit price of cereal complex fertilizer and urea. Follow-up discussions with selected farmers were planned and conducted to clarify the survey findings and probe for explanations of the results. Table 1 shows that millet farmers using chemical fertilizers were found distributed across sample villages. They included both landowners and farmers using lands of others. The farmers using chemical fertilizers reported having production areas ranging from 4 to 24 hectares. Different application rates and methods were observed. The application rates were found not to be uniform, but rather treatments applied to "hot spots" (areas of pronounced nutrient and/or water stress). Farmers' explanations were that they sometimes were forced to invest in fertilizer because either they lacked sufficient quantities of farmyard manure for their crop needs or because they were aware that the poor quality of manure was insufficient to correct the nutrient deficiency. Fertilizer applications were also used to improve yield from very late planting. Use of urea typically was found to be one strategy farmers use to fight against *Striga*. In Table 2, we see that all the farmers using chemical fertilizer also used organic matter, other chemical inputs for pest control and intercropping consistent with traditional local practices.

Table 1. Descriptive information on the subset of millet farmers using chemical fertilizers.

		Land		Fertilizer			Supplementary Urea	
Farmer's Name	Village	Tenure	Area	Type	Dose*	Method	Dose	Method
			ha		kg ha^{-1}		kg ha^{-1}	
Bakary Coulibaly	Dilaba	Landowner	10.00	CC	100	localized	0	0
Mamadou Drago	Dougouba	Exploitant	10.00				75	broadcast
Bakary Djiré	Dougouba	Landowner	5.00	CC	75	localized	25	localized
Fousseini Diarra	Cinzana-Village	Landowner	4.00	CC	50	broadcast	0	0
Kassim Tangara	Cinzana-Village	Landowner	12.00	CC	100	broadcast	0	0
Sitapha Daou	Konogola	Landowner	6.50	CC	100	localized	0	0
Adama Keita	Konogola	Landowner	12.50	CC	100	localized	0	0
Lassina Samouga	Cinzana-Gare	Exploitant	6.00	CC	50	broadcast	0	0
Bakary Diarra	Konogola	Exploitant	24.00	CC	50	localized	50	localized
Abdoul Karim Koné	Konogola	Exploitant	6.00	CC	100	broadcast	50	broadcast

*Fertilizer dose was reported by farmers as the number of 50 kg bags used per ha. However, the application treatment of "hot spots" or larger areas where, for example, the planting was late. Therefore, the dose rate should not be interpreted as uniform across the production area. CC= cereal complex fertilizer, 15-15-15.

Table 2. Organic matter, other inputs and intercropping practices within the subset of farmers using chemical fertilizers.

		Organic			Other	Inter-
Farmer's Name	Village	Inputs	Dose	Method	Inputs	cropping
			kg ha^{-1}			
Bakary Coulibaly	Dilaba	manure	96	placement	seed treatment	cowpea
Mamadou Drago	Dougouba	manure	?	placement	seed treatment	cowpea
Bakary Djiré	Dougouba	manure	15	placement	insecticides	cowpea
Fousseini Diarra	Cinzana-Village	manure	15	broadcast	seed treatment	cowpea
Kassim Tangara	Cinzana-Village	manure	30	broadcast	seed treatment	cowpea
Sitapha Daou	Konogola	manure	50	broadcast	seed treatment	cowpea
Adama Keita	Konogola	manure	50	broadcast	seed treatment	cowpea
Lassina Samouga	Cinzana-Gare	manure	10	broadcast	seed treatment	pulse
Bakary Diarra	Konogola	manure	25	broadcast	seed treatment	pulse
Abdoul Karim Koné	Konogola	manure	50	broadcast	seed treatment	cowpea

Information extracted from government reports

Yields of the principle crops (in kg/ha) show little improvement over the period 1985 to 1997 (Table 3). It is unfortunate that data for the more recent years 1998 and 1999 are not yet available. Millet, sorghum and corn yields vary substantially from year to year (probably due to rainfall) but with no clear trend. Rice yields have shown consistent improvement due principally to improved seed. Cotton yields are trending lower perhaps due to reductions in application of fertilizer and expansion of production on less suitable lands. An alternative explanation for declining cotton yields is the recent introduction of a lower yielding but high quality cotton variety. Again, the available data are insufficient to fully account for the observed variations in average yields in recent years.

Table 4 provides a breakdown of the actual yields and target yields for major crops by production area in Mali. It is evident from the table values that yields for millet and sorghum vary across production areas. Achieving the target yield levels in 2005 will require systematic institutional interventions to promote nutrient management strategies tailored to fit the different circumstances of soil–water-plant relationships. Up to date monitoring and evaluation of crop production will also be needed, so that under-performing areas can be targeted for special help. At the present time there is too little information available to assess progress toward national production goals for the major crops.

Table 3. National average yields of selected crops.

Year	Millet	Sorghum	Corn	Rice	Cotton
	--------------------------------------	kg ha^{-1}	--------------------------------------		
1985	557	955	1136	662	1208
1986	1036	1123	1285	1157	1200
1987	980	1112	1655	1181	1328
1988	887	1045	1512	1451	1330
1989	836	990	1501	1244	1315
1990	777	944	1291	1463	1227
1991	607	657	1157	1436	1344
1992	828	1090	1382	1775	1266
1993	549	645	1005	1758	1296
1994	426	753	1103	1735	1199
1995	639	764	1135	1652	1088
1996	550	835	1288	1529	1207
1997	790	999	1598	1894	1075

Source: data collected from the DNSI (Direction Nationale de la Statistique et de l'Informatique) files from 1980 to 1998.

Table 4. Major crops grown in Mali and their actual and target yields by production area (IER, 1995).

Crop	Actual Yield[a]	Target Yield[b]	Production Area
	-------------------- kg ha^{-1}	--------------------	
Millet/Sorghum	930	1200	South
Millet/Sorghum	735	825	Center
Sorghum	600	750	North
Maize	2000	2745	South
Maize	1300	1785	South-West
Irrigated rice	4500	6000	Anywhere
Irrigated rice	1400	2500	Anywhere
Cowpea	50	150	Anywhere
Peanut	890	1480	Anywhere
Cotton	1250	1500	South

[a] year 1995
[b] year 2005

Cultivated areas for millet, sorghum, and corn have declined in recent years while cultivation areas have expanded for rice and cotton (Table 5). Based on these data, the Government is failing in its five-year targets for increased millet productivity and increased area of millet production. Increased productivity and area of rice production offset some of the declines in millet, sorghum and corn, but rice cultivation is not an option for many farmers. Food security in Mali cannot be maintained in a context of a growing population without a technical transformation of production systems for millet and sorghum.

Table 5. Total cultivated areas in Mali for selected crops.

Year	Millet	Sorghum	Corn	Rice	Cotton
	---------------------------------- hectares ----------------------------------				
1985	909571	387182	89310	165176	119399
1986	840688	424874	109042	184833	145927
1987	821877	417692	128984	190597	151812
1988	781763	491223	142902	163079	149526
1989	1195898	679114	142902	231262	189335
1990	1083091	774470	174612	230919	188090
1991	1213367	808719	169958	196631	205331
1992	1074722	706583	185749	263019	215266
1993	1060515	933834	191563	233194	246472
1994	1345855	1031131	256925	246465	200368
1995	1403831	876610	284208	284003	269362
1996	1285540	851006	205364	302669	336224
1997	935655	540668	181324	324152	420359

Source: data collected from the DNSI (Direction Nationale de la Statistique et de l'Informatique) files from 1980 to 1998.

Product prices at the producer level (at harvest period) have shown relative stability throughout the period 1980-1996 (Table 6). Some year-to-year variation is expected reflecting farming conditions and the holdover stocks of previous years. Again it is unfortunate that in the year 2000, national average product prices by commodity are not yet available for the years 1997-99. However, in an effort to compare the available product price data with the current market conditions in the Cinzana area, we surveyed producer prices for millet, sorghum, peanut and cowpea for the harvest period of 1999. We found product prices for millet (50 CFA/kg) and sorghum (60CFA/kg) were significantly below the national average producer prices of 1997 (the latest available national prices). Our data suggest millet and sorghum producers are suffering the lowest producer price levels in the last six years.

Table 6. National average product prices at the producer level, at harvest period (Nov. – Jan.).

Year	Millet	Sorghum	Corn	Rice	Cotton
	----------------------------------	CFA kg^{-1}	----------------------------------		
1980	25	25	25	31	55
1981	35	35	35	38	55
1982	43	43	45	50	65
1983	45	45	48	55	65
1984	50	50	50	60	75
1985	66	48	65	65	198
1986	51	48	46	70	123
1987	56	50	33	89	158
1988	49	46	34	81	140
1989	41	41	34	73	147
1990	34	34	29	84	175
1991	54	49	43	87	154
1992	47	42	35	56	141
1993	57	52	41	61	141
1994	47	42	36	79	294
1995	63	62	58	94	361
1996	98	99	83	117	307
1997	85	87	75	109	267
1998	105	98	80	123	288
1999**	50	60			

Source: data collected from the DNSI (Direction Nationale de la Statistique et de l'Informatique) files from 1980 to 1998.

**Average producer prices, 1999 Cinzana survey.

Interpretation of the nominal prices presented in Table 6, must take into account the devaluation of the West African currency (FCFA) on January 12, 1994. The devaluation was designed to adjust the currency closer to underlying market values and thereby improve market efficiencies. The large and sudden change in the currency rate produced a significant reaction among farmers who were affected by increased production costs (especially for imported inputs, such as chemical fertilizer) and lagging producer prices for millet and sorghum (consumed or sold predominantly in local markets). While the currency adjustment will undoubtedly contribute to economic efficiencies in the long run, poor farmers have absorbed the short-term transition costs. A full analysis of the consequences for food security and environmental nutrient balances is not available, but existing data and local experts report that rice and cotton farmers are coping with the currency devaluation by decreasing rates of input application while increasing areas under cultivation (Table 4). Millet and corn areas increased in 1994 and 1995 but were down in 1996 and 1997. Sorghum area was up in 1994 but has trended down in the most recent years. The effect of the 50% decrease in the value of the CFA franc is most clearly evident in the change of the nominal price of cotton from 141 in 1993 to 294 in 1994. Because cotton production is an export-oriented activity, it is most exposed to currency values (Table 6).

Another price policy reform in 1998 eliminated the export tax on live animals leaving Mali. The purpose was to remove a competitive barrier for export oriented production of live animals and, as a by-product, increase production of manure for domestic use. The impact of this policy on farmers, consumers prices, food security or nutrient balances? It seems that no study is yet available to assess this impact.

Efforts were made to track the down-stream, value-added activities of processing, packaging, transport, storage, but unfortunately DNSI does not have such information. However, based on local surveys as reported below, much of the total production of millet never enters the marketplace, but rather is stored and processed within the household. Surplus millet is sold or bartered in the local markets.

The Minister of Agriculture (Rural Development), has access to additional information on quantities and application rates of manure/compost and commercial fertilizer, but this information is considered to be very sensitive policy information and is confidential (may not be cited). The failure to share this information illustrates the closed process of policy formulation in Mali.

Information from marketing agents

Seasonal changes in the unit prices of selected inputs and crops for 1999 are summarized in Table 7. Chemical fertilizer prices are seen to be stable throughout the year. Unit labor costs are highest in the period of land preparation. Analysis and recommendations for the timing of manure and compost application need to take into account both the synchrony of soil-plant nutrient exchange and the variable costs of farm labor. Product prices for millet were halved from 100CFA in the preharvest to 50CFA in the harvest period of 1999. Such variation in the price of this consumer staple (millet) accounts for the efforts by farmers themselves to store grains for future consumption and sale.

Table 7. Change in the price in the Cinzana area during the 1999 growing season.

Input or Crop	May – July (pre-season)	Aug. – Oct. (pre-harvest)	Dec. – Jan. (harvest)	Feb. - April (post harvest)
	------------------------------ F CFA ------------------------------			
Farm labor (day^{-1})	1000	850	800	750
Fertilizers (kg^{-1})				
Urea (46-0-00)*	200	200	200	200
DAP (18-46-0)*	220	220	220	220
Cereal blend (15-15-15)*	200	200	200	200
Crops (kg^{-1})				
Millet	70	100	50	60
Sorghum	80	110	60	70
Peanut	300	400	150	200
Cowpea	350	400	200	250

* (% N – P_2O_5 – K_2O)

Information from local sources and surveys

Fertilizer application rates vary by type of farmer. In particular, the rates of manure/compost application vary with the class of farmers as determined by ownership of animals, farm equipment, family labor, and other factors. Table 8 gives average application rates of manure/compost for the 3 classes of farmers (classes adopted by I.E.R.) and 2 cropping systems of Mali (Dembele et al., 1998). Clearly, the relatively wealthy farmers with more animals and equipment have the manure and means to haul the manure to the fields.

Table 8. Average application rates of manure/compost (kg ha^{-1}).

Farmer class	Village of Dilaba * (millet monoculture)	Village of M'Peresso (cotton cropping system)
	---------- kg manure/compost ha^{-1} ----------	
I (relatively wealthy farmers)	4000	5200
II (relatively poor farmers)	1000	2800
III (poor farmers)	1000	1500

*The village of Dilaba is located at about 9.6km from Cinzana and was included in our baseline survey.

Recent research on nutrient balances and the importance of manure and nutrient cycling

Below are some selected references of recent articles on national or regional nutrient balances and the importance of manure and nutrient cycling. It is significant that much of the research is based on local initiative and reflects the capacities of local research institutions International research partnerships bring added value to the research process in Mali.

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DUIVENBOODEN N. VAN.,1990. Sustainability of West African cropping system in terms of nutrient elements. A study for the 5th region of Mali. CABO, Wageningen, The Netherlands.

HOEFSLOOT B., VAN DER POL F. et ROELEVELD L., 1993. Jachères améliorées. Options pour le développement des systèmes de production rurale au Mali. Vol 2. IER/KIT, Bamako/Amesterdam, The Netherlands.

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SMALING E.M.A., STOORVOGEL J. J. et WINDMEIJER P. N., 1993. Calculating soil nutrient balances in Africa at different scales. II. District scale. Fertilizer Research 35:237-250.
VAN DER POL F., 1992. Soil mining. An unseen contributor to farm income in southern Mali. Bulletin 325. Royal Tropical Institute. Amsterdam. The Netherlands.
VAN DER POL, F and TRAORE B., 1993. Soil nutrient depletion by agricultural production In Southern Mali. Fertilizer Research 36:79-90.

Information obtained from interviews with project leaders, participants and beneficiaries

Through interviews with project leaders and participants we explored for cases and evidence that research on soil and nutrient balances have influenced on-farm practices, government programs or policies. Interviews also tried to generate input on how the research on nutrient management might be used in the future to influence or change development policies and programs. We also tried to identify references to any government policies effecting farm or consumer prices, food security or nutrient balances. Finally, we searched for examples where research staff had been called upon to provide critical information on soils to policy-making groups within the country. Did the information provided make a difference? In cases, where technical recommendations were not followed, what were the reasons and consequences?

The results of these interviews were disappointing. Few cases could be identified where research on soil and nutrient balances has influenced government programs/policies. At the national level, nutrient balances reported by IFDC have resulted in a huge donation of DAP and urea fertilizers by the Japanese government to Mali. This donation, referred to as KR2, was meant not only to “hold” the price of fertlizer, but also to increase application of fertilizers, thus improve nutrient balances. Again how nutrient balances have been affected is yet to be assessed. However, the KR2 fertilizers are being sold at the same price as the normal DAP by dealers all over the country.

At the village level, the IER research team has been using nutrient balances to help selected collaborating farmers appreciate more the magnitude of the nutrient mining of their fields. For example, our Dougouba farmer, Mr. Lassine Djire, had a negative balance of: -105.8 kg N/ha, -17 kg P/ha, -54 kg K/ha. After appropriate explanations and recommendation of management practices, the fertilizer requirement (urea, DAP, and bulk 15-15-15) to replace these nutriments were given to him. A similar approach was adopted with the Cinzana farmer, Mr. Saouty Toure.

Unfortunately, no case could be found where a research scientist or any agricultural agent had been called to provide critical information on soils to policy-making groups within the country. This result is not surprising, but it does illustrate the disconnect between research and policy-making in Mali. Researchers feel they have relevant technical knowledge and data on matters of agricultural policy and they express frustration that these technical findings are not considered in the normal process of policy formulation.

The above is consistent with the historical pattern (from the 60's to early 80's) where the institutional recommendations of IER failed to be adopted or followed by farmers because these recommendations were in most cases either not economically sound (such as fertilizer recommendation on millet/sorghum), or not socially acceptable (such as crop residue management), or not appropriately targeted to farmer classes (manure/compost management). The consequences or implications were the emergence of farming systems programs (Programme and Equipes SPGRN) to handle the social and economic aspects of promising technologies.

Institutional conditions/constraints

In the third-year review, a number of problems became apparent. It was discovered that the implementation of the core experimental trials was flawed in ways that compromised the integrity of the experimental design. The lessons derived from this unfortunate result, however, may prove to be most valuable to the U.S. and Mali partners. For all concerned, it was important to face the problem and consequences of the compromised designs and to commit to re-running the experiments in the next cycle. The episode clearly demonstrated that project performance requires full commitment to plans and project oversight. These were not errors we would expect from the very capable Mali team, if they were fully committed and attentive to field operations. However, difficult working conditions and financial insecurity (based on low wages) can degrade the performance of individuals and institutions that are otherwise very capable.

Field working conditions are difficult and compensation is low by international standards. Employee turnover is not a serious problem only because external opportunities are very competitive. However, employees expend considerable energy seeking training and alternative employment. Consultation, secondary employment, and such are important sources of supplementary income.

Post-graduate education and publication is seen as the best path to improving one's economic standing. The Mali team requested consideration for post-graduate research opportunities with opportunities for degree training, and they were clearly disappointed that degree training was not provided within the scope of the project.

Fruits of international collaboration

With regard to the SM-CRSP project, the collaboration with U.S. universities is very beneficial to IER in several ways such as:

- Technical backstopping in the design, implementation, and reporting of research activities
- Capacity building of IER through training and providing equipment such as computers and laboratory materials
- Providing to some scientists of IER opportunities for exchange visits and participation in international meetings
- Opportunities to conduct "side research" on subjects which may be seen as "basic research" and otherwise not allowed under normal funding of IER. These side research activities include aspects such as methods of soil analysis, and P fixation capacity of soils.

The collaboration between IER and SM-CRSP has included a transfer of technology of significant importance to soil management including composting of Tilemsi phosphate rock with manure or other source of organic matter. In fact 15 and 22 farmers, each surveyed during the initial baseline evaluation, will be involved during the 2000 growing season in the 2 components of this activity.

The LaboSEP of IER and its collaborators have been introducing the SM-CRSP model, NuMaSS by making on-farm testing (since the 1999 growing season) of the recommendations from this model. This testing has included demonstrations/explanations to farmers, extension agents, and research scientists. Based in part on these early trials, two types of problems are anticipated in the use of this model: (i) soil testing required for the farmers and (ii) the ability of extension agents to get all other data required to run the model. Other pertinent observations made by research collaborators in Mali are that the SM-CRSP model does not make recommendation for cotton and irrigated rice, the crops which use 94% of the fertilizers used in Mali (Kieft et al., 1994). Further, the SM-CRSP model does not currently include rock phosphates in its recommendation.

Conclusions

Change comes slowly in Mali, in part because the resources and technical support to sustain intensification of agriculture are not available to farmers. The project takes a realistic approach to soil nutrient management, using local organic matter (manure) in combination with small dosage of locally available chemical fertilizers.

Farmers, food processors and consumers would clearly benefit from development of market-oriented decision tools based on integration of relevant databases and information systems. Nutrient management strategies are sensitive to market prices. The aggregate price information presented in government reports suggests greater price stability than actually exists at the farm level. Farmers report seasonal variation and price manipulation in local markets. The decision support tool will effectively exploit the availability of market data generating estimates of economic returns.

For professional scientists, it is discouraging that their advice and studies are not given more consideration in policy-making. Research on nutrient management, particularly research on nutrient balance, should be used to bring to farmers and policy makers the magnitude of soil degradation. Nutrient balances can also be used to influence the involvement of the Government in sustainable agriculture such as investing in soil fertility recapitalization. In these matters innovative decision support technology may help elevate the quality and range of technical applications at the farm level and in agriculture sector policy formulation.

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