Increasing Food Security with Agrometeorological Information: Mali's National Meteorological Service Helps Farmers Manage Climate Risk

World Resources Report Case Study

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Suggested Citation: Hellmuth, Molly, D.Z. Diarra, C. Vaughan and R. Cousin. "World Resources Report Case Study. Increasing Food Security with Agrometeorogical Information: Mali's National Meteorological Service Helps Farmers Manage Climate Risk." World Resources Report, Washington DC. Available online at http://www.worldresourcesreport.org

INTRODUCTION

Throughout the 1970s and 1980s, a series of drought-related famine events plagued the Sahelian region.[1] Underscoring the critical link between climate and agricultural production, these events prompted Mali's national meteorological service, Direction Nationale de la Météorologie (DNM), to begin supplying local farmers with weather and climate information in 1982. By providing farmers with forecast information at critical points in the growing season, the meteorological service hoped to help rural communities manage the risk associated with a variable climate.

Recognizing the important interaction between meteorological factors and agriculture, the agrometeorological project was the first in Africa to supply climate information directly to farmers. It was also the first to teach farmers to measure climatic variables themselves, and the first to help farmers develop the skills necessary to use climate-related information in agricultural decision-making. And while the project was originally a modest one – dependent almost entirely on external funding – the last decades have seen it grow with government support. At present, Mali's agrometeorological project is a large-scale government-sponsored program involving government agencies, research institutions, media outlets, extension services, and farmer groups. The project uses a number of innovative methods, including roving seminars, to increase Malian farmers' ability to manage climate-related risk.

Since 1982, more than 2,500 farmers have directly participated in the program. Evidence suggests these farmers are able to use climate information to make better management decisions.[2] Anecdotal evidence also indicates that the project has empowered the farmers to take more risks, invest more in new technologies, and seek agricultural information from other sources. Farmers affiliated with the project consistently report higher yields, and correspondingly higher incomes, than farmers who have not used agrometeorological information.[3]

The success of Mali's agrometeorological project can be attributed to several factors, including its community-level focus and the creation of a unique pathway of communication – connecting farmers, agricultural extension workers, the meteorological service and a multi-sectoral team of national and regional experts. However, the project has also run into challenges – particularly the difficulty of providing reliable local-scale forecasts regarding the onset of the rainy season and the timing of possible dry spells. Despite these challenges, the agrometeorological project illustrates how useful climate information can be for rural communities. It also highlights the extent to which well-designed projects can facilitate the use of climate information by small-scale farmers.

BACKGROUND

One of the most socially and politically stable countries in West Africa, Mali nevertheless struggles with persistent food insecurity. More than 51 percent of Mali's 13.1 million people live on less than one dollar a day, and 11 percent are estimated to be undernourished. Despite recent strides in reducing Mali's food deficit, the absolute number of Malians who are severely undernourished has increased along with the country's growing population.[4]

Mali's struggle with food security has also been shaped by the country's evolving agricultural policy. Under colonial rule, the government encouraged the export of crops required by French industry, prioritizing cash crops at the expense of food items. When independence finally came in 1960, a socialist development strategy focused on commodity-based rural development without increasing food production. Indeed, Malian food production stagnated throughout the 1960s and 1970s; this situation was exacerbated by a series of droughts that ravaged West Africa through the late 1970s and early 1980s.[5]

In the mid-1980s, concern over Mali's deteriorating food security led to market reform measures that sought to increase farmer income and the incentives associated with producing cereals for market. Partly spurred by these reforms, total cereal production in Mali increased from 1.6 million tons in 1987 to 2.2 million tons in 1997.[6] The situation further improved in the first decade of the twenty-first century, with total cereal production at 3.8 million tons in 2007.[7]

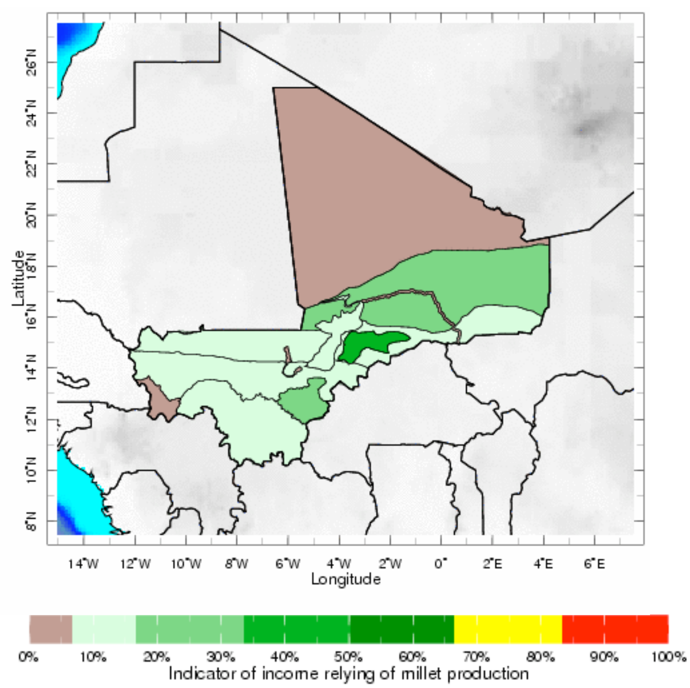

Figure 1: Percentage of income relying on millet production by livelihood zone (FEWSNET defined livelihood zones)

Despite these improvements, 4 out of 10 Malian children are underweight and 11 percent of the total population is undernourished.[8] In a country in which income is predominantly derived from agriculture (see **Figure 1**), much of this can be explained by the fact that Malian farmers continue to struggle with low technical capacity, a dearth of improved technologies, and severe imperfections in labor, food, and financial markets.[9] These impediments to production reduce yields, incomes, and ultimately food security.

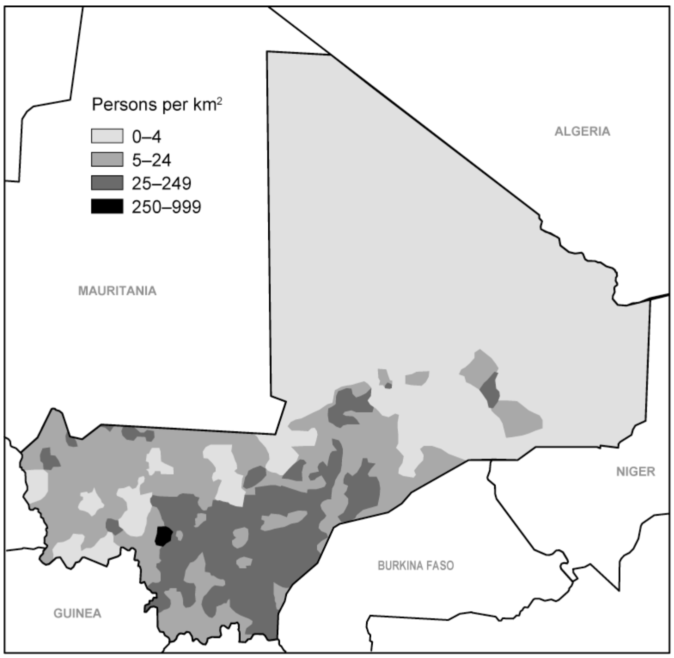

Figure 2: Malian Population Density. Source: Center for International Earth Science Information Network. www.ciesin.org

The persistence of Mali's food deficit is also linked to a heavy reliance on agriculture in the face of an inhospitable climate. While less than 4 percent of Mali's land-area is suitable for cropping, 80 percent of its population depends on agriculture for its livelihood. And even in the country's relatively rainy south, where most of Malians live (**Figure 2**), frequent drought makes predominantly rainfed agriculture a high-risk venture. As a result, Mali's cereal production is highly correlated to rainfall (see **Figure 3**).

DESCRIPTION OF CLIMATE RISK

Mali's climate is marked by a short, highly variable rainy season that usually falls between July and September. During this season, Mali's relatively wet southern region receives an annual average of 140 cm (55 inches) of rainfall. In the drier Sahelian zone, annual averages are closer to 23 cm (9 inches). In both areas, actual year-to-year (as opposed to average) rainfall is highly erratic, and droughts are both frequent and intense. Along with its Sahelian neighbors, Mali experienced a particularly extreme drought event in 1972-84; throughout the region, more than 100,000 people died and 750,000 were completely reliant on food aid for survival.[10]

Both the causes and the consequences of this drought have been extensively studied. Though one line of investigation originally blamed anthropogenic forces including deforestation and land use change for the region's severe drought in the 1972-84, recent research has demonstrated that the impact of global ocean temperatures on the region's climate also played a role.[11] In addition to a long-term drying trend, the region's rainfall varies cyclically over decades.

Climate predictions for the next few years remain highly uncertain, with some models predicting drying and others getting progressively wetter.[12] Temperature is expected to increase over the coming century.[13] A recent study showed that the number of extremely dry and wet years will likely increase during the present century.[14] This climatic uncertainty underscores the need for Mali to continue to improve its ability to manage climate-related variability. One project designed to address this, started by Mali's Direction Nationale de la Météorologie, has helped Malian farmers develop their ability to use climate information to manage risk since 1982.

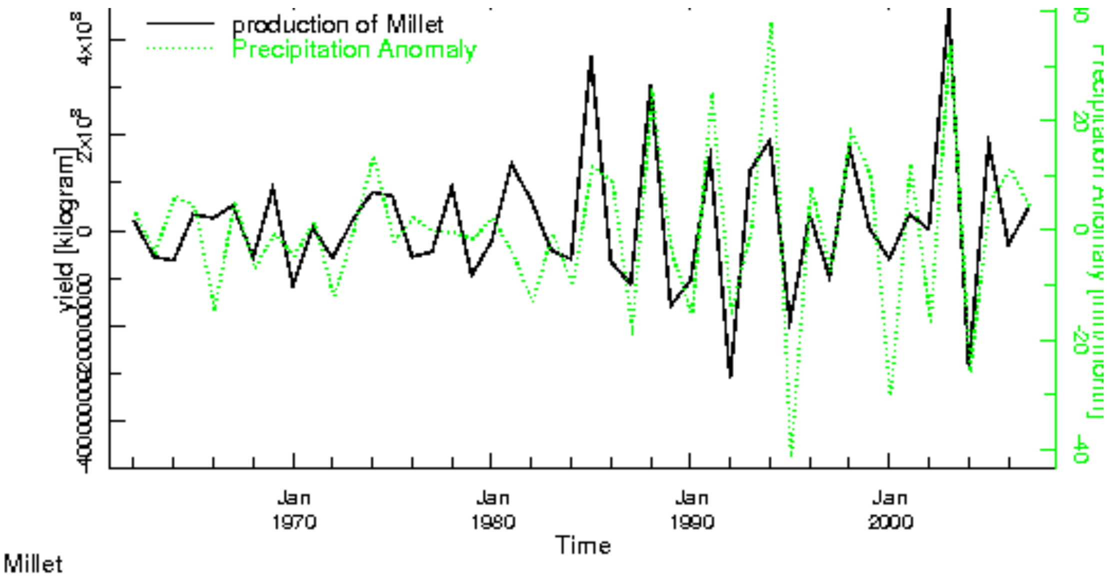

Figure 3: Millet production (FAOSTAT) and seasonal (May-Oct) rainfall (GPCCC) anomalies (correlation: 0.63)

THE AGROMETEOROLOGICAL PROJECT

In the wake of the 1972-84 drought, local, regional, and global institutions took steps to minimize the impacts of drought in the Sahel. A project led by Mali's national meteorological service was designed to help rural communities use meteorological information in agriculture-related decision-making. The project was carried out with technical support from the World Meteorological Organization (WMO) and the AGRHYMET Regional Centre and was funded by the Swiss Agency for Development and Cooperation.

First launched in 1982, Mali's agrometeorological project initially sought to identify whether and how climate information might be useful to farmers already receiving advice on seed selection, soil management and crop rotation from agricultural extension officers. As a first step, project staff visited farmers to ask what kind of information might be useful to them. Overwhelmingly, farmers requested information on the onset and end of the rainy season and the amount and distribution of rainfall. Once these needs were identified, steps were taken to enable farmers to access and make use of this kind of information.

In the first year, work focused on 16 farmers growing pearl millet, sorghum, maize, cotton, and groundnut in the southern region of Bancoumana. Each farmer managed two plots, one experimental plot in which they made decisions based on agrometeorological information and another in which they relied on traditional indicators – including the appearance of certain birds, the dropping of fruits from certain trees, and the movement of termites – to help them decide when to prepare fields, how and what to sow, when to weed, and when to apply inputs such as fertilizer and pesticide. Farmers in the program were able to transmit their experience to their neighbors, providing knowledge to the farming community as a whole.

The farmers were given gauges to measure rainfall in their fields and were trained in how to use their measurements to help them make decisions based on sowing calendars, which indicate suitable planting dates and appropriate crop varieties depending on rainfall. Farmers received 10-day bulletins on hydrological, meteorological, agricultural, and pest conditions in addition to daily and three-day weather forecasts (see **Table 1**). Farmers were regularly visited by project staff, who gathered feedback to improve the project itself.

In addition to the work conducted directly with farmers, the project also fosters cooperation and capacity-building in and between agricultural stakeholders. Much of this work is conducted by a multi-disciplinary working group. The group, which meets regularly at the ministry of agriculture, includes representatives from the meteorological service, the ministry of agriculture, agricultural research institutes, rural development agencies, farmer groups, and the media. The group works together to ensure that Malian farmers are able to use climate information to make decisions about their livelihoods. To this end, each member of the group provides specific inputs:

- Farmers define the climate-related data and products they need
- The meteorological service analyzes technical aspects of these data and products
- The Ministry of Agriculture, extension services, and research groups work on issues related to food production, crop health/protection, and choice of crop varieties
- The rural development agencies focus on capacity building and information dissemination
- The media sensitize users and disseminate climatic and agrometeorological information.

In the years since the project was started, one of the group's most important functions has been to act as a "boundary organization," bridging the gap between the climate and agricultural communities by interpreting climate information in order to provide advice to farmers. The multidisciplinary nature of the group also allows different expertise to be brought to bear on agriculture and food security problems.

In the first year of the project, the farmers reported increased yields in the plots where the farmers had used agrometeorological information. This prompted neighboring communities to request rain gauges, agrometeorological information, and training as well. To meet this demand, the project gradually expanded, training new farmers every year since 1982. By 1990, some 80 farmers had been formally trained, with many more receiving second-hand information through informal networks. At this point, the project managers reached out to national and rural television and radio networks to help them reach a broader audience.

In 1993, the project held its first stakeholder workshop in order to encourage participants to evaluate activities. Evaluation workshops are now held every two years in each of the six districts in which the project is held. This has also coincided with a scaling-up of project activities, resulting in the following:

- The number of farmers trained by the project is now more than 2,500.
- Local production of rain gauges has begun and is beginning to replace the more expensive imported gauges.
- Four local-level multidisciplinary teams have been created. These groups complement the national-level group, allowing the project to work more closely with farmers.
- Over 50 bicycles have been provided to representative farmers to facilitate the recording and transmission of rain gauge data to the national meteorological services, via regional offices.
- Agrometeorological information is now provided to an expanding number of farmers' organizations, rural programs, development agencies, and NGOs, including, for example, the Compagnie Malienne du Développement des Textiles (CMDT), the Office de Riz Ségou (ORS), the Office de la Haute Vallée du Niger (OHVN), and the Programme d'Appui aux Initiatives des Producteurs et Productrices Agricoles (PAIP/HELVETAS).

At present, data is collected from diverse sources (including the World Meteorological Organization (WMO), the International Research Institute for Climate and Society, the African Centre of Meteorological Application for Development (ACMAD), the national meteorological service, rural development and agricultural extension agents, and farmers) before being processed at three different levels. These include:

- Seasonal forecasts are produced by ACMAD using data from international sources. Information from these forecasts is not provided directly to farmers, but is processed by the multidisciplinary working group for use in preparing 10-day bulletins. The information is also supplied to the government for use in food security planning.
- Daily to three-day weather forecasts are prepared by the meteorological service according to WMO standards and are downscaled to specific target areas or regions. These forecasts are broadcast by national and local radio stations and the information is used by farmers in decision-making – including, for instance, when to prepare land, sow, and/or apply fertilizer and pesticides.
- The 10-day bulletins produced by the multidisciplinary working group provide basic information and advice to farmers, and to national policy makers on the food security status of the country. Disseminated by radio and television, the bulletins report on the state of crops, water resources, and weather conditions; they also provide important information on how to treat crop disease, manage pastures, care for animals, and navigate agricultural markets. In many cases, these bulletins also predict future conditions.

Given Mali's high illiteracy rate, radio broadcasts are a particularly important means of reaching rural people. According to an audience survey carried out in 2003 by Mali's Office du Radio et de la Télévision, 80% of radio audiences in the project areas follow the agrometeorological bulletins. Television is a less useful medium, as fewer than 1% of Malians own a television set, and these people are unlikely to be farmers. Nonetheless, the same survey found that 50% of the television audience followed the agrometeorological bulletins. Climate information is broadcast in French (the country's official language) and in all major local languages (e.g. Bamana, Bobo, Bozo, Dogon, Peulh, Soninke, Sonrai, and Tamatcheque).

Throughout the last decade, farmers reported significantly higher income from fields where agrometeorological information was used as compared to that from fields in which decision-making was based on traditional indicators (see **Table 2**). More recent figures from 2010 (see **Table 3**) demonstrate substantial increases in the yield of maize, sorghum and pearl millet, compared to national averages, in fields in which agrometeorological information is used.

Though further studies should be done, it seems clear that increases in production are tied to increases in farmers' ability to understand and assimilate agrometeorological information. By keeping close records of rainfall, farmers are also producing invaluable climatological profiles of their own fields and villages. Farmer statements suggest that they feel they are exposed to lower levels of risk as a result of the information, and are thus more confident about purchasing inputs such as improved seeds, fertilizers, and pesticides.

ROVING SEMINARS

Based on these results, the Malian government recognized the positive impacts of this project, and endorsed it with a financial commitment to strengthen the meteorological service. Improved buildings for the service opened in 2004, and about US$1.2 million was allocated for new weather stations and equipment in 2005–2006. More recently, the project has begun offering roving seminars on the use of weather and climate information for agriculture.

With the assistance of the World Meteorological Organization and the Spanish Meteorological Agency, these seminars are held in local communities throughout the country. Like the project itself, the overarching goal of these seminars is to increase agricultural production through the development of skills that lead to the effective management of climate risks and the rational use of natural resources. Specific objectives include informing farmers of the effects of weather, climate and climate change on rural activities; distributing and training farmers on the use of rain gauges; and developing a core group of farmers to further collect weather and climate data. To date, more than 500 farmers have participated.

Experience from these seminars has demonstrated that while there is a great deal of enthusiasm from farmers regarding the use of climate information, a number of challenges still exist. For instance, many farmers are not able to read or write, which limits their ability to record and understand climate data. There are also not sufficient funds to provide all farmers with the tools and training required to use agrometeorological information on their fields. Project officials are also worried about the recovery of data from the rain gauges that have been distributed, and are hoping to create methods to collect and use this data.

EXPLAINING THE SUCCESS OF THE AGROMETEOROLOGICAL PROJECT

Several factors have contributed to the success of this project, including:

- The drought-induced famine of the mid-1970s was a stark demonstration of the effects of climate on peoples' livelihoods; thus politicians began to give higher priority to managing climate risks
- Initial long-term support and commitment from the principal donor, as well as continued technical support from the World Meteorological Organization and more recently support from the Malian government
- The project's farmer-centered approach, which has led to the development and delivery of climate products and services that meet their needs
- Effective communication channels, especially between representative farmers and multidisciplinary working groups
- The use of radio as an effective medium for information dissemination.
- From the beginning, the project worked directly with community-level stakeholders and established two-way information flows.

CHALLENGES REMAINING

Despite its usefulness, the agrometeorological project remains limited. For instance, the project has so far focused on just a small range of crops, mainly cereals and cotton. Incorporating more staple food crops would allow the project to make a greater impact on food security. In addition, the project has so far not been able to meet the needs of herding families – a large and economically important group throughout the country. The project has also faced challenges associated with the reliability of local-scale information including downscaled seasonal forecasts, information on dry spells, and onset date for certain locations. More data are also needed on local soil conditions and water availability.

The project has also faced communication problems including difficulties in translating the more technical terms into local languages. Poor radio reception in some areas and little formal education among farmers have also posed challenges. Of course, these are symptoms of a broader challenge. Nevertheless, agriculturalists' understanding of the implications of weather and climate for farmers' practices has developed markedly in recent years and there is now a sizeable body of knowledge, together with some useful products, ready for extension. If this knowledge and these products could be used to complement the advice to farmers currently provided by the project, the additional impact on yields and incomes could be substantial.

In addition, the multidisciplinary-team approach has run into difficulties because of the different disciplinary interpretations of a given problem. For example, while the agrometeorologists tend to advise delayed sowing in order to minimize the risk of early-season drought, the agriculturalists prefer to promote more drought-resilient crop varieties and other technologies as the solution.

Finally, links to markets are crucial to the success of projects such as this one. Without access to a market, there is little or no incentive for farmers to increase production.

CONCLUSIONS AND LESSONS LEARNED

Ultimately, the project has shown that science, notably the increased skill of seasonal forecasting, could be used to provide farmers with a longer lead-time for their decision-making. The results of this long-term project indicate that the regular provision of agrometeorological information helps farmers manage the risks associated with increased climate variability. The project has successfully built a framework for gathering, analyzing, processing, and disseminating information that farmers can use. A particularly important role has been played by the project's multidisciplinary working group, which has served as a boundary institution by "translating" climate data into practical advice.

The evidence suggests that when farmers have good climate information:

- They are able to make better management decisions that lead to higher yields and incomes
- They are also prepared to take more risks, investing in new technologies that can raise yields and incomes still further
- They start to seek information from other sources to improve decision-making
- They are also able to undertake better actions for adaptation to climate change

The Malian government has witnessed the project's success, and has consequently committed itself to funding the project now that the external donor agency has withdrawn. The government is also investing further in the meteorological service and in new equipment and stations, in recognition of its important role in the country's development. Some challenges remain, however. Funding for extension is still very limited so that for example field visits have had to be reduced. And it is recognized that better integration of the products and knowledge developed through agricultural research could significantly enhance benefit to farmers.

TABLES

Table 1: Advice for farmers based on agrometeorological conditions during the period 11-20 July 2006 and valid for the period 21-31 July 2006. Courtesy of DNM.

LOCATION	ADVICE TO FARMERS
Sikasso, Bougouni, Kolondiéba, Koutiala, Kangaba, Kéniéba, Kita, Bancoumana, Siby, Dangassa, Dialakoroba, and Naréna	Can plant 90-day pearl millet or sorghum during the 10-day period 21–31 July 2006
Banamba	Can plant 90-day maize, groundnut, or cowpea if cumulative rainfall during 21–31 July 2006 is equal to or exceeds 10 mm
Mopti, Bankass, Koro, San, Kolokani, Nara, Nioro, Diéma, and Yélimane	Can plant 90-day pearl millet, sorghum, groundnut, or cowpea
Pastoralists and agropastoralists are advised to provide more feed for their livestock and to respect local rules regarding herd management and grazing areas, in order to ensure that livestock do not damage growing crops.	

Table 2: Crop yields and farm incomes for farmers taking management decisions with and without agrometeorological information, in the 2003-04 season.

Crop	Devel. zone	Field type	Area (ha)	Average yield (kg/ha)	Gross income (US$/ha)	Income gain in agromet fields (%)
Pearl millet	OHVN	Agromet	2,600	1,204	175	26
		Non-agromet	67,168	957	139	
	DRAMR	Agromet	750	757	110	10
		Non-agromet	45,790	690	100	
	ORS	Agromet	10,400	1,247	181	48
		Non-agromet	461,915	840	122	
Sorghum	OHVN	Agromet	5,375	1,427	193	42
		Non-agromet	470,996	1,005	136	
	DRAMR	Agromet	28,275	955	129	10
		Non-agromet	222,662	871	118	
	ORS	Agromet	2,850	1,562	212	56
		Non-agromet	179,853	1,002	136	

Maize	OHVN	Agromet	6,075	1,984	249	80
		Non-agromet	27,079	1,105	139	
Groundnut	DRAMR	Agromet	6,060	874	237	25
		Non-agromet	102,113	702	190	

Note: DRAMR = Direction Régionale d'Appui au Monde Rural; Source: SDC *et al.*, 2004.

Table 3: Crop yields for farmers taking management decisions with agrometeorological information compared to national averages, in the 2010 season. Data courtesy of DNM.

	MILLET			SORGHUM			MAIZE		
	AgroMet	**Average**	**% Change**	**AgroMet**	**Average**	**% Change**	**AgroMet**	**Average**	**% Change**
LOCALITIES	**Kg/ha**	**Kg/ha**	**%**	Kg/ha	Kg/ha	**%**	Kg/ha	Kg/ha	**%**
Ouélessébougou	1079	846	28%	1112	932	19%	2000	1331	50%
Bénéco	875	846	3%	1014	932	9%	2163	1385	56%
Dongorona	1312	846	55%	1142	932	23%	2199	1385	59%
Sougoula	1212	846	43%	2060	932	121%	1620	1385	17%
Dierra	1122	846	33%	1156	932	24%	1260	1385	-9%
Sanankoro Djitoumou	1395	846	65%	1300	932	39%	2270	1385	64%
Siramana	1165	846	38%	1317	932	41%	2566	1385	85%
Dialakoroba	1260	846	49%	1201	932	29%	1468	1385	6%
Sanankoroba	1117	846	32%	1011	932	8%	2842	1385	105%
Sananbélé	992	846	17%	1481	932	59%	2021	1385	46%
Average	**1152,9**	**846**	**36%**	**1279,4**	**932**	**37%**	**2040,9**	**1385**	**48%**

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