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Evaluating the Impact of the Wula Nafaa Natural Resources Management Program in Senegal on the Socio-Economic Status of the Population: A Quasi-Experimental Design Analysis

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List of Acronyms

DHS	Demographic and Health Survey
IFAD	Agricultural Fund for Agricultural Development
IRG	International Resources Group
OECD	Organization for Economic Cooperation and Development
PCA	Principal Component Analysis
UN	United Nations
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

This study is part of a larger retrospective of USAID's natural resources management and conservation programs in Senegal over the past 30 years, with a particular focus on the past 10 years.

It has become increasingly apparent in recent years that natural resource management rests on three interrelated development dimensions: environmental management (*Nature*), economic considerations (*Wealth*), and governance systems (*Power*). The three dimensions have formed the foundation of the Wula Nafaa program, which started in 2003 and is expected to end in 2014. Wula Nafaa's overall objective is to contribute to poverty reduction and sustainable local development by increasing the income of rural producers and the local communities through the empowerment of local authorities and the promotion of integrated, decentralized, participatory resource management.

The nature and power dimensions of Wula Nafaa will be analyzed in two separate investigations as part of the overall Wula Nafaa retrospective. The present study focuses on wealth.

The study attempts to answer the question of whether the program has resulted in increased household wealth -- or, equivalently, lower poverty -- in the project area. Quasi-experimental design is used to answer that question. The quasi-experimental design methodology compares changes over time for the treatment group (population living in the Wula Nafaa program area) and the control group (a similar population living outside the Wula Nafaa program area).

Wealth is multi-dimensional. It includes both physical assets and human capital, particularly education and nutrition. To overcome the limitations of measuring wealth through income and expenditure, researchers have developed a proxy measure in the form of an asset index. The index is a set of weighted indicators associated with financially-based definition of wealth, including durable assets such as refrigerators, television sets and motor vehicles. The indicators extend to other items of material comfort, including infrastructure and housing characteristics such as material of dwelling floor, main source of drinking water, type of toilet facility, and type of fuel used for cooking.

To derive an asset index that incorporates non-arbitrary weights, researchers have increasingly relied on Principal Component Analysis (PCA), a standard technique for computing statistically derived weights that can be used to compare the socio-economic status of households or populations over time and across space. Data used to derive

the asset index for this study were obtained from the 1992-93, 1997, and 2010-11 Senegal Demographic and Health Surveys (DHS).

The PCA results show that Wula Nafaa has achieved measurable gains across the board. Wula Nafaa has accelerated wealth creation. The wealth status of households was higher in the control areas than in the Wula Nafaa areas in 1997, before Wula Nafaa was launched. The situation was, however, reversed with the introduction of Wula Nafaa.

The wealth status pattern in the Wula Nafaa areas relative to the control areas in 1992-93 was similar to the pattern observed in 1997, providing further evidence that the introduction of Wula Nafaa in 2003 reversed a *longstanding* pattern in favor of the control areas to a new pattern in favor of the Wula Nafaa areas. Since physical assets are accumulated over time and last longer, this finding is likely to reflect structural – rather than temporary – effects, with long-term implications on living standards.

The PCA investigation also indicates that most of the benefits of the Wula Nafaa program have accrued to rural areas, where the poorest segments of the population are located.

Wula Nafaa has succeeded on other counts. A comparison of the employment status in both areas reveals that Wula Nafaa has generated significant employment security to both men and women and that the benefits to women have been more substantial. In addition, equality in employment opportunities between the poorest and richest quintiles is, on balance, more prevalent in Wula Nafaa areas than in the control areas for both men and women, suggesting that the benefits of Wula Nafaa have narrowed the wealth equity gap in the program area.

An equivalent comparison shows that equality in education status is higher in the Wula Nafaa than in the control areas for both men and women and that equality in educational opportunities between the poorest and richest quintiles is higher in the Wula Nafaa areas.

An examination of four widely used nutrition indicators reveals that the overall nutrition status is higher in the Wula Nafaa areas than in the control areas. This finding is particularly meaningful when stunting for under-five children is considered. Called “shortness” or *chronic* malnutrition, stunting is the most relevant long-term indicator of poverty or the overall well-being in a community because it reflects deprivation over a period of months or years.

INTRODUCTION

Background and Objectives

The present study is part of a larger retrospective of USAID's natural resources management and conservation programs in Senegal over the past 30 years, with a particular focus on the past 10 years. The retrospective is intended to consolidate USAID gains and further corroborate lessons learned from the implementation of the *Nature*, *Wealth*, and *Power* framework. Results of the study would guide future program directions and show how best to respond to new challenges as they emerge.

Three decades ago, rural development and natural resource management programs were predominantly driven by a strategy emphasizing technical solutions to perceived environmental crises. More recently, it has become increasingly apparent that natural resource management rests on three interrelated development dimensions: environmental management (*Nature*), economic considerations (*Wealth*), and governance systems (*Power*). From this perspective, natural resource conservation should be seen not only in the context of resource utilization, but also from the perspective of opportunities for sustainable economic opportunities. Similarly, property rights -- communal or private, formal or informal -- lay the foundation for natural resource utilization.

Implementation of Wula Nafaa[1] started in 2003 and is expected to end in 2014. The overall objective of the program is to contribute to poverty reduction and sustainable local development by increasing the income of rural producers and the local communities through the empowerment of local authorities and the promotion of integrated, decentralized, participatory resource management (IRG 2008). Program implementation is based on the premise that improved economic incentives and enhanced local governance will enable local communities to manage natural resources more sustainably.

The nature and power dimensions of Wula Nafaa will be analyzed in two separate investigations as part of the overall Wula Nafaa retrospective. The present study will focus on wealth. The analysis will attempt to answer the question of whether the program has resulted in increased household wealth -- or, equivalently, reduced poverty -- in the project area.

[1] Wula Nafaa means the benefits of the forest in the local Mandinka language.

Organization of the Report

The report is divided into six sections. Following this introduction, the evaluation methodology will be discussed. Section 3 will present the results of the Principal Component Analysis, a statistical methodology selected for this study. The wealth status of households in the Wula Nafaa and control areas will be investigated in Section 4. Section 5 will analyze the impact of Wula Nafaa on the employment, education and nutrition status of the rural communities affected. Major conclusions will be summarized in the final section. Additional, more detailed information is provided as annexes to the report.

METHODOLOGY

Quasi-experimental Design

USAID evaluations have generally emphasized what activities are being offered, what and how activities have been implemented, and whether expected results have been occurring. Emphasis has been placed on performance or process evaluations that have incorporated before-and-after comparisons, and have tended to rely on less formal modes of inquiry and less rigorously defined methods. One of the most recent USAID reforms has been to revitalize program assessments to include impact evaluations that "measure the change in a development outcome that is attributable to a defined intervention." These evaluations "are based on models of cause and effect and require a credible and rigorously defined counterfactual to control for factors other than the intervention that might account for the observed change" (USAID 2011).

Thus, impact evaluations focus on outcomes that reflect changes in well-being that can be attributed to a particular intervention such as whether people are healthier, better educated, or less vulnerable to adverse shocks. Evaluating the impact of that intervention hinges on a fundamental question: What would the situation have been if the intervention had not taken place?

The answer to that question has varied along a continuum of complexity and rigor, but has concentrated on the identification of changes in key welfare indicators among a group of participants through descriptive monitoring to impact evaluations. While descriptive monitoring leaves ample room for differing interpretations of how much the identified change can be attributed to the intervention, impact evaluation relies on more sophisticated methods to disentangle the net gains from that intervention. Impact evaluations vary in complexity from randomized designs to quasi-experimental methodology, to statistical controls and simulations using computable general equilibrium models.

Quasi-experimental design will be used in this investigation.[2] Quasi-experimental design is an experimental design methodology that does not meet all the necessary requirements to control influences of extraneous variables. Ideally, all variables in an

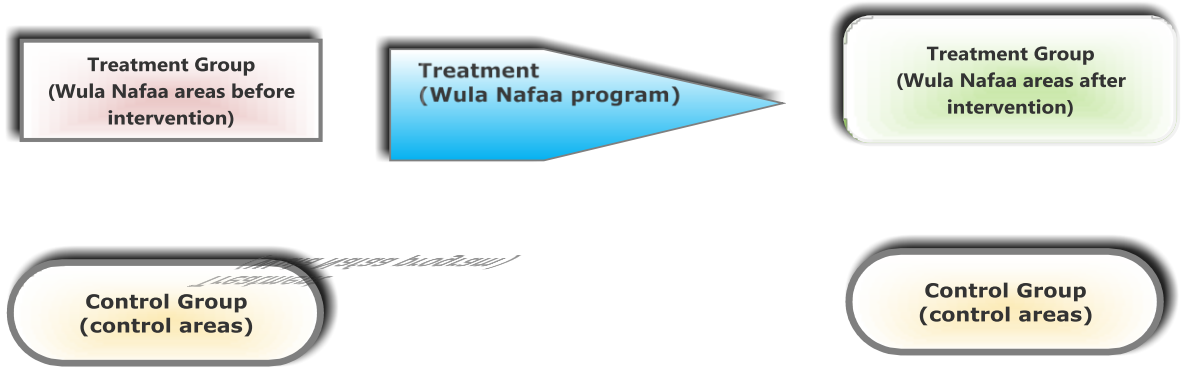
[2] Evaluations where a treatment group and a control group are selected randomly to assess the impact of new drugs, and certain health and nutrition interventions are routine or otherwise prevalent. In international development, randomized evaluations have been conducted on topics as diverse as the effect of school inputs on learning (Glewwe and Kremer 2005) or moral hazard and adverse selection in consumer credit markets (Karlan and Zinman 2005). However, research involving randomization remains the exception in international development, especially in agriculture and natural resources management.

experiment will be controlled. In such an experiment, if all the controls work as expected, it is possible to conclude that the results of the experiment are due to the effect of the variable being tested. More generally, experimental design enables the investigator to make claims of the following nature: "The two situations were identical until the intervention was introduced. Since the intervention is the only difference between the two situations, the new outcome was caused by that intervention."

The quasi-experimental design methodology used here will be based on comparing the treatment group (population living in the Wula Nafaa program areas) and the control group (population living outside the Wula Nafaa program area). It compares the *changes* in outcomes over time between a population that is enrolled in a program (the treatment group) and a population that is not (the comparison group).[3]

> Quasi-experimental design compares the ***changes*** in outcomes over time between a treatment group and a control group.

This comparison will de facto involve four different groups, not only two (see diagram below). The distinction between the four groups will be based on two determining factors: time and space. In addition to the group that received the treatment (population that benefited from Wula Nafaa), the three other groups are not affected by the treatment: the treated group prior to its treatment (population living in the Wula program areas before the program was introduced); the control group in the period before the treatment occurred (i.e., before Wula Nafaa was introduced to the Wula Nafaa program area); and the control group in the current period.



[3] Following the literature, the event for which an estimate of the causal effect is sought is called *treatment*. The *outcome* is what will be used to measure the effect of the treatment. The treatment and control groups do not necessarily need to have the same pre-intervention conditions. The two groups may well have different characteristics. However, many of those characteristics (e.g., level of economic development; a region's location close to the ocean or in a forested area) can reasonably be assumed to remain constant over time or at least over the course of an evaluation.

The rationale behind this empirical approach is that if the two Wula Nafaa and the two control groups are subject to the same time trend, then potential confounding factors are removed and the outcome – that is, the impact of Wula Nafaa -- can be estimated (see, for instance Lechner 2011; Card and Kruger 1994).[4]

Wealth Defined

Following the poverty reduction literature (See, for instance, USAID 2002; USAID 2006; World Bank 2001a; World Bank 2002; Sen 1993), wealth refers to whether households or individuals possess enough resources or abilities to meet their needs. From this perspective, wealth is multi-dimensional.[5] It includes both physical assets and human capital that relate to the vulnerability dimension of well-being, defined as the probability or risk of being in poverty – or falling deeper in poverty – at some point in the future. Vulnerability is a key dimension of well-being because it affects households' or individuals' behavior in terms of asset ownership, production patterns and coping strategies. In rural communities, vulnerability may be triggered by unexpected shocks such as illness, or seasonal events such as unemployment and crop failure.

In practice, wealth is measured by income indicators and ownership of human capital, particularly education and nutrition. Greater security can be achieved through income, including from employment. The relationship between poverty and employment is well established. The vast majority of people throughout the world depend on their labor as a primary source of income. Expanding employment opportunities for the poor may lead to skill acquisition among low-income groups, and most people move out of poverty by increasing their earnings from work.

[4] Fundamentally, quasi-experimental design is identical to the controlled experimental design, except that the subjects cannot be randomly assigned to either the experimental or the control group, or the researcher cannot control which group will get the treatment. Equivalently, participants do not all have the same chance of being in the control or the experimental groups, or of receiving or not receiving the treatment.

[5] According to the World Bank, "poverty is pronounced deprivation in well-being, and comprises many dimensions. It includes low incomes and the inability to acquire the basic goods and services necessary for survival with dignity. Poverty also encompasses low levels of health and education, poor access to clean water and sanitation, inadequate physical security, lack of voice, and insufficient capacity and opportunity to better one's life" (World Bank 2001a). The UN has a similar definition of poverty.

A close association also exists between education and higher earnings from nonagricultural activities. There is consensus among researchers that education is, in the long run, as important to poverty reduction as physical capital accumulation. In many settings, it is indeed the primary source of physical wealth.

Theoretical as well as empirical studies have shown the benefits associated with education, and the role schooling plays at both the individual and society levels (see for example, McMahon 1999 and Acemoglu 2009). Education is particularly important for girls and women, and investing in their education is one of the most effective ways to reduce poverty. This is true not only because education is an entry point to other opportunities, but also because the educational achievements of women can have ripple effects within the family and across generations (UN 2005).[6]

The relationship between human capital and maternal and childhood nutrition is equally strong. The *Lancet* series on maternal and child undernutrition (Victora et al. 2008) reviewed the associations of maternal and child undernutrition with human capital and risk of adult diseases in low- and middle-income countries. Analyzing data from five cohort studies from Brazil, Guatemala, India, the Philippines, and South Africa, the authors concluded that indices of maternal and child undernutrition were strongly associated with adult outcomes such as height, schooling and income or assets, and that preventing undernutrition would bring about health, educational and economic benefits.[7]

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[6] After examining the characteristics of households moving out of or falling into poverty in Ethiopia, one study (Bigsten et al. 2003) concluded that households with at least primary education have a higher probability of getting out of, and a lower probability of falling into, poverty. Another study (Fuwa 2007) used an approach based on socioeconomic groups to investigate the patterns of "poverty exits" in a village in the Philippines. Four socioeconomic groups were identified: the irregularly employed, the tenant-farmer, the small-owner and the regularly-employed. The study found that education was a key determinant in the movement toward the higher employment status. Grootaert et al. (1997) have found that, for rural areas in Côte d'Ivoire, each additional year of education in the household is associated with a 2000 CFA franc increase in expenditure per capita. A study conducted in Ghana on the impact of schooling (Gyimah-Brepong and Asiedu 2009) has shown that the higher the education level, the lower the probability of being poor and the smaller the income and expenditure gaps.

[7] A growing body of evidence has shown that undernutrition has a wide range of effects that impede not only children's development in the short term, but also their cognitive abilities and productivity in adulthood -- with measurable economic impact. Undernutrition affects health and survival through higher mortality and morbidity among neonates, infants, and children. Early childhood undernutrition also affects human performance through reduced motivation and persistence, lower physical-work capacity, and suboptimal cognitive development. Depriving infants and young children of the basic nutrition needed for growth and development sets them up to fail in life. In the long run, early childhood undernutrition may result in permanent changes in body structure and metabolism that may lead to higher risk for adult-onset chronic illnesses and disability.

An Asset-based Approach to Measuring Household Wealth

Economists have traditionally measured wealth using direct measures of economic status, including income and expenditure. However, direct measures of wealth have severe limitations, particularly in a developing-country context. Not only that income data are often unavailable, they are also inherently unreliable (see, for instance, McKenzie 2003, Filmer and Pritchett 2001).

Income data are associated with high non-response rates, and under- or over-reporting of income items used in standard-of-living surveys. Income estimates are also misleading because they fail to capture barter and similar non-monetary transactions. In addition, income in many developing areas is typically seasonal, especially for farmers, small-business owners and the informal sector. Taking a snapshot of their income at a single point in time will be highly non-representative, and capturing income information through interviewee recollection has well-known limitations due to the high potential for recall bias.

Economists have shown that expenditure or consumption data are associated with more robust conclusions on wealth than income-based indicators (see, for instance, Deaton 1997) mainly because households tend to be more forthcoming about sharing expenditure information. Expenditure data may also reduce the importance of seasonality because households tend to save part of their income for leaner times. However, many limitations remain -- including data inaccuracy due to recollection bias, the difficulty of measuring non-monetary transactions. Expenditure and consumption data are also expensive to collect and require complex statistical analysis techniques.

To overcome some of these limitations in measuring wealth, researchers have developed a proxy measure in the form of an asset index.[8] The household asset index is a proxy measure consisting of a set of weighted indicators associated with a financially-based definition of wealth, in the form of durable assets[9] such as refrigerators, television sets and motor vehicles. Those indictors are extended in the literature to other items of material comfort, including infrastructure and housing characteristics such material of dwelling floor, main source of drinking water, type of toilet facility, and type of fuel used for cooking.

[8] The asset index has also been termed in the literature as wealth index, index of living standards, socio-economic status index, and household asset index.

[9] Durables are manufactured products such as an automobile or a household appliance that can be used over a relatively long period without being depleted or consumed.

Asset-based analysis has several key advantages over income or expenditure approaches. First, asset data minimize error: When asking people what they own from a list of assets, there is often less likelihood of measurement or recall problems. Second, they are more accurate approximations of socio-economic status because they measure "permanent income" or financial stock, rather than "current income" or financial flow -- and hence are less prone to fluctuation. Third, since assets are accumulated over time and last longer, asset-based indicators describe long-term living standards more accurately than an income snapshot and reflect long-term household wealth, a critical feature when analyzing household socio-economic status over time.[10]

Although reliance on the wealth index is a relatively new development in the international development literature, it has emerged as the standard for analyzing socio-economic disparity. The index has been used as an indicator of relative wealth by the World Bank,[11] in the UNICEF Multiple Indicator Cluster Surveys, in the Demographic and Health Surveys (DHS), and in IFAD's routine surveys to assess the impact of its rural agricultural development projects worldwide.

> Asset-based analysis minimizes error, provides more accurate approximations of economic status, and reflects long-term household wealth.

Weighting household assets

As noted above, the household asset index is a set of indicators to which specific individual weights are assigned. Those indicators include items related to such categories as durable assets, sources of water supply, and type of toilet facilities and floor material.

It is tempting to think that since there is no *a priori* system of weighting the various assets, the most straightforward way to proceed is to assign an equal weight to each asset. However, despite its appeal in terms of simplicity and apparent objectivity, numeric equality is arbitrary and leads to inaccurate results. Assigning equal weights to all assets is equivalent to saying that individuals with different economic resources and standards of living will be assigned the same wealth status. For example, an individual

[10] In addition, adoption of the wealth index was based on the findings that its use resulted in outcomes similar to those obtained from an income, consumption or expenditure methodology (see, for instance, Filmer and Pritchett 2001; Lindlow 2002; Rady et. al 2009).

[11] Using an asset index, the World Bank developed a series of reports of health indicators by population wealth quintile for countries included in the Demographic and Health Surveys program. The reports have become an important source of information on poor-rich inequalities in child health in low- and middle-income countries.

who owns a radio and a bicycle would be assigned the same score as an individual who owns a television set and a motor vehicle.

To derive a wealth index that incorporates non-arbitrary weights, researchers have increasingly relied on Principal Component Analysis (PCA), a standard technique for computing statistically derived weights that can be used to compare the socio-economic status of households or populations over time and across space.

PCA offers several other advantages. First, it is a methodology in which the distribution of household assets weights luxury assets more heavily. Second, PCA determines the statistical relationship among a large, pre-determined set of indicators such as household assets by re-expressing them in terms of their underlying or latent structure. As such, it is an ideal data reduction tool for filtering out the statistical noise associated with highly correlated or redundant asset variables, especially when the distribution of variables varies widely across households.

Since the principal focus of PCA is on differences among groups of individuals -- defined in terms of the wealth or assets of the households where they reside -- it is a powerful tool for measuring relative wealth.[12] In this context, a household is defined as rich (poor) when it has more (less) than what is common to other households or what defines an average household in a given society.

The asset index can also be used to compare households (or any other living units) across settings (e.g., countries or rural/urban settings) or over time, provided the separate indices are calculated using the same variables. Since tPCA asset index is a relative measure of wealth, it is sensitive to contextual variations across countries or rural-urban settings.[13]

Data Sources, Sample Selection and Period Covered

Senegal has collected extensive demographic and socio-economic data from various surveys conducted over the past 30 years. In addition to three census rounds (1996,

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[12] Relative wealth and relative poverty are equivalent concepts because they are inversely related. Relative poverty is defined in reference to the overall distribution of income or consumption in a country. While the relative poverty line could be set at a given percentage of the country's mean income or consumption, absolute poverty is anchored in an absolute standard of what households should be able to count on in order to meet their basic food and non-food needs. The absolute standard is generally based on food-energy intake or the cost of basic needs.

[13] Since it is inappropriate to define an individual as poor if (s)he owns a car, yet lives in a rural community that has no electricity or piped water, this study uses a composite asset index that adjusts for rural urban differences.

1988 and 2002), a variety of surveys were conducted at the national level, including a 1978 survey on fertility; a 1993 survey on migration and urbanization; two household surveys in 1994-95 and 2001-2; a 2005 child labor survey; a 2006 poverty monitoring survey; and four demographic and heath surveys (DHS) conducted in 1986, 1992-93, 1997, 2005 and 2010-11.

Data used in this study are from the 1992-93, 1997 and 2010-11 DHS surveys.[14] None of the other surveys listed above could be used, either because they are not easily accessible to researchers or because the data contained in those surveys do not provide enough consistency over the survey rounds to be of any use in an impact evaluation.

Since Wula Nafaa has been implemented over the past 10 years, results for the 1997 and 2010-11 DHS are used in the analysis. Reference to the 1992-93 survey data are made only to place the results in a broader historical perspective.

DHS data typically draw upon responses to questions about household assets included in the DHS questionnaire, which were generally similar for all three surveys. The DHS surveys gathered information on a large number of indicators about employment; education; health, nutrition, and population; service use; and relevant behaviors of household members.

A major advantage of the DHS is that once the final report is published the original data set is made available to researchers, provided the output from the analysis is shared publicly. To download databases, researchers subscribe free of charge after submitting a brief description of their research interests. The DHS datasets can be downloaded in several formats: SPSS, SAS, STATA, and as flat spreadsheets. The list of variables and codebook of values for each variable are also made available. We used Microsoft Office Excel to extract the relevant data items from the flat data files and performed most of the analysis using imDEV, a statistical Excel add-on.[15]

Each survey consists of several datasets. The main set is for individual women records, but there are datasets for births, children, males, households, couples, and HIV test

[14] The Demographic and Health Surveys program is implemented by ORC Macro with support from USAID and other bilateral and multilateral organizations. Over 300 large DHS household surveys have been carried out at periodic intervals in over 90 countries across Africa, Asia, Latin America, the Middle East, and the former Soviet Union. Surveys are conducted under the auspices of, and in close collaboration with, national institutions. (For detailed information, see www.measuredhs.com.)

[15] The DHS surveys are major undertakings. For instance, the 2010-11 survey was based on about 8,000 households. Information on about 2,000 indicators was obtained mainly through interviews with about 5,000 men and 16,000 women. Downloading the DHS data and extracting the most relevant indicators for this study from the 1992-1993, 1997 and 2010-11 required an extensive and meticulous data management and analysis effort.

results. Many variables can appear in multiple datasets. For the purposes of this assignment the “households recode” dataset was the main data source.

A “geographic dataset” is also available for most DHS surveys, starting in the mid-1990s when GPS equipment became more widely accessible. A small spreadsheet contains geographic coordinates (latitude and longitude) for each cluster of sample households.

DHS surveys use a two-stage sampling procedure, first selecting locations for clusters, then selecting 20 households around each cluster. Individual household GPS coordinates are not available; all households in the vicinity of a cluster are assigned the central coordinates of the cluster.

With the geographic coordinates for each cluster, we could breakdown the sample dataset by province and district. Using a map of districts where Wula Nafaa has been active, we identified household clusters in the DHS survey that fell in Wula Nafaa districts. Within each district, the specific rural communities where Wula Nafaa has been implemented were identified. Wula Nafaa rural communities were compared with a control group consisting of sample households from surrounding rural communities. The household sample sizes used for this study are as follows:

	2010-2011	1997
Wula Nafaa	1,070	456
Control	1,480	983

The rural communities in Wula Nafaa (49) and control areas (84) were identified using Wula Nafaa program documents as well as direct interviews and other communications with local and foreign experts with particular knowledge of the Wula Nafaa and control areas and their geographic and historical context (a complete list of those rural communities is provided as Annex I). When identifying rural communities in the Wula Nafaa and control areas, particular care was taken to exclude from the sample the rural communities where the World Bank-financed Sustainable and Participatory Energy Management project (PROGEDE)[16] was implemented so that the results can be attributed solely to Wula Nafaa. Rural communities in the control areas were selected for their proximity and similarity to the Wula Nafaa areas.

We used ArcMap, a geographic mapping and analysis application, to identify the specific rural communities to which each household in the sample belonged.

[16] PROGEDE focused on the implementation and monitoring of over 300,000 hectares of environmentally sustainable community-managed forest resource systems in the Tambacounda and Kolda regions, forming in the process a managed protection zone around the Niokolo-Koba National Park.

Limitations of the Analysis

Since this investigation is observational in nature and no randomized treatment is made, the possibility exists – as with any quasi-experimental design -- that identified variations in the indicators used for analysis are spurious and due to some factor other than Wula Nafaa. However, there is wide agreement that though quasi-experimental designs do not allow the researcher to make definitive causal inferences, they provide the most rigorous analysis tools when experimental methods cannot be applied.

A second limitation of the study is that the employment, education and nutrition results were obtained by comparing the Wula Nafaa and control households in 2010-11, but no comparison over time could be made due to lack of data on those indicators before the 2010-11 DHS survey.

ASSET VARIABLES AND PRINCIPAL COMPONENT ANALYSIS RESULTS

Asset Variables Selected

The analysis is based on 18 variables with particular relevance to household wealth. These assets are divided into four broad categories: ownership of durable assets such as television sets and refrigerators; sources of water supply such as water piped into the compound, a well or a spring; the type of toilet facility used; and the main material of dwelling floor. Other relevant variables -- such as household ownership of livestock, household use of farming tools, number of rooms in the dwelling, and main cooking fuel used by households -- could not be included for lack of data across the surveys used.

Asset Factor Scores

A critical feature of the PCA-based asset index is its capacity to yield a smooth distribution of socio-economic status among the target population. Using a broad range of variables is a necessary condition to a meaningful analysis. It has been shown (McKenzie 2003) that using only one or two categories of variables (say, ownership of durable assets and/or type of toilet facility) is unlikely to capture inequality between households, making differentiation among socioeconomic groups difficult. This is all the more critical when similar groups are considered, such as those living in rural Senegal.

PCA can be most appropriately applied when the distribution of assets varies widely across households and when the asset variables are correlated. Assets that are more equally distributed among households carry a low weight in PCA results. An asset that all households own or that no households own will have a zero standard deviation and therefore zero weight.[17] Conversely, assets that are more unequally distributed among households are given more weight.[18] Thus, since assets with low PCA weights are of little help in differentiating among households, the analysis should focus on the assets that have the highest PCA weight.

In broader terms, a variable with a positive PCA factor score (i.e., high weight) is associated with greater wealth or higher socio-economic status, and a variable with a

[17] A variable is a number that may take different values in different situations. For instance, a wealthy individual may own more of particular asset than a poorer individual. Variations among variables are measured by the standard deviation, a statistical measure of the spread of a series of values of a variable around its mean.

[18] An equivalent interpretation of the PCA coefficients is as follows: If ownership of an asset is highly indicative of ownership of other assets, its coefficient will be positive; if ownership of an asset contains no information about ownership of other assets, its coefficient will be near zero; and if ownership of an asset means that a household is unlikely to own other assets, its coefficient will be negative.

negative factor score is associated with lesser wealth or lower socio-economic status. A variable with a zero factor score will not be useful in differentiating among households regarding their wealth.

Table 1 lists the variables used in this study, by wealth asset category – durable assets, sources of water supply, type of toilet facility, and type of floor material. It also shows the PCA factor scores (weights) for each variable included in the analysis for 1997 and 2010-11. Factor scores are presented for the total sample and by urban-rural location for both the Wula Nafaa and control areas.

Table 1 indicates that a large proportion of the variables have a low factor score (in absolute terms) hovering around zero over time and across locations. These include bicycles, cars/trucks in the durable asset category and pond/lake/spring or public tap in the source of water supply category. The low factor score associated with these variables will not be useful in comparing the wealth status of the populations in the Wula Nafaa and control areas. For instance, since very few people own a car or a truck, this asset cannot be used to make meaningful differentiation among households. Nor can we use a pond/lake/spring to differentiate among those households because this is the most common source of water supply in the area.

PCA weights are optimal weights; that is, for a given set of data, no other set of weights could be more successful in accounting for variance in the observed variables.

Other variables have very low (negative) factor scores – such as earth/sand floor or the absence of toilet facility – indicating that those variables are associated with a relatively high degree of poverty.

Variables with *consistently* highest factor scores – those ranging between 0.20 and 0.41 in both urban and rural areas and throughout the entire period -- are those associated with ownership of television sets and refrigerators, and with access to electricity and piped water into the compound. Based on these weights, it can be concluded that households with more television sets and refrigerators and which have access to electricity and water piped into the compound would have higher socio-economic status than the rest of the households.

Based on the above distribution of the factor scores among the wealth items used in this investigation, the analysis will be limited to the wealth indicators with the highest wealth scores: ownership of television sets, ownership of refrigerators, access to electricity, and access to water piped into the compound.

Table 1: Principal Component Analysis Asset Factor Scores, 1997 and 2010-11(*)												
Variable	Factor score											
	1997						2010-11					
	WNRU	WNR	WNU	CRU	CR	CU	WNRU	WNR	WNU	CRU	CR	CU
Durable assets												
Electricity	0.36	0.32	0.40	0.36	0.38	0.36	0.39	0.37	0.41	0.40	0.35	0.39
Radio	0.16	0.13	0.24	0.16	0.18	0.20	0.16	0.20	0.21	0.11	0.17	0.18
Television	0.27	0.29	0.25	0.27	0.26	0.35	0.38	0.36	0.40	0.39	0.36	0.38
Refrigerator	0.24	0.30	0.26	0.24	0.33	0.36	0.30	0.24	0.32	0.31	0.26	0.31
Bicycle	-0.01	-0.05	0.09	-0.01	-0.07	-0.05	0.00	0.03	0.06	-0.06	0.12	-0.05
Motorcycle/scooter	0.15	0.08	0.24	0.15	0.13	0.07	0.21	0.21	0.21	0.19	0.25	0.21
Car/truck	0.08	0.03	0.15	0.08	0.19	0.20	0.08	0.10	0.08	0.11	0.06	0.13
Source of water supply												
Water piped into compound	0.32	0.27	0.32	0.32	0.28	0.28	0.35	0.21	0.39	0.35	0.20	0.39
Pond/lake/spring	-0.03	0.00	0.00	-0.03	0.01	0.01	-0.08	-0.12	0.00	-0.07	-0.21	-0.01
Public tap	0.14	0.26	-0.04	0.14	0.12	0.12	-0.02	0.02	-0.07	0.01	-0.10	-0.03
Well	-0.33	-0.36	-0.26	-0.33	-0.24	-0.24	-0.26	-0.10	-0.35	-0.28	-0.09	-0.36
Toilet facility												
Flush	0.05	0.07	0.06	0.05	0.24	0.24	0.16	0.07	0.19	0.20	0.08	0.18
No facility/bush	-0.29	-0.28	-0.25	-0.29	-0.24	-0.24	-0.28	-0.38	-0.15	-0.21	-0.44	-0.17
Pit/latrine	0.28	0.27	0.23	0.28	0.21	0.21	0.19	0.37	-0.06	0.09	0.40	-0.08
Floor material												
Cement	0.35	0.29	0.34	0.35	0.23	0.23	0.23	0.35	0.35	0.26	0.25	0.06
Dung	-0.08	-0.05	0.00	-0.08	0.00	0.00	-0.17	-0.19	-0.19	-0.11	-0.13	-0.07
Earth/sand	-0.35	-0.33	-0.39	-0.35	-0.34	-0.34	-0.25	-0.21	-0.21	-0.31	-0.18	-0.31
Vinyl	0.16	0.28	0.08	0.16	0.23	0.23	0.17	0.09	0.09	0.09	0.08	0.06
Sample size	456	338	118	983	712	271	1,070	657	413	1,480	1,085	395
(*)WNRU: Wula Nafaa area, rural and urban; WNR: Wula Nafaa, rural areas; WNU: Wula Nafaa, urban areas. CRU: control area, rural and urban; CR: Control area, rural; CU: Control area, urban.												
Source: Principal Component Analysis results												

Classification of Households into Socio-economic Groups

DHS survey data on the household assets and characteristics listed in Table 1 served as a basis for deriving an asset index that has structural validity; that is, one that could be used to effectively discriminate among economically well-off and worse-off households. To capture such inequality and to confirm the internal validity of the derived asset index, households were ranked into quintiles from poorest to richest. A critical feature of the PCA-based asset index is its capacity to yield a smooth distribution of socio-economic status among the target population. As noted earlier, this feature is of crucial importance when similar socio-economic groups are being considered, such as those living in rural Senegal.

Table 2[19] shows that using the PCA asset index to categorize the households into quintiles, from poorest to richest, yields significant differences among socio-economic groups in the Wula Nafaa areas. Clearly, households in the fourth and fifth quintiles have more of each asset than households in the lower quintiles. Note also that the distribution of those assets changed from 1997 to 2010-11, reflecting a relative increase in wealth in the region. For instance, the percentage of population having access to electricity in the highest quintile increased from slightly over 58 percent in 1997 to 100 percent in 2010-11. Similarly, the percentage of population owning a television set in the fourth quintile increased from 0 percent in 1997 to nearly 53 percent in 2010-11. This distribution pattern is further illustrated for access to electricity in Figure 1.

Table 2: Wealth index in Wula Nafaa areas: distribution by quintile, 1997 and 2010-11 (percentage of households associated with each wealth asset)

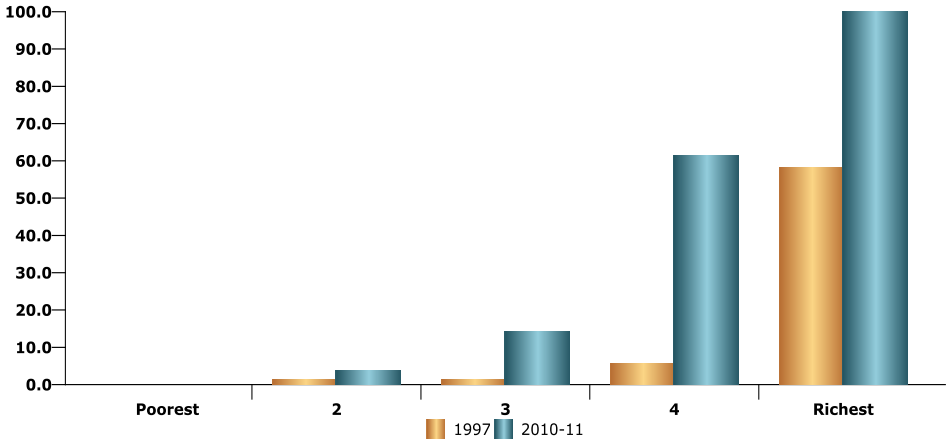
Wealth item	1997					
	Quintile					Average (*)
	Poorest	2	3	4	Richest	
Electricity	0.0	1.1	1.1	5.5	58.2	13.2
Television	0.0	2.2	1.1	0.0	30.8	6.8
Refrigerator	0.0	0.0	0.0	0.0	15.4	3.1
Piped water	0.0	0.0	0.0	4.5	41.1	9.1
Wealth item	2010-11					
	Quintile					Average (*)
	Poorest	2	3	4	Richest	
Electricity	0.0	3.7	14.0	61.2	100.0	35.8
Television	0.0	2.3	8.4	52.8	94.4	27.6
Refrigerator	0.0	0.0	0.0	2.8	50.0	10.6
Piped water	0.0	0.0	7.6	20.7	74.9	20.6

(*) Weighted by the number of households in each group

Source: Principal Component Analysis results

[19] Data in Table 2 are used for illustration purposes only. A full discussion of the results and their implications is presented in the next section. Detailed tables by year, geographic area, rural and urban location and income quintile are provided as Annex II.

Figure 1: Percentage of Households with Access to Electricity in Wula Nafaa Areas in 1997 and 2010-2011, by Income Quintile



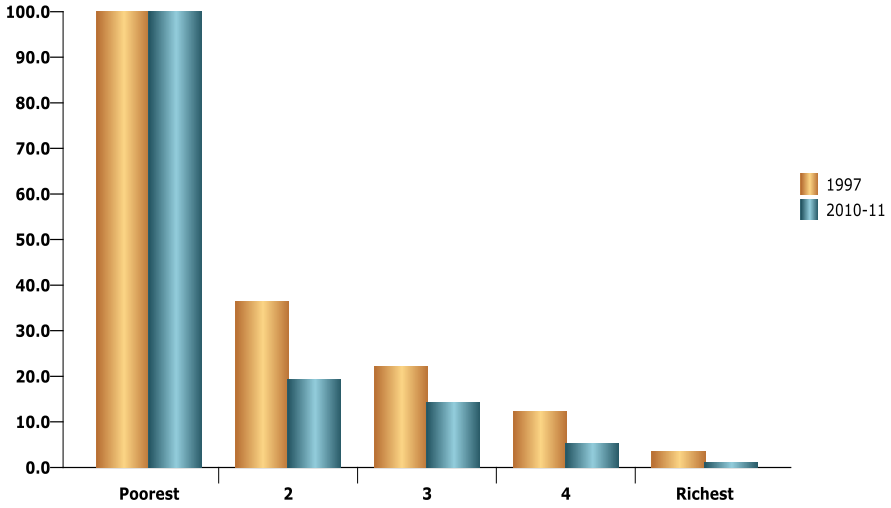
It is very important to note that this pattern is completely reversed for asset indicators with the lowest scores. As shown in Table 3, a higher percentage of households in the lower quintiles live in dwellings with earth or sand floor and no toilet facility – two dwelling characteristics with the lowest factor scores. Note also that the percentage of dwellings with those two characteristics tended to decrease over time for all households and more particularly for the lowest wealth quintile, reflecting the relative decrease in poverty in the region. This reversal in pattern for dwellings with no toilet facilities is further illustrated in Figure 2.

Generally, households in the fourth and fifth quintiles will own assets with high factor scores, whereas only a small percentage of the households in the first and second quintiles will own those assets. Conversely, a higher percentage of the households in the first and second quintiles will own assets with low factor scores.

Table 3: Wealth index in Wula Nafaa areas: distribution by quintile, 1997 and 2010-11 (percentage of households associated with wealth asset with the lowest PCA scores)

Wealth item	1997					
	Quintile					Average (*)
	Poorest	2	3	4	Richest	
No toilet facility/bush	100.0	36.3	22.0	12.1	3.3	34.7
Earth/sand floor	100.0	83.3	74.7	16.7	2.2	55.4
Wealth item	2010-11					
	Quintile					Average (*)
	Poorest	2	3	4	Richest	
No toilet facility/bush	100.0	19.2	14.0	5.1	0.9	27.9
Earth/sand floor	62.4	74.3	42.1	21.2	6.6	41.4
(*) Weighted by the number of households in each group						
Source: Principal Component Analysis results						

Figure 2: Percentage of Dwellings with No Toilet Facilities in Wula Nafaa Areas in 1997 and 2010-11, by Income Quintile



WEALTH STATUS OF HOUSEHOLDS IN WULA NAFAA AND CONTROL AREAS: OWNERSHIP OF DURABLE ASSETS AND ACCESS TO ELECTRICITY AND PIPED WATER

Table 4 describes the wealth status of households in the Wula Nafaa rural communities and the control group in 1997 and 2010-11. The percentage of population owning durable assets and having access to electricity and water piped into the compound was higher in the control rural communities than in the Wula Nafaa rural communities in 1997, before Wula Nafaa was launched. The differential is reflected in the ratio (less than unity) of the Wula Nafaa households possessing each wealth asset relative to the same households in the control communities possessing each asset.

> After trailing behind before Wula Nafaa was initiated, the Wula Nafaa program areas have outpaced the control areas in durable asset ownership and material comfort.

The situation was reversed with the introduction of Wula Nafaa. In 2010-11, the ratio for each wealth item was higher than 1, reflecting the fact that the percentage of households in the Wula Nafaa areas owning the same durable assets and having access to electricity and piped water exceeded the percentage of households associated with the same indicators in the control areas. This evolution in favor of the Wula Nafaa can be clearly detected in Figure 3.

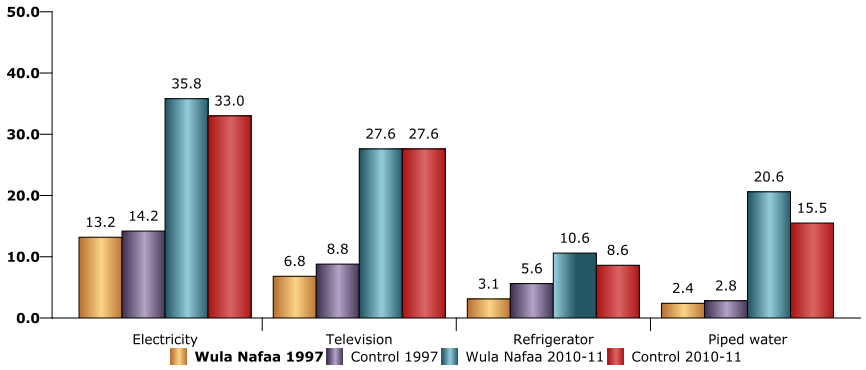
Table 4: Wealth status in Wula Nafaa and control areas, 1997 and 2010-11

Wealth Item	Percentage of population having wealth item					
	1997			2010-11		
	Wula Nafaa (a)	Control ((b)	Ratio (a)/(b)	Wula Nafaa (a)	Control ((b)	Ratio (a)/(b)
Electricity	13.2	14.2	0.93	35.8	33.0	1.08
Television	6.8	8.8	0.77	27.6	27.6	1.00
Refrigerator	3.1	5.6	0.55	10.6	8.6	1.23
Piped water (*)	2.4	2.8	0.86	20.6	15.5	1.33

(*) Rural areas only

Source: Principal Component Analysis results.

Figure 3: Percentage of Households Having Wealth Assets in Wula Nafaa and Control Areas (1997 and 2010-11)



It is worth noting that the wealth status pattern in the Wula Nafaa areas relative to the control areas in 1992-93 was similar to the pattern observed in 1997. This finding provides strong evidence that the introduction of Wula Nafaa in 2003 reversed a longstanding pattern in favor of the control areas to a new pattern in favor of the Wula Nafaa areas.

This result was significant across the board, but more substantial for certain items. For instance, the percentage of households owning a refrigerator in the Wula Nafaa areas, which was 45 percent lower in 1997, became 23 percent higher in 2010-11, for a net gain of nearly 70 percent over the control areas (compare corresponding ratios in Table 5, which illustrates this reversal further).

Table 5 shows that the annual percentage increase for all asset indicators was higher in the Wula Nafaa areas than in the control areas – over 30 percent higher for electricity, over 40 percent higher for television sets and piped water, and over 460 percent higher for refrigerators.

Table 5: Annual percentage increase in wealth status: Wula Nafaa and control areas, from 1997 to 2010-11

Wealth item	Wula Nafaa areas	Control areas
Electricity	13.5	10.2
Television	23.5	16.5
Refrigerator	18.7	4.0
Piped water	9.7	6.8
Source: Principal Component Analysis results.		

Table 6 demonstrates that the poorest segment of the population, which tends to be located in rural areas, have benefitted the most from Wula Nafaa. The table presents the annual increase from 1997 to 2010-11 in the percentage of rural and urban

households having access to electricity and piped water -- the two wealth indicators that have exhibited the highest PCA factor scores on a consistent basis throughout the 1992-193/2010-11 period (see Table 1). A comparison of the ratios of the percentage increase in the Wula Nafaa and control areas are significantly lower for the urban population (0.64 and 0.51) than for the rural population (1.05 and 3.78), indicating that most of the benefits of Wula Nafaa have accrued to the rural population.

Table 6: Percentage of households having access to electricity and piped water in Wula Nafaa and control areas: percentage increase from 1997 to 2010-11, by rural and urban location

	Rural			Urban		
	Wula Nafaa (a)	Control (b)	Ratio (a)/(b)	Wula Nafaa (a)	Control (b)	Ratio (a)/(b)
Electricity	431	411	1.05	46	71	0.64
Piped water	185	49	3.78	50	98	0.51

Source: Principal component Analysis results

WEALTH STATUS OF HOUSEHOLDS IN WULA NAFAA AND CONTROL AREAS: EMPLOYMENT, EDUCATION AND NUTRITION STATUS

Employment

Table 7, Figure 4 and Figure 5 describe the employment status of the adult population in the Wula Nafaa and control areas in 2010-11.[20] Employment status is determined by whether the person is currently working and whether he/she worked in the past 12 months, all year, for cash only, and as self-employed only.[21]

Table 7: Employment status in Wula Nafaa and control areas, 2010-11, by gender

Employment status	Percentage of population					
	Men			Women		
	Wula Nafaa areas (a)	Control areas (b)	Ratio (a)/(b)	Wula Nafaa areas (a)	Control areas (b)	Ratio (a)/(b)
Currently working	57.9	55.0	1.05	65.1	58.1	1.12
Worked past 12 months	57.9	55.2	1.05	65.7	58.1	1.13
Worked all year	50.6	40.7	1.24	72.5	61.0	1.19
Worked for cash only	59.8	58.2	1.03	73.4	72.8	1.01
Worked as self-employed only	82.7	82.3	1.00	86.3	68.2	1.27
Source: Principal Component Analysis results						

[20] Change in employment, education and nutrition status over time could not be investigated in this study because no data are available in the 1992-93 and 1997 DHS surveys. The discussion in this section will therefore be limited to a comparison of employment, education and nutrition indicators in the Wula Nafaa and control areas in 2010-11. However, since the pattern of these indicators in 2010-11 is similar to the wealth assets discussed in the previous section during the same period, there is no reason to believe that they did not follow the same patterns before 2010-11.

[21] Self-employment was selected over two related indicators included in the DHS survey (working for farm family member or working for someone else) because self-employment was associated with higher wealth in the PCA results. Similarly, working for cash only was selected over two related indicators included in the DHS survey (compensation in-kind or compensation for a combination of cash and in-kind) because working for cash only was associated with higher wealth in the PCA analysis. For instance, the percentage of self-employed in the Wula Nafaa areas is distributed as follows:

Gender/quintile	Poorest	2	3	4	Richest
Women	22	61	74	78	89
Men	46	51	50	72	84

As indicated by the ratio of the Wula Nafaa to control areas, the percentage of adult male population is higher for all employment status indicators in the Wula Nafaa areas – by 5 percent for current employment and employment during the past 12 months, and by as much as 24 percent for all-year employment.

As summarized in the separate ratios for men and women, the employment differentials are substantially higher for women than for men for three of the five indicators (12 percent for current employment, 13 percent for employment during the past 12 months, and 27 percent for self employment). In combination, the two results demonstrate that Wula Nafaa has generated significant employment security to men and women alike and that the benefits to women have been more substantial.

Figure 4: Employment Opportunities for Men in Wula Nafaa and Control Areas in 2010-11 (percent)

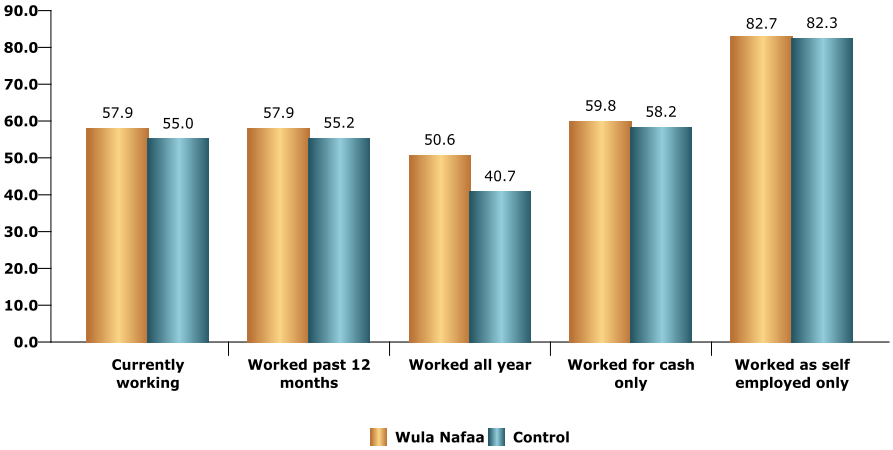
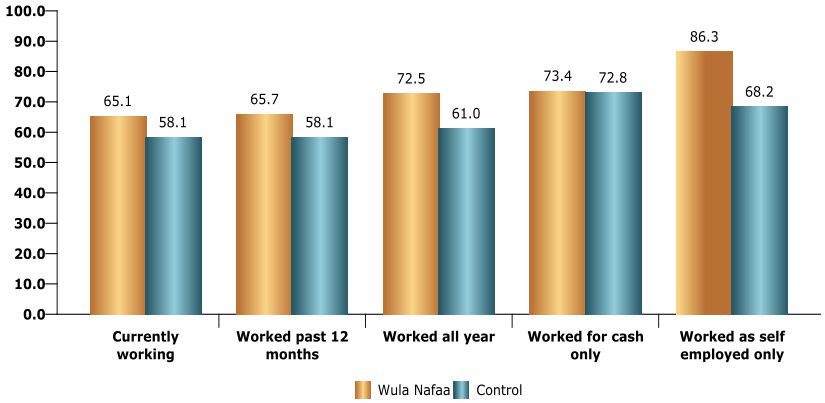


Figure 5: Employment Opportunities for Women in Wula Nafaa and Control Areas in 2010-11 (percent)



The low to high quintile ratio is a statistical measure of inequality. It is the ratio between the rate prevailing in the poorest population quintile and that found in the richest quintile.[22] A higher (lower) coefficient indicates higher (lower) equality in wealth status. Table 8 presents equality coefficients for the four employment indicators in the Wula Nafaa and control areas by gender. For men, three of the coefficients are higher for the Wula Nafaa areas (current employment, employment in the past 12 months and employment all year) against one coefficient for the control areas (self employment).

Table 8: Employment equality coefficients in Wula Nafaa and control areas in 2010-11, by gender

Employment status	Wula Nafaa areas		Control areas	
	Men	Women	Men	Women
Currently working	0.93	1.13	0.76	0.91
Worked past 12 months	0.93	1.10	0.77	0.91
Worked all year	0.39	0.24	0.36	0.41
Worked for cash only	0.55	0.25	0.56	0.43
Worked as self employed only	0.85	0.95	1.19	0.76
Source: Principal Component Analysis results				

For women, three of the coefficients are higher for the Wula Nafaa areas (current employment, employment in the past 12 months and self employment) against two coefficients for the control areas (working for cash and self employment). This comparison reveals that equality in employment opportunities is, on balance, more prevalent in Wula Nafaa areas than in the control areas for both men and women, suggesting that the benefits of the Wula Nafaa natural resources management program have narrowed the wealth equity gap in the region.

Employment opportunities in Wula Nafaa vs. control areas

- Wula Nafaa has generated higher employment opportunities for both men and women
- Employment opportunities have been higher for women than for men
- Wula Nafaa has reduced employment inequality between the poorest and the richest

[22] The low to high quintile *difference* is another statistical measure of inequality. It is the value of the lowest quintile minus the value of the highest quintile, expressed in absolute value.

This finding is all the more important because high levels of income inequality contribute to high levels of poverty in three major ways. First, for any given level of economic development or mean income, higher inequality implies higher poverty because a smaller share of resources accrues to those at the bottom of the distribution of income or consumption. Second, higher levels of inequality may reduce the benefits of growth for the poor because a higher initial inequality may lower the share of the poor's benefits from growth. Third, individuals and households do not assess their levels of welfare only in terms of their absolute level of wealth or poverty -- they also compare themselves with others.[23] Therefore, for a given level of wealth, high inequality has a direct, negative effect on welfare.[24]

It is important to note that the difference between the employment equality coefficients for men and women is higher for three employment indicators in the Wula Nafaa areas (current employment status, employment in the past 12 months and self employment) against only two indicators in the control areas (employment all year and employment for cash only), suggesting that equality in employment opportunities for women relative to men is higher in Wula Nafaa areas than in the control areas.

Education

The education status in Wula Nafaa and control areas in 2010-11 is summarized in Table 9 and Figure 6. The population with no education is, on average, about 71 percent of the total population in Wula Nafaa areas and 74 percent in the control areas, indicating a higher education status in the Wula Nafaa areas. A comparison of the poorest to richest quintile ratios in both areas shows that equality in education status is higher in the Wula Nafaa than in the control areas for both men and women.[25]

Table 9: Education status in Wula Nafaa and control areas in 2010-11, by gender

Area	Percentage of population with no education			Inequality coefficient	
	Men	Women	Weighted average	Men	Women
Wula Nafaa area	69.3	78.1	70.9	1.20	1.05
Control area	73.1	77.4	73.8	1.33	1.18
Source: Principal Component Analysis results					

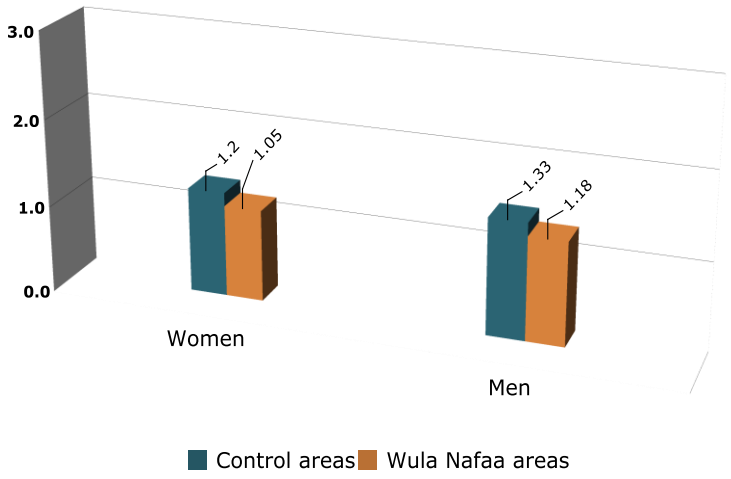
[23] This is consistent with the relative deprivation theory developed by W.G. Runciman (Runciman 1966).

[24] It should also be noted that several studies have shown a strong link between equitable distribution of environmental benefits and poverty alleviation (see, for instance, USAID 2006 and Naschold 2002).

[25] Since the figures in the table describe the population with *no* (not *with*) education, a lower coefficient (that is, a lower poorest/richest quintile ratio) indicates lower inequality (or, equivalently, higher equality) between the poorest and richest segments of the population.

Although the percentage of women with no education is nearly identical in the Wula Nafaa and control areas (about 78 percent and 77 percent, respectively), the poorest to richest quintile ratio for women is lower for Wula Nafaa than for the control areas (1.05 and 1.18, respectively), reflecting higher equality in educational opportunities between the poorest and richest quintiles in the Wula Nafaa areas.

Figure 6: Inequality Coefficients for Education Status in Wula Nafaa and Control Areas in 2010-11, by Gender



This finding is important for at least two reasons. First, education is associated with positive direct, indirect and intergenerational effects (for details, see Section 2.2). Second, education plays a key role in the changing dynamics of poverty in Senegal. A recent study (Diawara 2011) shows that the higher the education levels in Senegal, the higher the probability of moving out of poverty. This result is reflected in the finding that all education levels have a positive and significant impact on the transition of cohorts from the poorest quintile to the richest. In addition, the results hold for different poverty lines, different concepts of poverty (extreme and moderate poverty), and different samples (women versus men).

Nutrition

According to UNICEF's 2012 State of the World's Children, 24,000 children under the age of five die every day — nearly all of them in developing countries. In Senegal, 34,000 under-five children die every year (UNICEF 2012). In up to one-half of the nearly 8 million annual deaths of under-five children worldwide, an underlying cause is nutrition. A 2006 World Bank review reports that among 10 selected risk factors of major

burden of disease in developing countries with high child mortality and high or very high adult mortality, five are directly related to nutrition (World Bank 2006).

The factors determining nutrition status are multisectoral. Any project activities that increase household income or improve household conditions have the potential to decrease chronic malnutrition. International research has shown that change in nutrition status is a practical indicator of the impact of poverty reduction programs. According to the Food and Agriculture Organization of the United Nations, the prevalence of chronic undernutrition is a relevant and valid measure of endemic poverty and is a better indicator than are estimates of per capita income" (FAO 2004). Child malnutrition indicators are also included as an indicator of poverty in the UN Millennium Development Goal system.

The nutrition status of women and under-five children in the Wula Nafaa and control areas is depicted in Table 10. Anemia, underweight, stunting, and wasting[26] are the four indicators most widely used to describe the nutrition status of a population.[27]

Table 10: Nutrition status of women and under-five children in Wula Nafaa and control areas, 2010-11

Nutrition indicator	Percentage of households	
	Wula Nafaa area	Control area
Women		
Anemia	59.0	61.0
Under-five children		
Underweight	5.5	6.3
Stunting	6.8	7.1
Wasting	2.1	1.2
Source: Principal Component Analysis results.		

[26] Figures discussed in this section are for severe underweight, stunting and wasting (see next footnote for definitions).

[27] *Malnutrition* refers to a variety of nutrition-related factors such as inadequate diets, infections, undernutrition, and micronutrient deficiency. *Undernutrition* refers to three normalized indictors: underweight, wasting, and stunting. Mild, moderate and severe *underweight* is a composite measure of short-term and long-term undernutrition, corresponding to less than one, two or three standard deviations from median weight for age of the reference population. Mild, moderate and severe *stunting* is an indicator for chronic undernutrition, corresponding to less than one, two or three standard deviations from median height for age of the reference population. Mild, moderate and severe *wasting* is an indicator for inadequate nutrition in the recent past, corresponding to less than one, two or three standard deviations from median weight for height of the reference population. Globally, the most significant contributor to the onset of *anemia* is iron deficiency. Among the other causes of anemia are: heavy blood loss as a result of menstruation; parasite infections that lower blood hemoglobin concentrations; and acute and chronic infections, including malaria, tuberculosis, and HIV.

An examination of the four indicators reveals that the overall nutrition status is higher in the Wula Nafaa areas than in the control areas (Table 10). At 59 percent, anemia for women is lower than in the control areas (61 percent). Although wasting among children is more prevalent in the Wula Nafaa than in the control areas, the percentage of underweight children is lower in the Wula Nafaa than in the control areas (5.5 percent and 6.3 percent, respectively) -- and so is the percentage of children suffering from stunting (6.8 percent and 7.1 percent, respectively).

Stunting merits particular mention. Called "shortness" or *chronic* malnutrition, stunting is the most relevant indicator of poverty or the overall well-being in a community because it reflects deprivation over a period of months or years. Occurring over time starting before birth, It is a form of malnutrition caused by poor maternal nutrition, poor feeding practices, poor food quality, and frequent infections slowing down growth. Children who are chronically malnourished suffer irreversible disability in mental and physical development, causing poor performance in school and reduced physical productivity for the rest of their lives.[28]

> The overall nutrition status is higher in the Wula Nafaa areas than in the control areas. In particular, chronic malnutrition, a long-term indicator of the overall well-being in a community, is lower in the Wula Nafaa areas than in the control areas.

Stunting is therefore a particularly appropriate indicator of wealth or poverty over the long term, unlike wasting or "thinness," a health state characterized by rapid loss of fat and muscle weight loss caused by inadequate nutrition in the recent past as a result of temporary shocks such as famine, floods, or epidemic illness. The measurable impact of Wula Nafaa in reducing stunting among children in the program area is particularly

[28] Substantial evidence shows that human capital in adulthood as a result of better childhood nutrition is associated with higher earnings. For instance, one study (Vogel 2012) analyzed the relationship between height and wages in Mexico and concluded that taller workers were paid higher wages. A prominent explanation for this finding was that physical growth and cognitive development shared childhood inputs, inducing a correlation between adult height and two productive skills: strength and intelligence. Investigating the height–cognitive achievement slope among Indian children, another study (Spears 2012) concludes that taller children perform better on average on tests of cognitive achievement, in part because of differences in early-life health and net nutrition. Another study (Thomas and Strauss 1997) shows that adult height affects wages in Brazil. Alderman et al. (2006) report that during droughts in Zimbabwe in the 1980s, infants younger than 2-years old had higher undernutrition due to low rainfall during that period. A study that followed these children to their young adult years showed that child stunting led to fewer completed years of school, translating into a 14 percent reduction in lifetime earnings. It has been estimated (Grantham-McGregor et al. 2007) that the overall loss in adult income from being stunted is about 22 percent.

significant because the proportion of children who are stunted in Senegal is 8 times the level expected in a healthy, well-nourished population (ORC Macro 2006).

CONCLUSIONS AND RECOMMENDATIONS

Wula Nafaa and Wealth

This study lends empirical support to the conclusion that Wula Nafaa has delivered a crucial impetus to poverty alleviation in the program area through physical asset growth and human capital accumulation. After trailing behind before Wula Nafaa was initiated, the Wula Nafaa program areas have outpaced the control areas in durable asset ownership and material comfort. They have also outperformed the control areas in employment, education and nutrition status.

The poorest segments of the population and women have been the primary beneficiaries of Wula Nafaa achievements, with positive effects on socio-economic equality. Equality in employment opportunities between the poorest and richest quintiles is, on balance, more prevalent in the Wula Nafaa rural communities than in the control group, and so is equality in education status. The benefits of Wula Nafaa have also narrowed the gender gap in the program area. The employment status in the Wula Nafaa rural communities and the comparison communities reveals that Wula Nafaa has generated significant employment security to both men and women, but that the benefits to women have been more substantial.

Gains to women and the poor are particularly noteworthy. According to the OECD Development Center, the Gender Inequality Index score in Senegal in 2011 places the country at 114 out of 146 countries. While Senegal is relatively well-off in comparison to some of its neighbors, inequality is widespread and, as a result of an inequitable distribution of wealth, there are relatively higher poverty levels in rural areas. In those families touched by poverty, women and girls are disproportionately affected (OECD 2012; CIDA 2012).

From Performance Monitoring and Evaluation to Impact Evaluation

Demonstrating that interventions cause development effects depends on theories and rules of causal inference that can support causal claims. In an attempt to provide the strongest evidence of the relationship between Wula Nafaa and its benefits, this evaluation has attempted to apply a rigorous methodology that extends beyond the

performance or process evaluation approach traditionally used to support the performance management or "Managing for Results" process.[29]

Since randomization was not feasible, not least because this is not a prospective evaluation – i.e., one that was not designed and built into program implementation -- a matching group was constructed to strengthen the causal mapping. Matching consisted of selecting a nonparticipant group comparable in essential traits to the Wula Nafaa rural communities. The counterfactual was constructed on the basis of the situation of program participants (Wula Nafaa households). Program participants were compared to themselves and to the matching group (matching non-Wula Nafaa households) before and after the intervention.

This study has demonstrated that the experimental design methodology offers a unique tool for evaluating the impact of natural resource management programs in the most rigorous way feasible, and that it could be successfully applied to other programs whenever data similar to those used in this study are available.

Determining When an Impact Evaluation Is Needed

To shed some light on when an impact evaluation should be conducted, USAID evaluation guidance (USAID 2011) states that "for Missions engaged in the preparation of a three- to five-year Country Development Cooperation Strategy, mission leadership will identify at least one opportunity for an impact evaluation for each Development Objective." However, the guidance does not specify when and on what basis impact evaluations should be conducted.

There is agreement that impact evaluations are time- and resource-intensive, and should be applied only selectively. For this reason, impact evaluations should generally focus on interventions where they are likely to be most useful – that is, when there is a clear need for the information to be generated as well a strong intent to use the findings. To justify mobilization of the technical and financial resources needed to conduct such a demanding task, the program to be evaluated should be strategically important, innovative (testing a promising approach), or replicable (can be scaled up or applied in different settings).

[29] It may be useful to contrast the methodology used in the present evaluation with a Wula Nafaa program evaluation conducted in 2006. After presenting a list of results from the performance management plan (PMP) related to the wealth component, the evaluation states: "Though difficult to monitor and to estimate with any degree of accuracy, such impacts are clearly widespread" (Weidemann Associates). But no evidence – anecdotal or otherwise – was given to substantiate the statement.

Determining if an Impact Evaluation Is Methodologically Feasible

The main challenge of an impact evaluation is to identify a valid counterfactual – that is, to determine what would have happened had the program not existed or, equivalently, to demonstrate the causal relation between the program and the outcome under consideration. Attribution is all the more challenging because it is rarely the case that the intervention is the sole cause of the change.

Quasi-experimental design is used in this investigation to address the attribution question. When considering the attribution question, it is critical to distinguish between an impact evaluation and a process or operational evaluation. While an impact evaluation attempts to establish causality through a valid counterfactual, a process evaluation compares what was planned with what is actually delivered to identify potential gaps between and realized outputs.

When considering the attribution question, it is equally important to bear in mind that an impact evaluation cannot be conducted through a "reflexive comparison," one in which program participants are compared to themselves before and after the intervention, thus serving as both treatment and comparison group. A fundamental drawback with reflexive comparison is that the situation of program participants before and after the intervention may change for reasons that have little to do with the program itself.[30]

[30] The best evaluation design will depend on a variety of factors, including the objective of the evaluation; data, budget and time constraints; whether the evaluation is designed to assess medium- or long-term impact once the intervention is completed; and the size and scope of the intervention. In certain cases, reflexive design may be the only way to perform an evaluation – for instance, in situations of full coverage interventions such as nationwide programs in which the entire population participates and there is no scope for a control group. Reflexive design can also be selected for reasons unrelated to feasibility. For instance, after recognizing that the method cannot be used to attribute changes to project activities, IFAD argues that "control groups are not appropriate for IFAD projects for two […] reasons: ethical concerns and the cost and complexity of project management. Ethical concerns arise because of the deliberate exclusion of control villages or households during the spread of the involvement in development activities or the engagement of other partners. Control groups also essentially double the cost of each assessment in terms of time and budget" (IFAD 2005). In those instances, the main points of comparison are found within the project area over time (changes from benchmark to completion) and, if available, with comparable national or sub-national indicators.

Building the Impact Evaluation into Program Design and Implementation

A series of concrete evaluation questions is the starting point of an effective impact evaluation. The evaluation questions should be tailored to the specific policy of interest and should identify the impact or causal effect of the program on the outcome under consideration.

This evaluation has analyzed the impact of Wula Nafaa on the socio-economic status of the local population only in terms of wealth creation and poverty reduction (*Wealth*). However, as defined in USAID's nature, wealth and power framework, natural resource conservation should be seen not only from the perspective of sustainable economic opportunities, but also in the context of the natural resource base and the governance architecture that lay the foundation for natural resource utilization.

Since no impact evaluation data were collected by Wula Nafaa program implementers on any of those three dimensions, this evaluation used DHS socioeconomic data that covered the Wula Nafaa program period. However, for lack of data on natural resource utilization and governance systems, the evaluation could not assess the impact of the program on natural resources (*Nature*) or governance systems (*Power*).

The lack of data to conduct a more comprehensive investigation indicates that an impact evaluation should be viewed as an integral part of program design. Early planning will enable the design of an impact evaluation based on the most rigorous and most suitable methodology available at the design stage. It will also provide the time and resources needed to: (1) verify the integrity of the treatment and comparison groups; (2) identify the indicators needed to analyze the evaluation questions; (3) collect the baseline data in the evaluation areas prior to the start of the program for both the treatment and comparison groups; and (4) carry out subsequent data collection, analysis and dissemination tasks.

Combining Impact Evaluation with Monitoring and Process Evaluation

Although an impact evaluation can be distinguished from other evaluation methods, it should not be conducted independently of program monitoring and process or operational evaluation (M&E). The impact evaluation complements the M&E system and is not a substitute for it.

Monitoring data enable program implementers to document beneficiary participation, how fast the program is expanding, how resources are being utilized and whether activities are being implemented as planned. The process or operational evaluation

compares what was planned with what is actually delivered to identify potential gaps between planned and realized outputs. As such, they represent a valuable source of information on how program implementation can be improved and on lessons learned for future program design and implementation.

However, the M&E framework does not demonstrate whether indicators, targets and achievements are a *result* of program interventions. It is the role of the impact evaluation to document whether program participants are benefitting from the program *and not from any other sources*.

Documenting both Effectiveness and Cost-effectiveness of Alternative Interventions and Implementation Approaches

Evidence from an impact evaluation should extend to individual program components, intervention alternatives and implementation approaches, so that stakeholders can assess which alternative is most effective in reaching a particular goal. When an impact evaluation is testing program alternatives, adding cost information enables policymakers to analyze various scenarios in terms of cost-effectiveness. Cost-effectiveness may be defined as the achievement of maximum provision of goods or services from given inputs. It helps identify interventions that use resources most efficiently. To be operationally most useful, an impact evaluation – which estimates the benefits and effectiveness side of the program – should be complemented with detailed information on the cost of the interventions being evaluated.

From Income and Expenditure to Asset-Based Analysis

This study has used the household asset index, a proxy for measuring income and expenditure. The asset index describes long-term living standards more accurately than an income snapshot because physical assets are accumulated over time and last longer. From this perspective, asset-based indicators reflect long-term household wealth, a critical feature when analyzing the socio-economic status of households over time.

To derive the asset index, the Principal Component Analysis (PCA) methodology was used to derive non-arbitrary weights. PCA was applied to available data on durable assets, sources of water supply, toilet facilities, and floor material to assess the impact of Wula Nafaa. A major conclusion of this study is that – in addition to the advantages of PCA over income- and expenditure-based approaches – the PCA methodology yields intuitive, robust and consistent results that can reliably be applied to assess program

impact in a variety of developing-country settings. The World Bank, UNICEF, IFAD and other development organizations have increasingly used the PCA methodology to capitalize on those characteristics.

Impact Evaluation Using DHS and Similar Wealth Asset Indicators

An important conclusion of this study is that the DHS surveys represent a source of relevant data of unparalleled depth that USAID should tap into to conduct its impact evaluations, whenever possible. Although health projects can benefit from DHS data the most, the methodology used in this study has demonstrated that the surveys can dependably be used to conduct impact evaluations of agricultural and natural resources management programs.

It can be argued that since the DHS surveys are typically conducted every 5-7 years in a given country, they may not coincide with the beginning and end of a program for which USAID may want to conduct an impact evaluation. However, in those cases USAID could collect comparable baseline and end-of-program information on such indicators as household assets, employment, and similarly practical variables that can be readily and most cost-effectively collected and analyzed to assess change.

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ANNEX I: List of Rural Communities in the Wula Nafaa and Control Areas

Wula Nafaa Areas	
Baghere	Koussanar
Balingore	koussy
Bamba Thialene	Kouthia Guaydi
Bambali	Maka Coulibantang
Bandafassi	Mangagoulack
Bassoul	Medina Sabakh
Bembou	Méréto
Boynguel Bamba	Missirah Simana
Dakateli	Ndame
Darsalam	Ndjirnda
Diegoune	Ngayene
Diende	Niagha
Dindifello	Nioro Alassane Tall
Dionewar	Oudacar
Diouboudou	Paos Koto
Djilor	Pass Koto
Djiredji	Sakar
Ethiolo	Simbandi Brassou
Karantaba	Sinthiou Bocar Aly
Kayemor	Sinthiou Malem
Keur Saloum Diane	Sinthiou Mamadou Bou
Keur Samba Gueye	Tenghory
Khossanto	Thietty
Kolibantang	Toubacouta
Koulor	

Control Areas		
Adeane	Ida Mouride	Niani Toucouleur
Bani Israel	Kahene	Ninefecha
Bele	Kandiaye	Oubadji
Bemet Bidjini	Kaour	Oulampane
Bemet Bidjini	Kartiack	Ouonck
Bignarabe	Keur Baka	Pakour
Bourouco	Keur Maba Diakhou	Palmarin Facao
Boutoucoufara	Keur Madongo	Paroumba
Coubalane	Keur Soce	Prokhane
Diamagadio	Komoti	Prokhane
Diambati	Koulinto	Sabodala
Dianke Makha	Koussan	Sadatou
Diannah Ba	Kouthiaba Wolof	Sama Kanta Peulh
Diaroume	Loul Sessene	Sansamba
Dimboli	Lour Escale	Sare Coly Sale
Diossong	Mabo	Simbandi Balante
Dioulacolon	Mangouroungou Santo	Sindian
Djibabouya	Mbellacadiao	Sinthiou Fissa
Djibanar	Medina Baffe	Suelle
Djilasse	Medina Baffe	Taiba Niassene
Djinaki	Mlomp	Tankanto Escale
Enampor	Ndiaffate	Tankon
Dougue	Ndiedieng	Thiankoye
Fass Thiekene	Ndoga Babacar	Thiare
Fimela	Ndrame Escale	Thiomby
Fongolimbi	Niaguis	Wack Ngouna
Gabou	Niaming	Yarang Banlante
Gainte Kaye	Niamone	Prokhane

ANNEX II. Durable Assets, Sources of Water Supply, Types of Toilet Facilities and Floor Material: Principal Component Analysis Results by Wealth Quintile

Table A-1: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, Wula Nafaa area (rural and urban), 1992-93

	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	0.0	0.0	0.0	27.1
Radio	10.4	52.1	87.5	91.7	95.8
Television	0.0	0.0	0.0	0.0	10.4
Refrigerator	0.0	0.0	0.0	0.0	8.3
Bicycle	12.5	6.3	31.3	25.0	35.4
Motorcycle/scooter	0.0	0.0	0.0	4.2	33.3
Car/truck	0.0	0.0	0.0	0.0	2.1
Source of water supply					
Water piped into compound	0.0	0.0	0.0	0.0	18.8
Pond/lake/spring	0.0	0.0	0.0	0.0	0.0
Public tap	0.0	0.0	0.0	8.7	2.1
Well	100	100	100	91.3	79.2
Toilet facility					
Flush	0.0	0.0	0.0	0.0	2.1
No facility/bush	100	47.9	4.2	0.0	0.0
Pit/latrine	0.0	52.1	95.8	100	97.9
Floor material					
Cement	2.1	6.3	12.5	66.7	80.9
Dung	4.2	6.3	12.5	0.0	2.1
Earth/sand	93.8	87.5	68.8	33.3	2.1
Vinyl	0.0	0.0	6.3	0.0	14.9
Average wealth mean score for first principal component	-1.40	-0.87	-0.54	0.02	2.31
Sample size (all households): 242					
Source: Principal component analysis results					

Table A-2: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, control area (rural and urban), 1992-93					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	0.0	0.0	0.0	25.0
Radio	13.0	72.8	58.7	84.8	94.6
Television	0.0	0.0	0.0	2.2	25.0
Refrigerator	0.0	0.0	0.0	0.0	15.2
Bicycle	12.0	7.6	7.6	27.2	28.3
Motorcycle/scooter	0.0	3.3	0.0	4.3	19.6
Car/truck	0.0	0.0	0.0	0.0	1.1
Source of water supply					
Water piped into compound	0.0	0.0	0.0	6.7	23.3
Pond/lake/spring	22.8	2.2	0.0	0.0	0.0
Public tap	2.2	9.8	9.9	19.1	14.4
Well	75.0	88.0	90.1	74.2	62.2
Toilet facility					
Flush	0.0	0.0	0.0	3.3	1.1
No facility/bush	100	90.2	31.5	7.6	2.2
Pit/latrine	0.0	9.8	68.5	89.1	96.7
Floor material					
Cement	0.0	16.3	27.5	48.4	71.7
Dung	25.0	4.3	2.2	0.0	0.0
Earth/sand	75.0	78.3	65.9	51.6	4.3
Vinyl	0.0	1.1	4.4	0.0	23.9
Average wealth mean score for first principal component	-1.90	-1.16	-0.16	0.60	2.47
Sample size (all households): 461					
Source: Principal component analysis results					

Table A-3: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, Wula Nafaa area (rural and urban), 1997					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	1.1	1.1	5.5	58.2
Radio	45.1	22.0	79.1	60.4	84.6
Television	0.0	2.2	1.1	0.0	30.8
Refrigerator	0.0	0.0	0.0	0.0	15.4
Bicycle	30.8	14.3	28.6	22.0	24.2
Motorcycle/scooter	0.0	2.2	3.3	5.5	15.4
Car/truck	0.0	1.1	0.0	4.4	3.3
Source of water supply					
Water piped into compound	0.0	0.0	0.0	4.5	41.1
Pond/lake/spring	0.0	0.0	3.3	0.0	0.0
Public tap	0.0	1.1	0.0	11.2	18.9
Well	100	98.9	96.7	84.3	40.0
Toilet facility					
Flush	0.0	0.0	1.1	1.1	2.2
No facility/bush	100	36.3	22.0	12.1	3.3
Pit/latrine	0.0	63.7	76.9	86.8	94.5
Floor material					
Cement	0.0	1.1	15.4	77.8	85.7
Dung	0.0	15.6	9.9	2.2	0.0
Earth/sand	100	83.3	74.7	16.7	2.2
Vinyl	0.0	0.0	0.0	2.2	12.1
Average wealth mean score for first principal component	-1.80	-1.15	-0.71	0.32	3.33
Sample size (all households): 456					
Source: Principal component analysis results					

Table A-4: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, Wula Nafaa area (rural), 1997					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	0.0	0.0	1.4	15.6
Radio	32.4	52.2	44.1	65.2	84.4
Television	0.0	0.0	0.0	1.4	18.8
Refrigerator	0.0	0.0	0.0	0.0	9.4
Bicycle	39.7	14.5	26.5	26.1	20.3
Motorcycle/scooter	0.0	2.9	0.0	5.8	12.5
Car/truck	0.0	1.4	0.0	1.4	4.7
Source of water supply					
Water piped into compound	0.0	0.0	0.0	0.0	12.9
Pond/lake/spring	0.0	0.0	1.5	2.9	0.0
Public tap	0.0	0.0	0.0	0.0	25.8
Well	100	100	98.5	97.1	61.3
Toilet facility					
Flush	0.0	0.0	1.5	0.0	3.1
No facility/bush	100	69.6	13.2	15.9	9.4
Pit/latrine	0.0	30.4	85.3	84.1	87.5
Floor material					
Cement	0.0	0.0	10.3	41.2	73.4
Dung	0.0	20.6	0.0	16.2	0.0
Earth/sand	100	79.4	89.7	42.6	12.5
Vinyl	0.0	0.0	0.0	0.0	14.1
Average wealth mean score for first principal component	-1.54	-1.01	-0.35	0.25	2.75
Sample size (all households): 338					
Source: Principal component analysis results					

Table A-5: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, Wula Nafaa area (urban), 1997					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	4.2	12.0	20.8	84.0	100
Radio	37.5	40.0	83.3	84.0	95.0
Television	8.3	0.0	0.0	20.0	60.0
Refrigerator	0.0	0.0	0.0	4.0	40.0
Bicycle	8.3	20.0	12.5	24.0	35.0
Motorcycle/scooter	0.0	0.0	0.0	0.0	50.0
Car/truck	0.0	0.0	0.0	0.0	15.0
Source of water supply					
Water piped into compound	0.0	12.5	12.5	56.0	65.0
Pond/lake/spring	0.0	0.0	0.0	0.0	0.0
Public tap	4.2	25.0	12.5	12.0	0.0
well	95.8	62.5	75.0	32.0	35.0
Toilet facility					
Flush	0.0	0.0	0.0	0.0	5.0
No facility/bush	37.5	24.0	0.0	4.0	0.0
Pit/latrine	62.5	76.0	100	96.0	95.0
Floor material					
Cement	8.3	56.0	100	96.0	85.0
Dung	0.0	0.0	0.0	0.0	0.0
Earth/sand	91.7	36.0	0.0	0.0	0.0
Vinyl	0.0	4.0	0.0	4.0	15.0
Average wealth mean score for first principal component	-2.39	-1.26	0.12	1.23	2.72
Sample size (all households): 118					
Source: Principal component analysis results					

Table A-6: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, control area (rural and urban), 1997					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	0.0	0.0	3.6	67.3
Radio	33.2	29.6	73.0	73.5	85.7
Television	0.0	0.0	0.5	2.6	40.8
Refrigerator	0.0	0.0	0.0	0.0	28.1
Bicycle	23.0	31.1	20.9	17.3	13.3
Motorcycle/scooter	0.0	1.5	2.6	12.8	15.3
Car/truck	0.0	0.0	0.0	0.0	7.1
Source of water supply					
Water piped into compound	0.0	0.0	0.0	1.0	40.2
Pond/lake/spring	0.0	1.5	2.6	2.1	0.0
Public tap	0.0	0.5	13.3	13.6	22.7
Well	100	98.0	84.2	83.2	37.1
Toilet facility					
Flush	0.0	0.0	0.0	0.0	12.3
No facility/bush	100	26.7	37.4	13.4	6.2
Pit/latrine	0.0	73.3	62.6	86.6	81.5
Floor material					
Cement	0.0	0.0	25.9	76.0	58.2
Dung	0.0	1.5	2.6	2.1	0.0
Earth/sand	0.0	0.5	13.3	13.6	22.7
Vinyl	100	98.0	84.2	83.2	37.1
Average wealth mean score for first principal component	-1.59	-1.09	-0.71	0.04	3.18
Sample size (all households): 983					
Source: Principal component analysis results					

Table A-7: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, control area (rural), 1997					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	0.0	0.0	0.0	17.3
Radio	9.1	53.1	61.8	64.3	83.5
Television	0.0	0.0	0.0	1.4	14.4
Refrigerator	0.0	0.0	0.0	0.0	7.9
Bicycle	17.5	33.6	31.3	14.0	7.9
Motorcycle/scooter	0.0	0.0	2.8	5.6	13.7
Car/truck	0.0	0.0	0.0	0.0	2.9
Source of water supply					
Water piped into compound	0.0	0.0	0.0	0.0	14.6
Pond/lake/spring	0.0	2.1	0.7	3.5	2.2
Public tap	0.0	0.0	8.3	15.6	23.4
Well	100	97.9	91.0	80.9	59.9
Toilet facility					
Flush	0.0	0.0	0.0	0.0	1.4
No facility/bush	100	62.4	14.0	38.7	13.8
Pit/latrine	0.0	37.6	86.0	61.3	84.8
Floor material					
Cement	0.0	0.0	0.0	44.4	70.5
Dung	0.0	8.5	1.4	13.4	1.4
Earth/sand	100	91.5	98.6	40.8	8.6
Vinyl	0.0	0.0	0.0	1.4	17.3
Average wealth mean score for first principal component	-1.46	-0.91	-0.38	0.23	2.59
Sample size (all households): 712					
Source: Principal component analysis results					

Table A-8: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, control area (urban), 1997					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	0.0	40.0	87.3	94.1
Radio	34.5	78.2	63.6	89.1	96.1
Television	0.0	0.0	5.5	41.8	80.4
Refrigerator	0.0	0.0	0.0	16.4	74.5
Bicycle	34.5	27.3	10.9	16.4	17.6
Motorcycle/scooter	1.8	7.3	10.9	20.0	19.6
Car/truck	0.0	0.0	0.0	1.8	21.6
Source of water supply					
Water piped into compound	0.0	0.0	1.9	38.9	82.0
Pond/lake/spring	0.0	0.0	0.0	0.0	0.0
Public tap	0.0	1.8	31.5	20.4	4.0
Well	100	98.2	66.7	40.7	14.0
Toilet facility					
Flush	0.0	0.0	0.0	5.5	44.0
No facility/bush	32.7	12.7	7.3	5.5	2.0
Pit/latrine	67.3	87.3	92.7	89.1	54.0
Floor material					
Cement	10.9	87.3	77.8	67.3	36.0
Dung	0.0	1.8	0.0	0.0	0.0
Earth/sand	89.1	10.9	9.3	5.5	0.0
Vinyl	0.0	0.0	11.1	21.8	48.0
Average wealth mean score for first principal component	-1.95	-1.40	-0.71	0.85	3.52
Sample size (all households): 271					
Source: Principal component analysis results					

Table A-9: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, Wula Nafaa area (rural and urban), 2010-11					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	3.7	14.0	61.2	100
Radio	49.1	52.8	74.3	77.1	86.9
Television	0.0	2.3	8.4	52.8	94.4
Refrigerator	0.0	0.0	0.0	2.8	50.0
Bicycle	47.2	54.7	59.3	51.9	55.6
Motorcycle/scooter	1.9	1.9	8.4	25.7	42.5
Car/truck	0.0	0.0	0.0	0.9	4.7
Source of water supply					
Water piped into compound	0.0	0.0	7.6	20.7	74.9
Pond/lake/spring	10.3	0.9	0.5	0.5	0.0
Public tap	9.9	9.9	11.9	15.9	2.4
Well	79.8	89.2	80.0	63.0	22.7
Toilet facility					
Flush	0.0	0.9	1.4	7.5	19.2
No facility/bush	100	19.2	14.0	5.1	0.9
Pit/latrine	0.0	79.9	84.6	87.4	79.9
Floor material					
Cement	0.0	7.9	53.7	67.9	60.6
Dung	37.6	17.8	3.3	1.9	0.5
Earth/sand	62.4	74.3	42.1	21.2	6.6
Vinyl	0.0	0.0	0.5	4.7	17.8
Average wealth mean score for first principal component	-2.40	-1.27	-0.50	0.89	3.24
Sample size (all households): 1,070					
Source: Principal component analysis results					

Table A-10: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, Wula Nafaa area (rural), 2010-11					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.0	6.1	0.0	16.7	68.0
Radio	25.0	62.9	79.7	80.3	85.9
Television	0.0	2.3	1.5	12.1	61.7
Refrigerator	0.0	0.0	0.0	0.0	11.7
Bicycle	40.2	51.5	72.2	59.1	53.9
Motorcycle/scooter	0.0	6.1	0.0	14.4	32.8
Car/truck	0.0	0.0	0.0	0.0	3.1
Source of water supply					
Water piped into compound	0.0	0.0	0.0	10.9	24.2
Pond/lake/spring	16.8	1.5	0.0	0.8	0.8
Public tap	10.7	7.6	10.5	17.2	11.3
Well	72.5	90.8	89.5	71.1	63.7
Toilet facility					
Flush	0.0	0.8	0.8	2.3	4.7
No facility/bush	100	71.2	11.3	17.4	3.1
Pit/latrine	0.0	28.0	88.0	80.3	92.2
Floor material					
Cement	0.0	1.5	9.8	55.3	72.4
Dung	50.8	22.9	14.3	4.5	3.9
Earth/sand	49.2	75.6	75.9	38.6	14.2
Vinyl	0.0	0.0	0.0	0.8	3.1
Average wealth mean score for first principal component	-2.02	-1.23	-0.22	0.75	2.69
Sample size (all households): 657					
Source: Principal component analysis results					

Table A-11: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, Wula Nafaa area (urban), 2010-11					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	2.4	36.9	84.3	100	100
Radio	36.1	61.9	81.9	86.9	84.8
Television	0.0	25.0	73.5	91.7	100
Refrigerator	0.0	0.0	12.0	23.8	86.1
Bicycle	44.6	42.9	59.0	46.4	63.3
Motorcycle/scooter	0.0	14.3	30.1	32.1	49.4
Car/truck	0.0	0.0	2.4	2.4	5.1
Source of water supply					
Water piped into compound	0.0	11.0	25.9	78.3	98.7
Pond/lake/spring	0.0	0.0	0.0	0.0	0.0
Public tap	6.0	17.1	11.1	2.4	1.3
Well	94.0	72.0	63.0	19.3	0.0
Toilet facility					
Flush	0.0	3.6	12.0	17.9	29.1
No facility/bush	22.9	4.8	6.0	2.4	0.0
Pit/latrine	77.1	91.7	81.9	79.8	70.9
Floor material					
Cement	26.5	66.7	70.7	63.1	46.2
Dung	2.4	1.2	0.0	0.0	0.0
Earth/sand	71.1	27.4	17.1	13.1	0.0
Vinyl	0.0	2.4	8.5	14.3	29.5
Average wealth mean score for first principal component	-2.72	-1.35	0.13	1.41	2.63
Sample size (all households): 413					
Source: Principal component analysis results					

Table A-12: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, control area (rural and urban), 2010-11					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	1.0	5.4	10.5	52.4	95.9
Radio	56.4	50.0	80.1	81.8	83.8
Television	0.3	2.7	6.4	40.9	87.8
Refrigerator	0.0	0.0	0.0	4.4	38.5
Bicycle	34.1	34.1	62.5	55.7	40.2
Motorcycle/scooter	0.7	2.4	4.7	27.0	32.8
Car/truck	0.0	0.0	0.3	1.0	4.7
Source of water supply					
Water piped into compound	5.5	5.1	4.1	2.4	60.9
Pond/lake/spring	9.6	0.0	0.0	0.3	0.0
Public tap	16.0	11.3	7.2	7.9	5.2
Well	68.9	83.6	88.7	89.3	33.9
Toilet facility					
Flush	0.0	3.0	3.0	5.1	22.3
No facility/bush	94.3	23.6	9.1	3.0	0.3
Pit/latrine	5.7	73.3	87.8	91.9	77.4
Floor material					
Cement	9.5	22.4	27.4	65.8	69.8
Dung	21.4	10.5	6.5	3.1	0.0
Earth/sand	68.0	65.3	62.3	27.5	3.1
Vinyl	1.0	1.4	3.8	3.1	8.9
Average wealth mean score for first principal component	-1.93	-0.97	-0.55	0.35	3.07
Sample size (all households): 1,480					
Source: Principal component analysis results					

Table A-13: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, control area (rural), 2010-11					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	0.5	7.3	1.4	17.4	61.7
Radio	52.1	56.0	73.4	80.7	86.9
Television	0.0	3.7	0.5	11.0	57.5
Refrigerator	0.0	0.0	0.0	0.5	14.0
Bicycle	23.5	33.5	55.0	61.0	62.6
Motorcycle/scooter	0.9	1.4	3.2	14.2	33.2
Car/truck	0.0	0.0	0.5	0.5	1.4
Source of water supply					
Water piped into compound	4.7	9.3	3.2	2.8	1.0
Pond/lake/spring	13.1	0.0	0.0	0.0	0.0
Public tap	21.0	15.8	4.2	6.5	6.7
Tanker truck	61.2	74.9	92.6	90.7	92.3
Toilet facility					
Flush	0.0	4.1	1.8	2.8	6.1
No facility/bush	99.1	55.0	4.6	8.3	1.4
Pit/latrine	0.9	40.8	93.6	89.0	92.5
Floor material					
Cement	7.9	31.0	10.6	32.7	66.2
Dung	22.8	15.3	10.1	5.6	1.9
Earth/sand	68.8	51.4	76.6	57.9	23.9
Vinyl	0.5	2.3	2.3	3.7	5.6
Average wealth mean score for first principal component	-2.19	-0.84	0.08	0.59	2.33
Sample size (all households): 1,085					
Source: Principal component analysis results					

Table A-14: Principal component analysis wealth index: percentage of households associated with each component by wealth quintile, control area (urban), 2010-11					
	Wealth quintile				
	Poorest	Second	Third	Fourth	Richest
	Percentage of households				
Durable assets					
Electricity	8.9	81.3	88.8	100	100
Radio	49.4	70.0	63.8	88.8	89.5
Television	2.5	55.0	70.0	95.0	98.7
Refrigerator	0.0	1.3	17.5	25.0	80.3
Bicycle	45.6	51.3	28.8	51.3	25.0
Motorcycle/scooter	1.3	7.5	32.5	25.0	43.4
Car/truck	0.0	0.0	2.5	1.3	13.2
Source of water supply					
Water piped into compound	1.3	9.2	36.7	87.3	98.7
Pond/lake/spring	0.0	1.3	0.0	0.0	0.0
Public tap	6.4	5.3	12.7	5.1	0.0
Tanker truck	92.3	84.2	50.6	7.6	1.3
Toilet facility					
Flush	0.0	6.3	20.0	17.5	42.1
No facility/bush	20.3	3.8	1.3	0.0	0.0
Pit/latrine	79.7	90.0	78.8	82.5	57.9
Floor material					
Cement	34.2	91.3	70.5	75.9	51.4
Dung	2.5	0.0	0.0	0.0	0.0
Earth/sand	62.0	8.8	6.4	2.5	0.0
Vinyl	1.3	0.0	12.8	6.3	8.1
Average wealth mean score for first principal component	-2.86	-0.92	0.18	1.33	2.44
Sample size (all households): 395					
Source: Principal component analysis results					