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Sustainable Development of the *Fadama* Lands in Northern Nigeria: A Review of the Potentials and Challenges

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Abstract

Attempt was made to review the potentials and challenges of fadama land development in northern Nigeria. In the vast drylands of northern Nigeria, the fadama is a critical resource because of its relatively high fertility and water retention not only in the rainy season but also during the usually protracted dry season. Notwithstanding its potentials, however, it appears that widespread fadama development, as is now being pursued under the World Bank-assisted National Fadama Development Project (NFDP) in collaboration with the Agricultural Development Projects, could pose serious long-run sustainability challenges. Environmental degradation, decline in soil fertility, rising cost and perhaps non-affordability to farmers of fadama development technologies, and conflicts among different fadama users are some of the challenges that must be addressed. Periodic soil and water quality tests, monitoring of groundwater table, appropriate choice of crop enterprises as well as definition and enforcement of necessary property rights with respect to fadama resources, are recommended against the sustainability challenges raised.

Introduction

Attention on irrigated farming in recent times appears to have focused on small-scale *fadama* development. This is consequential to the failure of large-scale irrigation, which the country has pursued for the last two decades, to yield the anticipated increase in food production despite the huge sums of money (more than $2.0 billion) spent on it (Umar and Iyem, 1994). The problems identified with large-scale irrigation schemes include the fact that they are highly capital-intensive and involve a heavy drain of scarce foreign exchange. In addition, they require the use of complex foreign technologies and are usually identified, planned and implemented without the involvement of the potential beneficiaries (i.e, a "top-down" approach). Furthermore, large-scale irrigation schemes characteristically require the construction of dams and impounding of large reservoir of water which have been discredited for the environmental degradation and conflicts they cause (Muazu and Abdulmumin, 1991; Rabiu and Ogunwale, 1991).

It is in apparent reaction to these serious short-comings of large-scale irrigation that emphasis is now shifting towards the development of small-scale irrigation especially in the *fadama* lands, for crop production. It appears to have been presumed that this strategy, apart from avoiding the other acknowledged shortcomings of large-scale irrigation would present less sustainability problems. But experience has shown that in Nigeria, the long-term impact of agricultural development policies are not properly evaluated before their implementation. This has often led to the failure of strategies which at the beginning had seemed to possess the highest potentials. The seemingly endless list of unsuccessful agricultural and rural development projects only emphasize the need for careful analysis of new strategies to avoid the mistakes of the past.

This paper, therefore, examines the potentials of *fadama* land development for irrigation in Nigeria and analyses the sustainability challenges posed by widespread adoption of this strategy. It is hoped that such an analysis would not only identify the potential benefits of *fadama* land irrigation but also indicate ways of avoiding the pitfalls associated with the continued use of the *fadama*.

Characteristics of *Fadama* Lands and the Current *Fadama* Development Efforts

Fadama is a Hausa word which means the land that is flooded during the rainy season. In agricultural usage, however, the word *fadama* commonly refers to all low-lying relatively flat areas either in streamless depressions or adjacent to the seasonally or perennially-flowing streams and rivers. According to Kolawole and Scoones (1994), the word *fadama* means the seasonally flooded or floodable flood plains along the major savanna rivers and/or depressions on the adjacent terraces. The word *fadama* is in contrast to *tudu* which means the upland.

Fadama in northern Nigeria, is synonymous to *bas fond* in Sahel, *wadi* or *khor* in Sudan and *dambo* in southern Africa (Scoones, 1992). The *fadama* lands have been described by Scoones (1992) as "wetlands in drylands" due to their moisture retention characteristic within the rhizosphere, not only in the wet but also in the dry season. Characteristically, Arnborg (1988) noted, the *fadama* land is marked by a flush of new vegetation at the beginning of the rainy season before the adjacent upland turns green, but it is most conspicuous after cessation of the rains when it remains prominently green as the surrounding upland rapidly turns brown and eventually bare. Further underscoring the characteristics of the *fadama* land, Arnborg described it as "a garden, a little paradise" in the vast drylands of northern Nigeria.

The problem is that *fadama* lands in most of the northern Nigerian States are usually small, relative to the total cultivable land area; the bulk being the dry upland. For instance, it has been reported that *fadama* covers only 798,000 ha out of the five million hectares cultivated in Bauchi, Kano, Jigawa, Sokoto, Kebbi, Kaduna and Katsina States (Kolawole and Scoones, 1994). This represents only about 15.77% of the total area cultivated, with the area varying from as low as 6.26% in Kano/Jigawa to as high as 39.25% in Sokoto/Kebbi States (Kolawole and Scoones, 1994). According to Adams (1989), only about 60,000-100,000 ha of *fadama* lands are cultivated in Kano and Jigawa States, while Sangari (1991, 1996) reported that the Donga and Taraba River basins provide about 100,000 ha of cultivated *fadama* in Taraba State. In the present Sokoto State, an estimated 154,524 ha of *fadama* land is under cultivation (SADP, unpublished data).

While the above-stated land areas are small relative to the total cultivated land mass in the various states, it must be noted that the *fadama* lands are very productive. Emphasising this fact, Iliya and Sindhu (1980) have noted that such lands posses a great potential for intensive agriculture.

Fadama land development in Nigeria is currently being undertaken under the World Bank-assisted National *Fadama* Development Project (NFDP) by the Agricultural Development Projects (ADPs) in various states in collaboration with the Federal Agricultural Coordinating Unit (FACU). It is estimated that the total *fadama* land area potentially available in the north and middle belt areas is about 3.1 million ha, which the NFDP plans to develop for small-scale irrigation (Awogbade, 1994). The approach being adopted is to impound flood waters, build small earth dams, and develop groundwater by sinking washbores and tubewells. It also involves the distribution to farmers, of small petrol water pumps for lifting water from the source. To facilitate the distribution of pumps and other improved inputs, farmers are encouraged to form *fadama* users' associations (FUAs). Attention of the Project appears to focus mainly on irrigated farming. It is not clear yet as to how the interest of other *fadama* users such as pastoralists and fishermen will be protected.

Potentials of *Fadama* Lands

The *fadama* lands have high potentials and agriculturally value several times more than the adjacent upland. For instance, Singh (1997) reported that the sale or lease value of *fadama* lands in the erstwhile Sokoto State was 4-5 times more than that of the upland. From agricultural viewpoint, there are at least three uses to which *fadama* lands could be put; these include arable farming, pastoralism and fish farming.

The significance of *fadama* lands in arable farming rests heavily on the fact that they normally have high levels of soil moisture not only in the rainy season but also during the dry season and in droughts. In a recent study in the Sokoto-Rima River basin, Singh and Yacouba (unpublished data) found that the *fadama* soils possessed good hydraulic properties as measured in terms of moisture retention, infiltration and hydraulic

conductivity. In addition, *fadama* lands usually have high level of plant nutrients. Table 1 summarises the physico-chemical properties of some *fadama* and upland soils obtained from various studies in Sokoto State. It can be seen from the Table that, on the average, the *fadama* soils have finer texture as well as higher pH, organic carbon, total nitrogen, cation exchange capacity, total exchangeable bases and base saturation than the upland soils (Singh and Babaji, 1989, 1990; Singh *et al.*, 1996; Singh, 1997). Given these properties, it seems that Singh (1997) was correct in stating that the *fadama* soils are texturally finer and nutritionally richer than the adjacent upland. Because of the above-stated characteristics, the *fadama* lands play very crucial roles in areas with low-fertility soils and inadequate rainfall such as most parts of northern Nigeria where less than 800 mm annual rain falls within about 100 days of humid season and where moisture balance indicates more than 500 mm deficit over the surplus (Agboola, 1979).

Table 1: Physico-chemical properties of some *fadama* and upland surface soils in Sokoto State

Parameter	*Fadama* soils from				
	Sokoto- Rima basin	University *Fadama* Farm	Kandoli Shela Valley	*Fadama* mean	Upland soils
Sand (%)	62	90	83	78	90
Silt (%)	25	2	10	12	5
Clay (%)	13	8	6	9	5
Texture	Sandy loam	Sand	Loamy sand	Sandy loam	Sand
pH in water	5.73	7.97	7.28	6.99	5.50
Organic C (%)	0.11	0.30	0.44	0.28	0.10
Total N (%)	0.007	0.03	0.05	0.03	0.01
C.E.C. (me/100g)	9.46	24.10	15.67	16.41	9.10
Total exch.bases	3.69	9.16	6.51	6.45	1.54
Base sat. (%)	39.00	37.77	41.11	39.29	17.00

Sources: Computed and compiled from Singh and Babaji (1989, 1990), Singh *et al.* (1996), and Singh (1997)

Due to high level of soil fertility and hydromorphic nature, *fadama* lands permit the growing of different types of crops throughout the year (Scoones, 1992; Fagbemi and Abdullahi, 1994). Hence, in northern Nigeria, it has been possible to diversify into the growing of high-value crops such as wheat, rice and vegetables whose production would have been otherwise impossible due to inadequate rainfall. In addition, availability of *fadama* lands has made multiple cropping possible within a year. Furthermore, the *fadama* cultivation increases food security by providing crops when other plots (upland) fail. The *fadama*, thus, reduces uncertainty in crop production.

Another significant aspect of *fadama* farming, which is linked to the relatively high fertility and moisture retention of *fadama* soils, is that the crop yields are invariably higher than in upland farming. For instance, in studies around Zaria area of Kaduna State, crop yield increases of up to 300% in *fadama* over upland farming have been reported (Scoones, 1992; Norman *et al.*, 1982). *Fadama* farming has also been noted to yield fairly high financial returns. Turner (1984) has argued, in the context of north central Nigeria, that the *fadama* lands provide about 22.5% of net farm income, notwithstanding the fact that they comprised only 9.4% of the

average farm area. Table 2 summarises the results of some empirical studies on profitability of *fadama* farming in northern Nigeria. It can be seen that in all the studies cited, positive net returns were reported.

The *fadama* land also contributes significantly to agricultural production in northern Nigeria by providing feed and water to the livestock especially during the dry season when the surrounding areas are dry or even bare. The *fadama*, therefore, serves as a transhumance migratory corridor for the pastoralists as they go in seasonal search of feed and water for their animals (Awogbade, 1994). Yet another economic activity supported directly by the *fadama* is fishing. Fishermen, both local and immigrants, usually converge on the *fadama* for fishing which is made possible by continuous water availability.

Through the above-stated advantages, the *fadama* promotes fuller employment of resources. For instance, labour and land that would have remained idle during the dry season are productively utilised, thereby enabling the farmers to earn extra income. In this way, it can be seen that *fadama* farming complements, rather than competes with upland farming.

In relation to irrigated farming, Umar and Iyem (1994) have identified some characteristic advantages which place the small-scale *fadama* irrigation, as is now being pursued, above the large-scale irrigation schemes established in the past. These include autonomy in management since land, pumps and tubewells normally belong to the individual farmer. This autonomy gives a farmer the best control over timing and quantity of water application, as well as flexibility in terms of decision-making regarding the crop types to cultivate and husbandry practices to adopt. This is in contrast to large-scale irrigation where most of these decisions are made for the farmer by the managers of such schemes regardless of the peculiarities and variable requirements of individual farmers. The other advantages identified include simplicity of the technologies involved as well as the relatively low cost of owning and operating the small-scale irrigation technologies. It should be added that the small-scale *fadama* irrigation requires less foreign exchange than the large-scale schemes. It reduces dependence on foreign "experts" and technology for construction and management of the schemes. In fact, the small-scale irrigation schemes are often established, maintained and managed by the farmers with little assistance (often in the form of sinking of washbores/tubewells and acquisition of pumps) from the government.

From the discussion so far, it can be deduced that the *fadama* lands have a crucial role to play in the expansion of food production in Nigeria. Nevertheless, the realisation of the potentials of *fadama* land development in the long-run, will be achieved only if a number of sustainability challenges are met.

Sustainability Challenges in *Fadama* Land Use

The challenges to sustainable *fadama* development could be discussed under the sub-headings (1) environmental degradation (2) effect of dam construction (3) sustainability of soil fertility (4) sustainability of small-scale *fadama* irrigation technologies, and (5) conflicts among *fadama* users.

Environmental degradation

Sustainable development could be viewed as maximisation of use of environmental assets or development without destroying the future of the natural capital stock. Therefore, the first concern in the *fadama* development should be a knowledge of its impact on the environment, for this would determine the sustainability of its use. According to Scoones (1992), a continuous use of *fadama* could cause environmental degradation through either lowering of ground water table or increasing the rate of soil erosion. A third factor, soil salinization/sodification due to the use of water of poor quality, may be added.

The lowering of ground water table could result if the rate of evapotranspiration exceeds the annual recharge from rainfall and/or ground water movement. Although quantitative information on site-specific evapotranspiration rates under irrigation schemes and cropping conditions are not widely available in Nigeria (with the possible exception of Abdulmumin, 1988, in Kadawa, Kano State), there are indications of very high evapotranspiration rates in the northern part of the country. As earlier indicated, the annual moisture balance in semi-arid northern Nigeria indicates more than 500 mm deficit over the surplus (Agboola, 1979). Donli and

Bauhin (1994) believed that the evaporation may be quite high in the irrigated flood plains of Yobe River. They noted that much of the water supplied to the farms by irrigation is lost by evaporation due to high temperatures and dry winds. Fagbemi and Abdullahi (1994), working with Katarawa *fadama* farmers in Kano State, observed that the evapotranspiration was so high that the flood receded as soon as the rains stopped and the entire *fadama*, except the major stream way, was dry in about two weeks. It has also been reported that in the Sahel Savanna of northern Nigeria, potential evapotranspiration exceeds rainfall by more than 1,600 mm per annum (Owonubi *et al.*, 1991).

Table 2: Average financial returns to *fadama* farming in northern Nigeria (naira per hectare)

Author(s)	Year of publ.	Study area	Enterprises	Average returns
Baba	1993	Bauchi State	Vegetables	4,856*
Baba and Adedibu	1998	Wurno area, Sokoto State	Garlic:	31,000
			Onion/tomato mix.:	27,500
Baba and Etuk	1990	Bauchi State	Vegetables	4,917
Baba and Wando	1998	Magama and Kontagora L.G.A., Niger State	Rice:	15,619
			Tomato:	14,770
Erhabor and Kalu	1990	Kadawa Irrigation Project	Wheat	3,773*
Ezeh and Orakwe	1990	Kano River Project	Wheat	3,628
Makarfi	1985	Kano River Project	Wheat	819
Tarfa	1990	Dadin-Kowa Irrigation Project	Wheat:	4,297
			Vegetable:	7,540

* Figures represent gross margins; other figures are net farm incomes

Source: Compiled from Baba (1993), Baba and Adedibu (1998), Baba and Etuk (1990), Baba and Wando (1998), Erhabor and Kalu (1990), Ezeh and Orakwe (1990), Makarfi (1985) and Tarfa (1990).

In a situation where the evapotranspiration exceeds rainfall, there may be the problem of ground water table depletion under widespread *fadama* cultivation, except where recharging by ground water movement exceeds the difference between rainfall and evapotranspiration. Whatever the case may be, the above review only underscores the need to monitor the hydrological processes at each *fadama* irrigation site and to take appropriate water conservation measures such as planting of cover crops, mulching, as well as water harvesting and storage, when necessary. If the ground water is allowed to fall, there could be drying-up of *fadama* with obvious environmental consequences. Monitoring the hydrological processes requires some expertise and the use of sophisticated instruments which must be provided from the beginning at each major *fadama* irrigation site.

Another important aspect of *fadama* land development is the monitoring of infiltration rate of soils at he site and the surrounding catchment area. Changes in infiltration rate are the result of changed soil properties lue to siltation, erosion or changed soil cover. Decreased infiltration increases runoff and consequent soil erosion s well as causes temporary flooding (water-logging) and longer term drying out of the *fadama*. For a sustainable evelopment and use of the *fadama* lands, therefore, a continuous soil testing for each site is necessary to onitor changes in soil properties. Furthermore, ameliorative steps should be taken to effect whatever changes

are required in order to avoid erosion and ensure sustainable crop growth. In addition, cropping systems should be such that exposure of the soil at any time is minimum in order to avoid erosion and reduce evapotranspiration. Another crucial determinant of erosion is over-grazing which could expose the soil to erosive forces.

The quality of water used for *fadama* irrigation is another determinant of environmental degradation. In northern Nigeria, available surface water is presently being overstretched by the new widespread *fadama* development activities. Added to this, is the fact that most of the surface water dries up very early in the dry season. The only alternative in such cases, is to develop ground water for irrigation. This is currently being achieved through the sinking of washbores and tubewells, and the distribution of small petrol pumps for lifting water from the underground sources. The ground water in the semi-arid environment usually contains a lot of salts. They are brought to the soil surface along with water and left there or within the rhizosphere after the water dries out under the influence of hot weather conditions. The excessive accumulation of salts could lead to the development of salt-affected soils through the processes of salinization and/or sodification, and hinder satisfactory crop growth. Such developments would compound the environmental degradation problem. Again, to avoid this problem, continuous site-specific soil testing is needed so that ameliorative soil treatment measures may be adopted as and when necessary.

Effects of dam construction

The effect of dam construction on *fadama* land use and sustainability is somewhat controversial. The stored water in dams is an insurance for irrigated farming as the water can be supplied as and when needed; the irrigated farming will not depend heavily on the vagaries of rivers and other water sources. In addition, the storage of water and its regulation through the reservoir could serve as flood control mechanism and thus, benefit the downstream farmers. However, at times of water scarcity, while the nearby area enjoys irrigation, the distant land faces a situation of aridity due to a serious lack of water in the rivers; some of them virtually dry up. In fact, noting the aridity that now characterises the Jere Bowl after the construction of Alau Dam in Borno State, Odihi (1994) maintained that the dam construction is capable of destabilising the *fadama*-based rural economy by presenting several obstacles.

Furthermore, the construction of dams across major rivers is known to be a threat to *fadama* land availability due to loss of large areas under the reservoirs. For instance, in Sokoto River Basin area, the construction of Bakolori Dam led to a loss of about 14,700 ha of *fadama* land just to irrigate 22,500 ha (Adams, 1983). Similarly, about 35,000 ha of *fadama* land was lost in the Dadin-Kowa area of Bauchi State and 100,000 ha in the South Chad Project in Borno State (Kolawole and Scoones, 1994). Nichol (1992) also estimated a loss of 656 ha of the pre-dam 876 ha of cultivable *fadama* downstream of the Jakara Dam. Most of the *fadama* lands lost in these cases usually belong to the peasant farmers who do not find adequate compensation in the area developed for irrigation by the dam management (Saidu, 1994).

Judging from the above review, it would seem that the dams could constitute a threat to *fadama* land availability, the advantages associated with them (as mentioned earlier) notwithstanding. The challenge is how to minimise further construction of large-scale dams. Similarly, ways and means need to be found to minimise the negative effects of the existing ones, such as water scarcity during the dry season and flood in the downstream areas due to excess release of water from the dam during the wet season.

Sustainability of soil fertility

As mentioned earlier, the *fadama* lands are reasonably fertile. However, continuous intensive cultivation would gradually deplete the soil nutrients. Managing the fertility of *fadama* lands in a sustainable fashion is, therefore, a challenge which should be treated as an integral part of the current *fadama* development strategies by the agencies concerned (i.e, NFDP, ADPs and FACU). An extensive network of soil testing needs to be established to monitor changes in soil fertility level and make appropriate fertilizer recommendations where necessary. It is worth mentioning that soil test-based recommendation ensures the most rational use of fertilizers

as it enables the farmer to apply the right amount to the most needy soil (Singh, 1990, 1995).

In addition, planting of legumes either in rotation or in mixture with other crops, should be given concerted attention in fertility management of the *fadama* soils. Singh (1995) stressed the need for developing high nitrogen fixing legumes for Sokoto and Kebbi States, and for inoculating the seeds with "appropriate" and "effective" strains of *rhizobia* to increase the symbiotic nitrogen fixing capacity of legumes. He further emphasised the use of organic manures where available, to maintain the fertility of soils. These recommendations should apply to upland as well as *fadama* land cultivation

Sustainability of small-scale *fadama* development technologies

The technologies employed under the current National *Fadama* Development Project include tubewells, washbores and small petrol water pumps. The first two are ostensibly to replace the traditional open wells, while the last one is to replace the traditional calabash and *shadoof* water lifting devices. In a study in Bauchi State, however, Baba (1989) recorded the drying up of several washbores during the irrigation season. A similar observation was made by Baba and Adedibu (1998) on tubewells in Sokoto State, and by Baba and Alassane (1997) in the Tarka valley of Niger Republic. This suggests that to continue to use these technologies especially under conditions of widespread adoption and possible declining water table, deeper drilling may be required. However, as pointed out by Carruthers (1968), the drilling and pumping costs increase with height. Furthermore, the pumps used depend on petrol fuel whose price is on the increase in Nigeria. Whether the profitability of *fadama* irrigation could be sustained in the future under these technologies, is not certain.

Furthermore, although the pumps are being sold to farmers in large numbers, there are no workshops to provide service support for them. If frequent breakdown or complete packing-up of the pumps are to be avoided, there may be a need to establish workshops close to the farmers to service and repair pumps without they having to cover long distances. If the places of repair are too far, it would mean that the farmers may have to leave their plots unwatered for some days in an attempt to reach such places with their pumps. This may create water stress which can be deleterious to crop growth and yield.

Conflicts among *fadama* users

According to Scoones (1991), conflicts over land use are likely to focus on areas of high productivity especially if these areas provide seasonally critical resources. This statement succinctly describes the scenario of *fadama* lands in northern Nigeria, as "wetlands in drylands". Because of the economic advantages they offer over the surrounding upland, *fadama* lands are critical resources. This, coupled with the fact that they are generally very limited in size compared to rest of the land, and that population pressure on land is increasing, makes the *fadama* land an area of conflicts par excellence.

The conflict could arise between arable crop farmers and pastoralists, between farmers and fishermen or between poor arable farmers and the wealthy ones. It could also arise over the distribution of irrigation water during the period of peak demand or scarcity. Conflict, sometimes violent, between farmers and pastoralists is a well-known phenomenon in northern Nigeria. The situation is particularly critical when the conflict is over the access to *fadama* land resources. The *fadamas* of northern Nigeria are important grazing resources for Fulani pastoralists. However, access to *fadama* lands is being increasingly restricted as arable farming expands under such programmes as the National *Fadama* Development Project. The problem is that the development of *fadama* appears to be geared towards the benefits of arable crop farmers. There does not appear to be any arrangement for the benefit of pastoralists who also utilise *fadama* resources. Fagbemi and Abdullahi (1994) perhaps underscored the dimension of the conflict by stating, with respect to Pinuwa *fadama* at Birnin Kudu, Jigawa state, that the *fadama* is on the route of transhumant cattle movement and that there is an entrenched standing conflict between farmers and *graziers* of the site. On the Mambilla Plateau, it is reported that the *graziers* still bring their cattle to the valley farmlands (*fadama*) to graze and drink water in the dry season, destroying crops and farmlands in the process. Although the valley is designated "farmlands", ownership claims are still made on them by *graziers* (Fagbemi and Abdullahi, 1994). The conflicts between *graziers* and farmers usually lead to

destruction (waste) of growing crops, death of animals and sometimes loss of human lives. Such waste of scarce resources cannot be afforded. The challenge to *fadama* development planners, therefore, is to design property and tenure rights mechanism that would accommodate the interests of all the *fadama* users. In particular, planners should study the *fadama* land properly and preserve blocks of land within the *fadama* with access routes and watering points for pastoralists.

Similarly, the effect of *fadama* development on fishermen should be critically examined and strategies designed to safe-guard their interests. There are indications of forced migration of fishermen from areas currently being developed for arable farming.

Conflicts among arable farmers could also arise because they command unequal resources. Investment in irrigation schemes, even at small-scale level, is fairly capital-intensive. Only the rich farmers could afford pumps, tubewells or washbores. The tendency is towards expansion of cultivation by rich farmers into the lands of the poor. To promote peace, equity and social justice, it may be necessary to subsidise heavily the cost of irrigation for poor farmers to enable them enjoy the benefits of irrigation along with their rich counterparts. The current efforts of the NFDP to organise the *fadama* farmers into FUAs seems to be appropriate and should be further intensified as it will enable the poor farmers to pool their resources together to acquire technologies which they could not finance individually.

Conclusion

Under the agro-climatic conditions of northern Nigeria, *fadama* lands play a crucial role in the economic activities of rural farmers. This is attributable to water availability in the *fadama* when other areas are dry. The current policy of *fadama* development in the country, therefore, appears to be a step towards exploiting the potentials of the highly productive *fadama*. However, in order to continue to exploit these potentials without endangering their future productivity, a number of challenges have to be addressed. These challenges are generally in respect of utilising the *fadama* lands without precipitating environmental degradation problems. It would be necessary to make environmental impact assessments relating to ground water level, changes in soil composition and soil erosion. To be able to make these evaluations, the *fadama* development must be conducted in collaboration with research institutes and universities. There will also be the need to adequately equip the universities and research institutes with the necessary instruments and materials for making the required tests. Furthermore, to avoid conflicts, *fadama* development must be undertaken in an integrated fashion, taking into consideration the interest of different categories of users (farmers, pastoralists and fishermen), and specifying and enforcing their property rights to the *fadama* resources.

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