Report on the Survey of Fish-Rice Producers of Baguineda, Kati, Koulikoro, Mali concerning Technology, Costs and Revenues of the Joint Production System and Proposal for its Adaptation and Expansion to Irrigated Rice Producing Areas Throughout Mali

prepared by

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INTRODUCTION OF THE FISH-RICE JOINT PRODUCTION SYSTEM TO MALI

Wherever paddy rice has been grown with gravity-fed irrigation, some fish come in naturally with the irrigation water. In Asia, where paddy growing has developed over the centuries into a fine art, farmers have built on this naturally occurring phenomenon and have developed a system integrating growing paddy and growing fish in the same fields at the same time. Rice yields are not adversely affected by adding fish and fish yields can reach several tons per hectare. This joint production system is highly profitable for Asian farmers by giving two products for the price of one and reducing the amount of farm chemicals needed and hence their cost at the same time.

USAID recognized that this system might be applicable to large areas of the Office du Niger and other irrigation perimeters in Mali. It financed a research project carried out by the Ministry of Livestock and Fisheries (MEP-DNP)[1] with the support of the Oregon State University (OSU) and University of Shanghai Ocean (USO). To make best use of the time of researchers, the system was tested in Baguineda[2] just outside Bamako rather than in the Office du Niger region, where there are large areas better suited to this type of production. Soils in Baguineda are more porous than is desirable. However, considerations of proximity to the capital city and its international airport overruled optimal location for the trials.

Trials were on appropriately-sized[3] plots and results were extrapolated up to a "per hectare" basis. The results of these trials confirmed that rice yields are on par with the average yields for the Baguineda irrigation perimeter (afterwards "Baguineda") while fish yields reach 1 metric ton per hectare. Net revenue for rice was estimated from initial research data of OSU-USO-DNP) to be about FCFA 250,000 per hectare for rice and about FCFA 300,000 per hectare for fish, i.e. farmers appeared to be able to earn more from their fish production than from their rice. And, based on experience in Asia, revenue can be doubled with modest improvements in management. When the researchers whose names appear on this report saw these results, we were excited enough to want to spread the word and to see this system further tested and then expanded to all irrigated paddy rice areas where it was found to be profitable.

Chris Harmer[4] and Kevin Cummiskey with the support of the US Peace Corps continued these trials on farmers' fields during 2011-2012 in the Niono area. They carefully documented their work. They established that joint fish-rice production could be profitable and documented what were the conditions necessary for farmers to achieve profitable production. They also showed that considerable outside technical and business training would be required initially to help farmers understand and adopt technologies which reduced costs, consistently raised fish production and led to profitable fish-rice production. They believe and witnessed that once those farmers

[1] Héry Coulibaly, Director of Fisheries, actively promoted and Alassane Touré "Sandy" led this research effort.
[2] Office du Perimetre Irrigué de Baguineda (OPIB)
[3] 1000 square meters or less
[4] Retired Environmental Engineer with food industry experience and then PCV

experience success, the technology and keys to profitability can ultimately start being passed farmer-to-farmer by word-of-mouth in the kind of over-the-back-fence discussions which were instrumental in the past in diffusing new technologies in US agriculture. Knowledge about the benefits of the fish-rice production system spread through and between the communities with less need for continuing financial and technical support than other fish-farming technologies.

The events of 2012 led to the suspension of Peace Corps' support for further work in field testing the fish-rice system. Agriculture, Business, Credit and Development LLC/SARL (ABCD)[5] sought donor support for continued testing and expansion of the system to new areas. When such support did not emerge, ABCD funded continued research itself. In April 2014 it fielded a team of enumerators[6]. They worked actively with Baguineda Fisheries Staff[7] and carried out a census of all respondents who had carried out rice-fish production in 2013.

More or less complete data are available for 10 of the 13 respondents who engaged in this type of production in that year. Results of that survey are presented below. They characterize with reasonable accuracy how producers carried out their 2013 fish-rice operations and what results they were able to achieve. Despite limited outside support, producers all produced some fish (in addition to their rice production). Although financial results were not favorable, producers retained an interest in the production system, understanding its potential for providing income to their family revenue streams and protein for family consumption despite limited initial success in 2013. Most producers continue with the system. ABCD will continue to work with Baguineda producers and will focus its efforts on making results profitable for the producers who continue to develop their fish-rice production in future years.

RESULTS OF THE CENSUS

All producers engaged in fish rice production in 2013 were interviewed. These results are based on those producers for whom accurate data was available. Some producers could not provide data on some variables. Results are for those producers who provided data on a given variable, in most cases 10 producers out of the total of 13.

RICE PRODUCTION

Yield

[5] Registered in both in Florida in the United States and Mali, ABCD provides assistance in improving governance and anti-corruption actions, financial control systems and design and evaluations and surveys of agriculture, finance, and food security. The company operates on solar-power. ABCD means business. Well-run businesses lead to development.

[6] ABCD assistants Ms. Ramata Sacko, Mayanga Soumahoro, Assitan Sow and Mariam Traoré

[7] Mamadou Traoré, Baguiineda Fisheries Department

Rice yields are on the order of 2-3MT per hectare, about what is expected for Baguineda. It does not appear that the reduction of planted area by up to 10% allocated to the pond and ditches needed to support the addition of fish to the production system had much effect on rice yields. If the highest and lowest yield cases are excluded, the average is 2.6 MT/hectare; if the two observations are included, the average yield is 2.9 MT/hectare. Thus, it does not appear that fish-rice production has any substantial negative effect on rice production; this finding confirms what has been observed in other studies which have also shown little or no effect on rice yield because of the addition of fish to the production system. The possible impact on reduction in agricultural chemicals use, costs, and environmental impacts was not assessed, because the fingerlings were introduced in August, and therefore their introduction would have come after normal fertilizer and herbicide application already taken place.

Paddy Price

The paddy rice price is FCFA 288 per kg. Assuming a conversion of 60%, this would put the price of hulled rice (*riz net*) at FCFA 480 per kg.

Bottomline

Rice yields and revenue from rice production do not appear to have been affected by the addition of fish production.

FISH PRODUCTION

Digging Ponds

No ponds were dug. All ponds had been dug in previous years.

Field and Pond size

The average size of fields was 704 square meters (.07 of a hectare). This is a reasonable size for testing the technology and for initial operations which are normally carried out on small fields. The largest field was 1,064 sq. meters and the smallest 338 square meters. (Four of the fields were measured again in May 2015 as a spot check; measurements were exact to the square meter; no changes had been made in field size in the interim.)[8] Almost all pond are within the rule-of-thumb (based on the literature and Malian experience in Niono) that suggests that plot size of 1000 square meters or less are best for achieving consistent water depths across the field, good management, efficient operation and high fish yields.

Pond Size

Ponds are in the range of 5-10% of the rice field area, which is adequate.

[8] Measurements done by ABCD research assistant Bengaly Kouyate and logistics assistant Karim Lassokpe.

Pond depth

Ponds are around 1.0 to 1.2 meters deep.

Trench depth is also important. Most but not all of the trenches were at or deeper than the recommended 50 cm. This depth keeps the water from getting too hot and losing oxygen; it also is too deep for wading birds to stand in and to catch the fish.

Stocking

Timing of Stocking

Stocking was done almost entirely in August apparently because of the lack of commercially produced fingerlings before then. Ponds should be stocked in June (1-2 weeks after water can be flooded into the pond to saturate the compost pile). Early stocking is recommended to allow a longer growing period without having to pump water after rice harvest. The pond is sealed off by mud until after rice transplantation; recently transplanted rice plants should not be disturbed by fish until they have had a chance to root properly. The pond should also be sealed off during and for a week after application of fertilizers and other chemicals to protect the fingerlings.

Tilapia and clarias (catfish) were stocked at the same time in almost all cases. Only one farmer stocked tilapia one month before clarias (a two month interval is recommended to allow tilapia to grow so that they are not cannibalized by the larger clarias).

Stocking rate

An average of 649 fingerlings was stocked per producer. Given average field size of 704 square meters, this gives and average stocking rate of 0.9 fingerlings per square meter. This is only slightly below the recommended level of 1 fish per square meter.

Ratio of tilapia to clarias

The ratio of tilapia to clarias fingerlings stocked is only 0.70 : 1. The ratio of **clarias to tilapia** is 1.42:1. In other words there are 42% more clarias than tilapia; this is the opposite of what is usual. Best practices call for more tilapia. The ratio of tilapia to clarias should be 3:1. Tilapia is the target species on which the production system is based. Clarias are included as a population control measure for the target population for fish production which is tilapia. Clarias in confined situations have been found to be very slow growing; their inclusion in the production system is primarily as a population control measure, not as a target for production. The ratio encountered appears to be related to the availability of more clarias fingerlings than tilapia rather than for any scientifically justified reason.

Average weight of tilapia and clarias fingerlings

Weight of fingerlings was mistakenly added together; average weights should have been calculated separately for tilapia and for clarias fingerlings.

The average weight of fingerlings is 27.6 grams.

Cost of fingerlings

Some fingerlings may have been provided free of charge by the Institut d'Economie Rural (IER) since a few producers reported zero cost for fingerlings.

The 7 respondents who reported purchasing fingerlings spent a total of FCFA 104,000 on average for their fingerlings.

Most producers reported buying fingerlings, at a cost of FCFA 100 for tilapia and about FCFA 200 for clarias. The average cost for one fingerling (all types taken together) was FCFA 164 each.

Given the average weight of fingerlings (27.6 grams), the cost of fingerlings is FCFA 5,942 per kilogram. That is approximately six times the market price for market-ready fish. The fastest-growing tilapia double in size about every two months under optimum conditions. This means it takes over five months of optimum growth just to recoup the excessive costs of the purchased fingerlings. Profitability under these conditions is virtually impossible.

From a business standpoint, it is important to determine if producers could obtain fingerlings at or below the market cost per kg for full-size fish (e.g. 1 F CFA per 1 gm of fingerling) by netting them in the canals or buying tiny fish from fishermen, who could not sell such fish at all or would have to sell them at a very low price per kilogram for consumption.

FISH HARVEST

Number of fish

Among producers who could identify the total number of fish and the number of tilapia in the total (7 producers), the total number of tilapia harvested was 2,189 out of 4,026 fish. 54% of the fish were tilapia and 46% clarias, a ratio of 1.2 : 1. The proportion of tilapia to clarias is far below normal, though some increase in tilapia population occurred, as compared to the high stocking rate for clarias (1.42 : 1).

Average Weight

The average weight of tilapia and clarias harvested was respectively 46 grams and 74 grams respectively. These are very small fish. They command low prices per kilogram

in the market, which is right by the Niger River where much larger fish caught by fishermen are available. Because of the large size of the Baguineda fish market (which caters mainly to fishermen), it is unlikely that fish harvested from the pond of any one fish-rice farmer would be large enough to depress market prices. Since producers all belong to the same cooperative, planning to avoid multiple producers harvesting their ponds on the same day should be feasible to keep from depressing prices.

Total production of fish

Fish production ranges from a low of 5 kgs to a high of 88 kgs.

Production per hectare

The important question for producers is how much profit they make from their fish rice operation. In particular they need to answer the question: is fish-rice production worth the extra effort above and beyond simply producing rice alone. If per hectare production is greater than 1 MT per hectare and if fish production costs can be kept low, the answer to that question is yes: it is profitable and worth the effort to produce fish and rice jointly.

Two of the producers got over 1 MT of fish per hectare. (Many more had more than Mali's Five-Year Plan goal of 375 kgs per hectare, although this target is too low to guarantee profitability.) The fact that two producers achieved over 1 MT of fish per hectare is an indication that with proper management, other producers can also get fish yields which are attractive and which would allow farmers to make significant returns from their fish. After several years of learning and refining their practice, some might even be able to make more profit from their fish than simply from the production of rice.

The impact of doubling per field profits on farm family food security cannot be overemphasized. A 2010 Peace Corps survey of 20 rice farming households in Niono showed that families of farmers who could only farm one crop of rice per year experienced food insecurity up to 4-6 months a year. Those who doubled their profits by farming a second season per year reported food insecurity of 0-2 months a year. Fish farming profits could be the equivalent of that second rice season, with none of the investment, work and risk.

Cost Data

Because of the late date of carrying out the survey (5 or 6 months after the previous fish harvest), reliable cost data could not be obtained. Also, IER provided fingerlings free of charge.

Additional costs were incurred by producers in pumping because water levels in fields are lowered right before the rice harvest to allow the rice to dry out for harvesting. In order to top-up the ponds after the harvest, water had to be pumped instead of flowing in by gravity due to low water levels in the canal. These costs are high but can only be

estimated. Anecdotal cost numbers for two of the trials in Niono and earlier data from trials in Baguineda indicate that post-rice harvest pumping costs could be equal to total fish revenues.

Part of the water level losses are from evaporation and cannot be prevented. But because of soil permeability, part are from infiltration. Infiltration could be reduced dramatically by lining ponds with clay which can be purchased at FCFA 20,000 ($40) per truckload. Data from east Africa showed decrease in infiltration after the ponds were treated with rice ash. It would be important to test different materials on different plots, that is: clay, termite hill clay or manure (or both). All of these options are suggested in the literature and are practically free. Future research focusing on Baguineda would require finding funding to 1) line ponds with clay and 2) to subsidize pumping costs where still necessary as part of the cost of having a convenient research site near Bamako. Baguineda is an ideal site from the point of view of researchers wanting to get out to the field and back in the same day; but because its soils are porous, the area is less than ideal for actual production.

It is hoped that more accurate cost data can be obtained when ABCD goes back to collect data for the 2015 season.

COMMONLY ACCEPTED GOOD PRACTICES for FISH-RICE PRODUCTION

SOILS

Soil and water level combinations should be such that ponds hold water even during the dry season so that losses are limited to evaporation. Baguineda soils in the area in which fish-rice production is being carried out do not meet this criterion: they are too porous to hold water once the level of the canals has been allowed to drop after the rice crop has been harvested. Nevertheless, because of its proximity to researchers and business support people, it makes sense to continue this type of production in Baguineda. Losses due to permeability could be offset through lining ponds with clay which is available locally; costs of the clay might be shared (or borne) by a donor interested in further evaluating this production system. (The PDG of ABCD succeeded in eliminating losses through permeability in a pond he build in laterite soils in Zambia by knocking down a termite mound and using its component material to line the pond.)

Some contribution to pumping costs might also be worth considering.

Optimally, testing and adaptation of the system should expand to other regions where soils have higher clay content, particularly the Office du Niger and parts of the Alatona area.

DRAINAGE

Optimally for farmers engaging in commercial production and wanting to sell all their fish at once, it should be feasible to empty ponds entirely through screens by gravity only and into drains to harvest the fish remaining in the bottom of the pond. The pond can thenbe easily cleaned and then to proceed with pond clean-out shortly after fish have been harvested. Farmers focusing on the village market or growing fish largely for family consumption can still do a creditable and profitable job of producing fish. They can harvest with nets even if they are unable to drain their ponds and can harvest little-by-little to meet family food needs or to satisfy the demand for fish in a small market. Some markets are so small that they might be saturated by disposing of all fish from one pond in a single market session. This is not the case with the Baguneda market.

TARGET FARMERS FOR THE SYSTEM

Fish production within the fish-rice system is a batch production system similar to raising broiler chickens for meat: all chicks (fingerlings) are brought in at the same time and all broilers (fish) are sold at the same time when they have reached market weight. It is similar to raising a crop of onions. So this operation is something that farmers will have no trouble grasping. It requires constant attention throughout the growing season. This explanation sheds light on why farmers rather than fishermen are better able to understand the concepts required for successful fish production.

Fisherman like hunters; they capture and kill naturally occurring stocks of wildlife (or fish). They do not grow what they capture but simply take what they can from what is found on their fishing grounds. The fish which are there are the product of a natural ecosystem and not of a planned production process.

Therefore, farmers (not fishermen) are the best candidates for adding fish to complement pre-existing rice production. This fact is important in designing programs to support the expansion of fish-rice production.

REVENUE

Two farmers obtained revenue on a per hectare basis in excess of FCFA 1 million (FCFA 1,600,000 and FCFA 1,200,000). Even higher revenues could be obtained if better management increased yield over the 1 MT per hectare level, an improvement which is certainly achievable. Two others obtained revenue in the FCFA 600,000 to 800,000 per hectare range. Increases are easily obtainable simply by stocking ponds shortly after rice is transplanted, following the 3 : 1 tilapia to clarias stocking rate and by stocking clarias of a smaller size and introducing clarias into the pond 2 months after tilapia are stocked.

NET REVENUE

The key to high net revenue is to keep down costs. The major costs needing to be reduced are those of fingerlings. The amount paid for fingerlings is prohibitive to any serious commercial production (FCFA 100 -125 and even FCFA 200 for clarias). Every

FCFA 10 increase in price raises the total cost of fingerlings by FCFA 100,000 on a per hectare basis. Therefore, for the system to "work" for farmers, i.e., for farmers to make money, the price of fingerlings has to be reduced dramatically.

Feed costs also have to be kept in check by feeding fish after the rice harvest with what is available "free-of-charge" on the farm itself (rice husks, manure, table scraps) and feeding hardly at all while the fish are "grazing" like "free-range cattle" in the rice paddy.

Pumping is prohibitive and needs to be avoided at all costs (or subsidized by researchers or donors if farmers are "helping" researchers by providing them with data on production as part of trials guided by researchers with donor support.)

PRODUCTION COSTS

Production costs could not be obtained with reasonable accuracy for the 2013 season in the survey which provided the data analyzed here. Periodic meetings with the farmers, call-backs with farmers and fisheries staff have sensitized producers and technicians to the need to accurately measure all costs, even costs which are subsidized, to establish the profitability of the system. As a result, data for 2015 should be better than that collected in this survey.

FIXED COSTS

POND AND TRENCH BUILDING

Donors interested in learning more about this production system, could consider subsidizing wholly or partially the cost of digging the pond and trenches to proper technical specifications. Such subsidies would encourage new entrants by removing the highest hurdle to adoption of the technology. It could be made clear to producers that the reason for the subsidy is to allow more farmers to adopt the system and to teach its effective operation to the donor, and as such constitutes enlightened self-interest on the part of the donor, rather than some altruistic (but misguided) gesture that then all farmers will feel entitled to.

Pond digging is a one-time activity and should be done in the off-season with family labor to keep costs down. If a subsidy for Baguineda farmers is called for, its reason needs to be clearly explained to farmers wanting to adopt the system as new entrants or to expand existing production to a second plot.

RECURRENT COSTS

REDUCE THE COST OF FINGERLINGS

The largest recurrent cost found in the survey is the acquisition of fingerlings. The cost paid in 2013 is prohibitive to profitable production even if farmers attain the target 1 MT/hectare of fish.

Fingerlings need to be obtained free by netting them in the canals if possible. If netting is not possible, they should be purchased from fishermen. For fishermen, fish averaging 30 grams constitute a by-catch, hardly of much interest in view of its lower price per kilogram compared to larger fish. Producers can explain to fishermen what they want (live, small, freshly caught tilapia, caught at night when the temperature is lower and carried to shore in buckets of water to keep them alive) and sold to producers at an agreed on a price. (About two months later, they will want small clarias, not bigger than twice the size producers' tilapia have grown to, to control breeding in pond and to allow a smaller number of tilapia to grow to larger, better-paying market weights. These too can be obtained from fishermen on a similar basis.)

EXTEND GROWING SEASON TO SIX MONTHS WITHOUT ADDING TO RECURRENT COSTS

Fingerlings need to be introduced as early as possible to avoid costs of pumping later in the season and to give fish the greatest amount of time to grow. The goal is to achieve a 6-month growing season without pumping. Tilapia can double in size in two months; thus it makes sense to introduce them in June rather than August. Bigger fish command higher prices. Fish less than 100 grams command lower prices; that is the size that were produced on average by Baguineda farmers in 2013.

Clarias need to introduced later, about two months later. The size should be no more than twice the size of the tilapia already growing in the pond to make sure that they do not cannibalize marketable fish rather than keeping the number of tilapia stable (by eating tilapia fry) so that fish bound for market get a chance to grow to a more marketable size.

At all stages of production, the focus has to be on reducing all costs, especially costs for prolonging the growing season by additional access to water. This focus includes avoiding dry season water charges (second season *redevance eaux*); irrigation perimeters charge second water fee to people who need water in the dry season. High-value vegetables can support this cost; two additional months for growing out the fish cannot. Likewise, where possible (it may not be possible in Baguineda), pumping costs have to avoided, since they almost certainly eliminate all potential profits.

FEEDING

Farmers should feed compost, manure and rice-bran which are basically free. They should not buy feed. Small tilapia should grow mostly from eating algae produced by proper fertilization of the pond. To get a nice green hue to the pond, add manure. If the producer's open fingers are visible when he puts his arm in the pond up to his elbow,

the pond needs to be fertilized; more manure should be added to increase the growth of algae.

Transplanting is required to create rows down which fish can meander and feed themselves on insects, fungi, and algae growing on the rice. During the rice production season, tilapia will require little in the way of feed. After the rice paddy is dried out in preparation for harvest, feeding will be required but should be achieved to the greatest extent possible with what farmers have available from as farm or household waste products. Feed purchases add to cost and make the whole fish side of the production system less profitable or even unprofitable.

HARVEST AND SALE

The harvest should be carried out one-time, if possible by draining the pond through a sieve to keep any small fish from escaping. In most areas of Mali where the fish-rice system is feasible, with proper advertising and good sized fish, producers find that people flock to the pond to buy. In Baguineda because of the proximity of the River and to a fish market, this may not be possible. Sales at wholesale generally require a discount of 10% which reduces profit by considerably more than 10%. By next year it should be possible to say by exactly how much.

Fish were found to be quite small in our census: tilapia were only 46 grams on average and all fish were only 74 grams. A minimum size for market acceptance is probably 100 grams. It is possible to achieve 200 to 250 grams over a six-month period. Market prices per kilogram were higher for larger fish in the Niono market. Market prices by size and season should be tracked in future work in Baguineda work.

THEFT CONTROL

Where more farmers are engaged in fish-only aquaculture and fish-rice production, theft goes down as the number of farmers involved in fish production; farmers watch over each other's fish. Also, as more people produce fish, word gets around that catching fish in canals and the river is fine, but netting them out of someone's pond is not. Putting some sharpened stakes to rip people's castnets may help. (Stakes sticking 30 cms out of the water look threatening to thieves and also make it more difficult for predatory birds to seize fish.) Collaboration of village headmen and local police to warn people not to fish in ponds and to arrest them if they do, will also help people differentiate between pond fish and canal/river fish. Some exemplary punishments by local authorities will help.

In an area west of Lafiabougou and Konibabougou, every year women and children gather mangoes from a communal grove of wild mango trees but leave export-variety mangoes which come from trees which someone planted not 5 meters away alone. It is also possible for people to be made to understand the difference between pond-produced fish which are privately owned like livestock and canal/river caught fish which are a common resource available to anyone in the comunity.

Predatory birds and frogs also prey on fish and eggs. Children armed with slingshots can reduce losses from both. The market for frogs' legs should remain good with the presence of European soldiers from MINUSMA; tourists also like frogs' legs and will eventually return when security conditions make travel to tourist destination safe again.

THE WAY FORWARD

Further work is needed in Baguineda focusing on the income and revenue and on the cost side of the balance sheet to confirm how best to help farmers achieve profitable operations.

Expansion of testing to other areas where conditions are more favorable for system success is also needed. The Office du Niger is prime among these areas. The Alatona area also offers good prospects.

This additional work can only be carried out with some donor support. ABCD has prepared an unsolicited proposal based on its ideas on how the system can be fine-tuned and prepared for roll-out should it prove profitable. ABCD is ready to work with any donor who is interested in supporting this highly promising production system.