African Journal of Science, Technology, Innovation and Development

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rajs20

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To cite this article: Gbetondji Melaine Armel Nonvide (2021): Reducing poverty through use of irrigation: Evidence from rice farming in Benin, African Journal of Science, Technology, Innovation and Development, DOI: 10.1080/20421338.2021.1923123

To link to this article: https://doi.org/10.1080/20421338.2021.1923123

Published online: 21 Sep 2021.

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African Journal of Science, Technology, Innovation and Development, 2021
https://doi.org/10.1080/20421338.2021.1923123
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Reducing poverty through use of irrigation: Evidence from rice farming in Benin

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An emerging body of literature has claimed that poverty is multidimensional and therefore the unidimensional measure cannot serve as a good proxy for poverty. The actual debate is about the inclusion of other dimensions in the poverty analysis framework. Regarding this, the current study examines poverty measurement in rice farming communities in the municipality of Malanville, Benin using both unidimensional and multidimensional poverty indices. It also assesses the effect of involvement in irrigation on multidimensional poverty through an estimation of a two-stage instrumental variable probit model. Results indicate that incidence of monetary poverty was 45.8%. In term of multidimensional poverty, 53.4% of the rice farmers were found to be multidimensionally poor. Overall, the analysis shows lower incidence of poverty for irrigation farmers compared to dry land farmers. We find that the use of irrigation contributes to reducing the likelihood of being multidimensionally poor by 11%. Other determinants include age of the farmer, gender, farm size, use of improved seed, access to credit, off-farm income and market participation. The positive relationship between use of irrigation and poverty reduction justifies the need for irrigation development targeting to implement poverty reduction policies in developing countries.

Keywords: rice, irrigation, multidimensional poverty, two-stage instrumental variable probit model, Benin

Introduction

The Benin National Institute of Statistics and Economic Analysis (INSAE) has been periodically carrying out integrated modular surveys on household living conditions (EMICoV). These surveys provide a general figure of poverty in Benin. According to the finding from EMICoV 2009, 2011, 2015, poverty is still a great challenge in Benin as poverty rate remains high over time (Table 1). For instance, monetary poverty has increased from 35.2% in 2009 to 36.2% in 2011 and to 40.1% in 2015 with unequal distribution between rural and urban area. It is more widespread in rural area where about 43.6% of people were poor in 2015. In addition to being most affected by monetary poverty, rural households have experienced a deterioration in their living conditions in 2015 compared to 2011. Non-monetary poverty incidence has increased from 32.9% in 2011 to 36.0% in 2015 while in urban area this has decreased from 26.4% in 2011 to 20.5% in 2015.

Poverty is pervasive in Benin and is more pronounced in rural areas where most of the population relies on agriculture as its major source of livelihood. Thus, the identification of factors that influence poverty level is key to ensure the effectiveness of poverty reduction policy in Benin. In this regard, past studies (FAO 2003; Tekana and Oladele 2011; Burney and Naylor 2012; Domenech and Ringler 2013) suggest that investing in smallholder irrigation is one of the most effective ways to develop smallholder agriculture, and thus contribute to poverty reduction. Studies (Bhattarai and Narayanamoorthy 2003; Hussain and Hanjra 2004; Hussain and Wijerathma 2004; Huang et al. 2006; Adeoti 2009; Hanjra, Ferede, and Gutta 2009; Bacha et al. 2011; Dillon 2011a, 2011b; Nkhata, Jumbe, and Mwabumba 2014) that have investigated the economic impact of the irrigation systems development have found that use of irrigation can enhance agricultural productivity, improve nutritional status, increase income and contribute significantly to food security and poverty reduction. In contrast to studies which have proven the benefits of irrigation development, other studies have shown mixed results about the impact of irrigation on the livelihood improvement. No linkage was found between irrigation, agricultural productivity and poverty reduction in Asia, in general, and in China and India in particular (Rosegrant and Evenson 1992; Fan, Hazell, and Throat 1999, 2000; Jin et al. 2002; Zhu 2004). Testing for differences in returns to production factors in South-eastern Nigeria, Urama and Hodge (2004) indicated that the responsiveness of farm output to labour input (0.50) and to other variable inputs (0.42) is higher than the returns to land and water inputs (−0.92). The mixed results of the impact of irrigation on poverty reduction raise important questions about the view that irrigation development is a good target for poverty reduction programmes. This paper provides responses by studying the impact of involvement in irrigation on poverty reduction in the context of Benin.

Public investments in irrigation in Benin started in the 1960s and many irrigation schemes have been developed in the country with support from international partners and donors. For instance, Chinese cooperation has intervened in many lowland areas and provided irrigation facilities on a total of 1400 ha of land (Djagba et al. 2014). The objective of these investments was to improve cereal production, especially rice productivity in order to improve food security and reduce poverty. Canal irrigation is used in all irrigated rice schemes in Benin with water pumped from a river and distributed into the farms through surface canals. Despite efforts by the Benin government, irrigation remains underdeveloped. Of a total of 322,000 ha of potential irrigable land, less than 8% are developed (FAO 2014). However, past studies have shown that investments in water management infrastructure such as irrigation is key for

Table 1: Poverty incidence in Benin from 2009 to 2015.

	2009			2011			2015		
	Benin	Urban	Rural	Benin	Urban	Rural	Benin	Urban	Rural
Monetary poverty	35.2	29.8	38.4	36.2	31.4	39.7	40.1	35.8	43.6
Non-monetary Poverty	35.0	29.1	38.3	30.2	26.4	32.9	28.7	20.5	36.0

Source: INSAE (2015); EMICoV 2009, 2011 and 2015

agricultural productivity improvement and poverty reduction (Hussain and Hanjra 2004; Dillon 2011a; Nkhata, Jumbe, and Mwabumba 2014).

Poverty is a complex phenomenon and there is no major indicator that can better inform on the poverty status of the individual. Although most of the studies on poverty have used a unidimensional measure such as income, employment, or food consumption expenditure (Greer and Thorbecke 1986; Bhattarai and Narayanamoorthy 2003; Bacha et al. 2011; Dillon 2011a, 2011b). However, an emerging body of literature (Atkinson 2003; Bourguignon and Chakravarty 2003; Wagle 2005; Alkire and Foster 2007, 2011; Alkire and Santos 2010; Decancq, Fleurbaey, and Maniquet 2014; Vijaya, Lahoti, and Swaminathan 2014; Whelan, Nolan, and Maître 2014) has defended poverty as multidimensional and, therefore, the unidimensional measure cannot be serve as a good proxy for poverty (Decancq, Fleurbaey, and Maniquet 2014). The actual debate is about the inclusion of other dimensions in the poverty analysis framework. With regard to this, the analysis of poverty in this study is carried out using both unidimensional and multidimensional poverty indices. The unidimensional measure is based on monetary poverty while the multidimensional poverty framework developed by Alkire and Foster (2007, 2011) is used to calculate the multidimensional poverty index. Other relevant interest in this study is the empirical evidence that beyond crop yield improvement and income increase, the use of irrigation positively affects the multidimensional poverty status of farmers.

The specific objectives of this study are to: (1) analyze the distribution of poverty among rice farmers using both unidimensional and multidimensional poverty indicators, and (2) assess the effect of involvement in irrigation on poverty reduction. The rest of the paper is arranged as follows. The multidimensional poverty framework of Alkire and Foster (2007, 2011) is detailed followed by materials and methods. Next, results and discussion are presented. Finally, we provide concluding remarks and policy implication of the findings.

Alkire and Foster’s framework for multidimensional poverty measurement

Alkire and Foster (2007, 2011) propose a multidimensional poverty measure using a counting approach. The multidimensional poverty approach refers to the number of deprivations that members of a household experience (Alkire and Santos 2010). Following Sen (1976) the approach comprises two steps which are the identification of the set of poor persons based on the number of deprivations they experience, and the aggregation measure that generates the headcount ratio, the average intensity of poverty and the adjusted headcount ratio called multidimensional poverty index (MPI).

Identification of the poor

Let n represents the size of the population and $d \geq 2$ be the number of dimensions under consideration. $y = (y_{ij})$, denotes an n × d matrix of achievements for individual $i = 1, 2 \ldots,$ n in dimensions $j = 1, 2 \ldots,$ d. Each row vector $y_{i.} = (y_{i1}, y_{i2}, \ldots, y_{id})$ describes the achievements in the different dimensions for individual *i*. Each column vector $y_{.j} = (y_{1j}, y_{2j}, \ldots, y_{nj})$ gives the achievements in dimensions j across individuals. Let $z_j > 0$ be the deprivation cut-off value or poverty line in dimension j. The sum of entries in any given vector or matrix *v* is denoted by |*v*|, while μ (*v*) is used to represent the mean of *v* or |*v*| divided by the number of entries in *v*. For any matrix of achievements y it is possible to define a matrix of deprivations $g^0 = [g^0_{ij}]$, whose typical element g^0_{ij} is defined by $g^0_{ij} = 1$ when $y_{ij} < z_j$, and $g^0_{ij} = 0$ when $y_{ij} \geq z_j$. Thus g^0 is a $n \times d$ matrix whose ij^{th} entry is 1 when an individual is deprived in dimension j and 0 otherwise. From this matrix, we can define a column vector of deprivation counts, whose i^{th} entry $c_i = |g^0_i|$ represents the number of deprivations suffered by an individual *i*. Notice that the matrix and vector can be defined for any ordinal and cardinal variable from the matrix of achievements y.

To identify who is poor, Alkire and Foster (2007, 2011) used a dual cut-off method. First it consists of defining a deprivation threshold ($z_j > 0$) in each dimension and concluding that an individual is deprived in dimension j if he/she experiences a lower level of achievements than the threshold. Second a poverty threshold k is defined as the minimum number of dimensions in which an individual must be deprived. Therefore, k ranges between 1 and d, and individual i is considered as poor if its total deprivation across dimensions is greater or equal to k. Alkire and Foster (2007) propose a threshold of 33%. Therefore, an individual who experienced a total deprivation more than 33%, is identified as multidimensionally poor.

Aggregation measures

The first measure to consider is the incidence of poverty which refers to the percentage of people who are multidimensionally poor. The incidence of poverty H = H (y, z) can be obtained as follows:

$$H = q/n, \tag{1}$$

where *q* is the number of poor people identified using the dual threshold method. This measure is analogous to the unidimensional headcount ratio and has the advantages that it is easy to compute and understand and can be calculated with ordinal data (Santos and Ura 2008). Considering this, Alkire and Foster (2007, 2011) have proposed the dimension adjusted FGT measures given by:

$$M_\alpha(y; z) = \mu(g^\alpha(k)) \text{ for } \alpha \geq 0. \quad (2)$$

$$\text{When } \alpha = 0, M_0 = \mu(g^0(k))$$
$$= HA \text{ is the Adjusted Headcount Ratio} \quad (3)$$

where A, the average intensity of poverty across poor can also be obtained from the following equation: A = c(k) / (q d) with c (k) the censored vector of deprivation counts. M_0 is the appropriate measure to be used when one or more of the dimensions to be considered are of ordinal nature, meaning that their values have no cardinal meaning (Alkire and Santos 2010). It satisfies dimensional monotonicity which means if a poor individual becomes deprived in an additional dimension, M_0 will increase. By the same way, if the poor who was deprived in three dimensions is now deprived in two dimensions only, so M_0 should fall.

Another key characteristic of M_0 is that it can be decomposed by population subgroup as follows:

$$M_0(x, y, z) = \frac{n(x)}{n(x, y)} M_0(x, z) + \frac{n(y)}{n(x, y)} M_0(y, z) \quad (4)$$

where x and y are the distribution of the two populations, (x, y) is the distribution obtained by merging the two populations, n(x) the number of individuals in x, n(y) the number of individuals in y, and n(x, y) the number of persons in (x, y). The overall poverty is the weighted average of subgroup poverty levels, where weights are subgroup population shares. This decomposition holds to any number of subgroups. Again, M_0 can be broken down by dimension to reveal the contribution of each dimension j to it.

$$M_0 = \sum_{j=1}^{d} \mu(g^0_{.j}(k))/d \quad (5)$$

where $g^0_{.j}(k)$ is the j^{th} column of the censored matrix $g^0(k)$. The contribution of dimension j to multidimensional poverty can be expressed as:

$$Contr_j = (\mu(g^0_{.j}(k))/d)/M_0 \quad (6)$$

Identifying the contribution of each dimension provides information than can be useful to reveal a configuration of deprivations and to target poor individuals in poverty reduction programmes.

Materials and methods

Study area and survey design

The study was conducted in the northern region of Benin in the municipality of Malanville. More details about the survey design can be found in Nonvide et al. (2018) and Nonvide (2018). Malanville is located at the Benin/Niger border along the Niger River. It covers an area of 3,016 km^2 of which 8,000 hectares is arable land. (Figure 1). Malanville has a Sudano-Sahelian climate with one wet season from May to October, covering then 5–6 months. The average annual rainfall, between 700 mm and 1000 mm (Nonvide et al. 2018), is low and leads to lower production, and thus to food insecurity and poverty (Table 2). The main occupations of the active population are subsistence agriculture, livestock rearing, fishing, small business, trade and crafts. Farmers cultivate various crops including rice, maize, sorghum, millet, cotton, and vegetables.

The study was conducted in the municipality of Malanville because it is known as the largest rice producing municipality in the country and is crossed by the Niger River and its tributaries, offering an important opportunity for rice production. Furthermore, in terms of size, yield and cropping season, the irrigation scheme of Malanville, constructed in 1970, is the most important rice scheme in Benin. Of the 516 ha of irrigable land, 400 ha were used in 2015 with average rice yield of 5.7 MT/ha, and rice is produced twice in a year by around 1054 farmers operating on the scheme. Water used for the irrigation is pumped from the Niger River and distributed to farms through surface canals.

Of the five districts in the municipality of Malanville, four were selected for the survey. Districts selection criteria include: (1) proximity to the irrigation scheme located in the district of Malanville, and (2) the production intensity of rice. Garou, Guene, Malanville and Tombouctou are the districts selected (Table 3), and two villages, including one high rice producing village and one low rice producing village, were purposively selected from each of these districts, for a total of eight villages. Village selection is done with the help of the extension officers in the municipality of Malanville. The high rice producing villages are known as main rice producers in the municipality. Rice production is the main activity in these villages whereas in the low rice producing villages this may not be the case.

Respondents' sampling design and method of data collection

Respondents' sampling design

The survey involved two groups of participants: irrigation farmers and dry land farmers. The irrigation farmers produce rice in the irrigation scheme of Malanville, and the dry land farmers produce rice under rainfed condition. In Benin, around 9% of the rice farm population are irrigation farmers; 37% produce rice under strict rainfed condition and 54% on the lowland (MAEP 2015). For each group of farmers, Cochran's (1977) sample size formula (equation 7) was applied to determine the optimal sample size required to be representative:

$$n = z^2 * p(1 - p)/m^2 \quad (7)$$

where: n = required sample size; z = confidence level at 95% (standard value is 1.96); p = estimated prevalence of rice farm attribute (proportion of rice farmers under

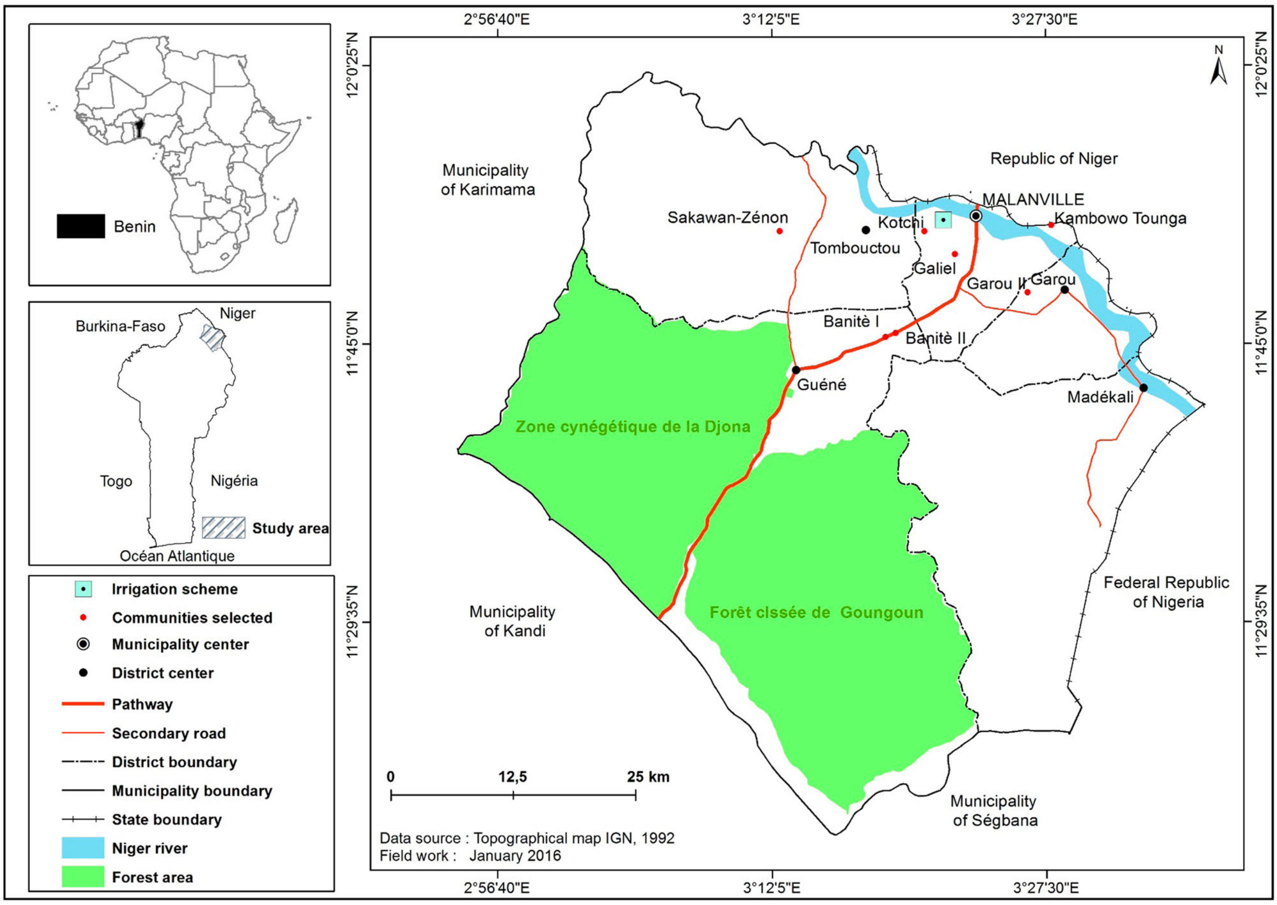

Figure 1. Map of Benin and municipality of Malanville showing the study sites.

Table 2: Socioeconomic characteristics of the municipality of Malanville.

Malanville	
Population (2013)	168, 641
Religion (%)	Muslims: 80, Others: 20
Child schooling rate (%)	28.4
Literacy rate (%)	14.1
Main economic activities	Agriculture, fishing, livestock, small business, trade and crafts
Major crops	Maize, rice, millet, sorghum, cotton, and vegetables
Food insecurity (%)	35
Poverty incidence (%)	42.5

Source: INSAE (2011, 2013)

Table 3: Rice production among districts in 2013–2014 cropping year.

Districts	Production (tonnes)
Malanville	15,594
Garou	9139
Guene	6238
Madecali	4456
Tombouctou	7128
Total for the municipality	42,555

Source: Centre d'Action Régionale pour le Développement Rural (CARDER-Malanville), 2015

irrigation and those under rainfed) in the study area; and m = margin of error at 5%. For irrigation farmers, using the above formula as $p = 0.09$, we obtained a sample size of 126. Similarly, for rainfed farmers with $p = 0.37$ the optimal sample size was estimated at 359. In order to minimize the sampling error, oversampling was done and the final sample size was 150 for irrigation farmers and 540 for non-irrigators.

The selection of the irrigation farmers was based on a list provided by the committee in charge of managing the irrigation scheme. A proportional sampling technique was employed to select 150 irrigation farmers as they were in groups of 20–100 farmers, for a total of 24 groups. This ensures fair representation of the different groups. For the selection of dry land farmers, a list of farmers known as rice producers was provided by the Chief of each surveyed village. About 90 and 45 farmers were randomly selected from each high rice producing village and each low rice producing village respectively, making a total of 540 dry land farmers. In all, the survey covered 690 rice producers including 150 irrigation farmers and 540 dry land farmers.

Method of data collection

Farm level data was collected using structured questionnaire from April to June 2015. Additionally, focus group discussions and key informants' interview were also used to collect information. Focus group discussions were held with rice farmers regarding (1) their awareness and indicators of poverty, (2) their perception on the dimensions (education, health, and living standard) of poverty, and (3) the weight they may assigned to each dimension. The focus groups were organized per community with separated group for men, women and youth. Between 8 and 10 members were invited for each group, to facilitate the discussion. In total, 26 group discussions were conducted including 9 groups of men, 9 groups of women and 8 groups of youth. Key informants' interviews were held with municipality and districts authorities, community' chiefs and civil servants. Interviews were based on the same subjects discussed during the focus group discussions.

Method of analysis

Monetary poverty measurement

In Benin, monetary poverty is determined through consumption expenditures. Consumption is a better proxy of poverty because it is subject to less variation than income. Also, income is difficult to measure in developing countries where it is largely derived from agriculture or from self-employment (Deaton and Zaidi 2002). In order to separate the poor from the non-poor, the INSAE has regularly computed absolute poverty line from EMICoV data and following the cost of basic needs approach developed by Ravallion and Bidani (1994). Therefore, the poverty line is defined as the minimum level of expenditures that meet food and non-food items of the individual. From 2011 to 2015, Benin annual poverty line has increased from CFA 120, 839 in 2011 to CFA 140, 808 in 2015 corresponding to an increase of about 16.5% (INSAE 2015).

In order to calculate the poverty indices, Foster, Greer, and Thorbecke (1984) formula was used. The general formula for the FGT measures is given by:

$$P_\alpha = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{Z - Y_i}{Z}\right]\alpha \tag{8}$$

where, α is the poverty aversion parameter, Z is the poverty line value, Y_i the expenditure of the *ith* poor groups of persons, n is the size of the population, and q the total number of poor in the sample.

When $\alpha = 0$, $P_0 = q/n$ = H. This is the incidence of poverty that is also called the head-count ratio which is the proportion of people falling below the poverty line. When $\alpha = 1$, $P_1 = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{Z - Y_i}{Z}\right]$ is the poverty gap index measuring the depth of the poverty. When $\alpha = 2$, $P_2 = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{Z - Y_i}{Z}\right]^2$ is the squared poverty gap index which measure the severity of poverty among the poor.

Multidimensional poverty measurement

The multidimensional poverty framework developed by Alkire and Foster (2007, 2011) is used to measure poverty. The MPI template is based on the same basic three dimensions (education, health, and living standard) used to calculate the Human Development Index (Alkire and Santos 2010). The dimensions, cut-offs and weights in this paper are presented in Table 4. Two changes have been made from the original template. First, following Vijaya, Lahoti, and Swaminathan (2014), the framework is adapted from the household to the individual as the unit of analysis and therefore two indicators 'Child school attendance' and 'Child mortality' were not included in the template. Vijaya, Lahoti, and Swaminathan (2014) argue that household measures do not capture intra-household differences in resource allocation. In addition, within a household, irrigation land share from the irrigation scheme is managed individually. Second, two indicators 'Informal training' and 'Access to health facilities' have been included in the template as indicators respectively for education and health dimensions. Regarding the specific context of the municipality of Malanville, where only about 14.1% of the population are literate (INSAE 2011), informal training is considered as an alternative option for reducing poverty. Here informal training refers to any training such as carpentry, mechanical, masonry, dressmaking, and hairdressing, among other.

The main challenge in constructing multidimensional poverty is the choice of the weights. The most commonly proposed methods to set the weights in the literature include equals weights, weights as a proportion, specific weights, statistical weights, regression-based weights, and the normative weights (Belhadj 2012). While none of these methods has been proved the best, the most used approach to weighting in multidimensional poverty measurement is the equal weighting (Alkire and Foster 2007, 2011; Alkire and Santos 2010; Belhadj 2012; Batana 2013; Vijaya, Lahoti, and Swaminathan 2014). The study adopts an equal weighting approach in which all the three dimensions for poverty are weighted equally, and within each dimension, all indicators are assigned equal weights.

The study also used a new approach to identify a weighting structure that is consistent with the value of each dimension in the specific context of the study area. This is based on the fact that weights should respect people's preferences about the dimensions (Decancq and Lugo 2010; Belhadj 2012). In fact, farmers and key informants were asked about their perceptions and weights they will assign to each dimension (education, health and living standard) of poverty. The rationale of this approach is that perception about poverty measurement may be different from one area to another. People do not give same weight to each of the poverty dimensions as used in Alkire and Foster (2007, 2011) framework. The new approach includes the perception of communities on the dimension of poverty and the weight they will assign to them. The result from this approach is compared to the result obtained using strictly equal weighting approach proposed by (Alkire and Foster 2007, 2011; Alkire and Santos 2010).

Probit regression analysis of the impact of irrigation use on poverty

In order to assess the factors that affect the multidimensional poverty status of the farmers in the municipality

Table 4: Dimensions, indicators, deprivation cut-offs and weights of the MPI.

Dimensions	Indicators	Deprived if	Weight
Education	Years of schooling	The individual has not completed primary school or any informal training	33%
Health	Nutrition	For the individual, there is nutritional information is malnourished (BMI < 18.5)	16.5%
	Access to health facilities	He/she does not have health insurance or cannot receive medical facilities from public or private services when needed	16.5%
Living standard	Electricity	The individual has no electricity	5.5%
	Improved sanitation	The individual has no toilet or has to share a toilet	5.5%
	Improved drinking water	The individual's drinking water is not from piped source, bore well or closed/open well, or safe drinking water is more than a 30-minute walk from home, roundtrip.	5.5%
	Flooring	The individual has a dirt, sand or dung floor	5.5%
	Cooking fuel	The individual cooks with dung, wood or charcoal	5.5%
	Asset ownership	The individual does not own more than one of: land, house, radio, TV, telephone, bike, motorbike or refrigerator and does not own a car or truck.	5.5%

Source: Adapted from Alkire and Santos (2010), and Alkire, Conconi, and Seth (2014)

of Malanville, a probit model for the probability of being multidimensionally poor is estimated. Probit model is a normal cumulative distribution function estimated using maximum likelihood estimates. Such model is referred as qualitative or binary choice model. The model is defined as follow:

$$Y_i = \beta_o + \sum_{j=1}^{k} \beta_j X_{ij} + \gamma I_i + \epsilon_i \qquad (9)$$

where Y_i is the binary response variable with value 1 if a farmer is poor and 0 otherwise.

$\beta_0, \beta_1, \dots, \beta_k$ are parameters to be estimated, X_j is a vector of explanatory variables, I_i is a binary variable with value 1 for irrigator and 0 for non-irrigator, and ε_i is the error term which is assumed normally distributed.

The involvement in the irrigation system is selective as producers decide themselves to participate or not. In addition, some unobservable factors such as motivation and skill, among other, may induce some farmers to use irrigation than other. So, equation (9) itself may suffer from self-selection and endogeneity problems. To control for this, we estimate a two-stage instrumental variable (IV) probit model (Rassen et al. 2008; Emmanuel et al. 2016), where the first stage corresponds to the estimation of the probability of using irrigation, and the second stage (structural equation) to the probability of being poor (equation 9).

Results and discussion

Descriptive results

Descriptive statistics for selected variables included in the model are presented in Tables 5 and 6. The results reveal that irrigators are relatively younger compared to non-irrigators (Table 5). Irrigation farmers applied a significantly higher rate of fertilizer and herbicide. The mean land under irrigation is 0.56 ha against 1.56 ha for dry land farmers. It is also observed that irrigation farmers sold a significantly higher proportion of rice compared to non-irrigators, implying that irrigation farmers are more oriented to market. Market participation is key to poverty reduction in rural communities (Shiferaw et al. 2011; Fisher et al. 2012). Irrigators also earned a significantly more off-farm income compared to non-irrigators. This suggests that the development of irrigation offers opportunities for off-farm work. This may be through increased demand for inputs and sale of output. About 81% of irrigators and 72% of non-irrigators are male (Table 6), suggesting that male farmers are more engaged in rice production. Irrigators have better institutional supports compared to non-irrigators in terms of access to extension services, credit and use of improved seed. This may be due to the fact that the development of irrigation is often accompanied by the facilitation of access to other inputs.

Expenses and monetary poverty

Figure 2 shows the distribution of the average annual consumption expenditures for irrigation and dry land rice farmers. The main components of expenditure comprise food, education, health, social contributions, and other miscellaneous expenses which include rent, electricity, fuel, clothing, communication, and transportation (Deaton and Zaidi 2002). Food is the first item on which farmers spend more than 50% of their income. The difference is significantly higher ($t = -3.29$) among farmers with irrigators spending on average 1371 CFA

Table 5: Description of continuous variables.

Variable definition	Irrigators (Mean)	Non-irrigators (Mean)	t-test
Age of the farmer (Years)	40.09	42.05	02.15**
Fertilizer (Kg/ha)	305.33	226.20	−10.38***
Herbicide (litre/ha)	02.81	01.75	−06.76***
Off-farm income (in CFA)	20,830	12,180	−2.60***
Farm size (ha)	0.56	1.56	11.04***
Market participation (Proportion of rice sold)	76.32	49.40	−12.30***

Note: *** significant at 1%, ** significant at 5%

Table 6: Description of categorical variables.

Variable definition	Categories	Irrigators (%)	Non-irrigators (%)	χ^2 value
Gender	1= Male	80.67	72.41	04.18**
	0= Female	19.33	27.59	98.53***
Extension services	1= Yes	94.00	48.89	
	0= No	06.00	51.11	53.67***
Access to credit	1= Yes	87.33	54.44	
	0= No	12.67	45.56	149.18***
Use of improved seed	1= Yes	100	44.07	
	0= No	00.00	55.93	

Note: *** significant at 1%, ** significant at 5%

per day against 1185 CFA for non-irrigators. Farmers spend between 16% and 17% of their income on education with irrigators spending significantly more compared to non-irrigators ($t = -4.74$). About 8% to 10% of income is spend on health with irrigators spending more compared to non-irrigators ($t = -2.81$). This may be due to the fact that irrigators are more exposed to water borne diseases. A small share of income goes to social contributions (5% to 6%) which include dowries, weddings, funerals and other ceremonies. It is also observed that irrigators spend significantly more compared to non-irrigators ($t = -1.94$).

Table 7 presents the headcount ratio, depth and severity of poverty for irrigation and dry land rice farmers. Using the national poverty line of CFA 140,808, the incidence of poverty was 45.8% for all rice farmers (Table 7). It was higher for dry land farmers (48.9%) than irrigation rice farmers (34.7%). Overall, the poverty incidence remains high in rice farming communities with significant difference between irrigation and dry land rice farmers. The distance between the poor and the poverty line (poverty gap) is relatively lower for irrigation farmers (0.07–0.22) and for dry land farmers (0.12–0.32). This indicates that majority of farmers live just below the poverty line. However, the poverty gap was significantly different between irrigation and dry land farmers ($p < 0.01$). When considering the severity of poverty, it is observed that this was (0.02–0.12) and (0.04–0.18) for irrigation and dry land farmers respectively. Income inequality among the poor is significantly higher for dry land rice farmers compared to the irrigation farmers. Overall, the monetary poverty analysis shows lower incidence, gap and severity of poverty for irrigation farmers compared to dry land farmers.

Multidimensional poverty analysis

Perceptions on dimensions of poverty

A hundred percent of farmers from the focus groups and key informants agreed on the existence of poverty in the municipality of Malanville. Regarding the perception on the dimensions of poverty, almost all the farmers and key informants perceive education, health and living standard as dimensions of poverty (Table 8). Only 3.8% of farmers disagree especially on education as dimension of poverty. According to them, deprivation in education is not an indication for poverty measurement.

Poverty dimensions weighting

Table 9 presents average weight proposed by farmers during the focus group discussions and key informants' interview. At least 30% of weights have been assigned to each dimension of poverty. The three dimensions are ranked in the following order: Education (36.5%), Living standard (32.5%) and Health (31%). However,

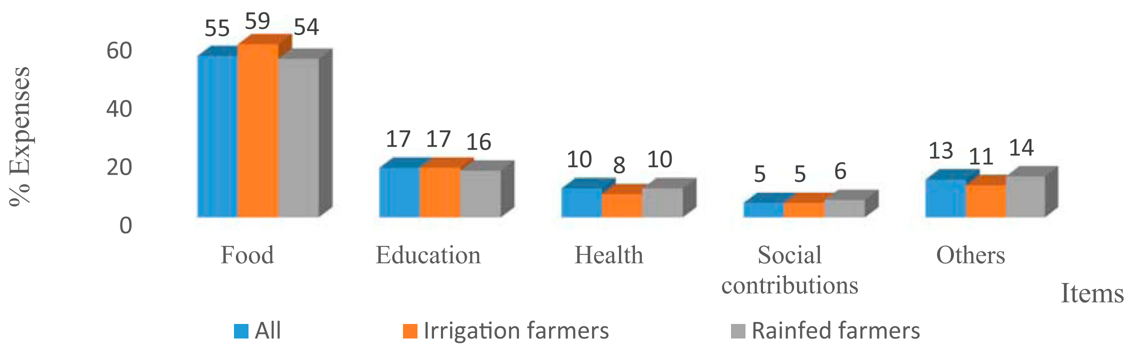

Figure 2: Distribution of expenditure between irrigation and dry land rice farmers.

Table 7: Poverty indices based on national poverty line.

Poverty index	All	Irrigation farmers	Rainfed farmers	Difference test
Poverty incidence (%)	45.8	34.7	48.9	9.56***
Poverty gap	0.11	0.07	0.12	3.42***
Poverty severity	0.03	0.02	0.04	1.69*

Note : *** significant at 1%, and * significant at 10%

Table 8: Perceptions on the dimensions of poverty.

	Focus groups			Key informants		
Dimension	Strongly Agree	Agree	Disagree	Strongly Agree	Agree	Disagree
Education	38.5	57.7	3.8	40.5	59.5	0.0
Health	15.4	84.6	0.0	13.5	86.5	0.0
Living standard	30.8	0.0	0.0	29.8	70.2	0.0

Table 9: Comparison of weighting structure proposed for multidimensional poverty index.

	Focus groups and key informants weighting			
Dimensions	Focus group	Key informants	Average	Alkire and Foster weighting
Education	36	37	36.5	33
Health	31	31	31	33
Living standard	33	32	32.5	33
MPI	0.532	0.534	0.533	0.538
Number of poor	367	368	368	371

compared to the equal weighting method proposed by Alkire and Foster (2007), there was no significant difference between the two approach of weighting and the MPI related to each approach.

MPI computation, decomposition and contribution of dimensions

The multidimensional poverty estimates are based on the same basic three dimensions (education, health and living standard) used to calculate the Human Development Index (Alkire and Santos 2010). The unit of analysis is the individual. About 53.8% of the rice farmers in the municipality of Malanville are classified as being multidimensionally poor (Table 10). The analysis by rice production system indicates that the incidence of poverty is higher for rainfed rice farmers (57.7%) than the irrigation farmers (39.6%). It is also observed higher multidimensional poverty incidence for women compared to men. To analyze how deprivation in each dimension and indicator affects poverty, the MPI is decomposed into the three dimensions and the related indicators (Table 11). This decomposition is useful for policymakers for implementing better poverty reduction policies by targeting the dimensions which most affect poverty. The results suggest that the highest contribution to multidimensional poverty is from the dimension of education (42.2%) following by living standards dimension (34.9%), and finally the dimension of health (22.9%). When using the indicators, the most contributor to poverty is ‘schooling’ following by ‘access to health facilities’ and ‘electricity’. This finding implies that access to education, health facilities and electricity are key for poverty reduction among rice farmers in the municipality of Malanville.

Determinants of multidimensional poverty: the role of irrigation

Overall, the MPI estimates reveal that real difference can be seen between irrigation and rainfed rice farmers. To

Table 10: Individual MPI and decomposition by rice production system and gender.

		Rice production system		Gender	
	All	Irrigation	Rainfed	Female	Male
Average intensity of deprivation	0.611	0.540	0.627	0.636	0.602
MPI	0.538	0.396	0.577	0.547	0.534
Total number of individuals	690	150	540	178	512

Note: MPI is the Adjusted Headcount Ratio; poverty cut-off = 33%

Table 11: Contribution of dimensions and indicators to poverty.

Dimensions	Indicators	All	Irrigation farmers	Rainfed farmers
Education	Schooling	0.422	0.506	0.406
	Dimension contribution	0.422	0.506	0.406
Health	Nutrition	0.031	0.014	0.034
	Access to health facilities	0.198	0.126	0.211
	Dimension contribution	0.229	0.140	0.245
Living standard	Electricity	0.085	0.087	0.085
	Improved sanitation	0.075	0.070	0.076
	Improved drinking water	0.054	0.044	0.056
	Flooring	0.047	0.045	0.048
	Cooking fuel	0.084	0.089	0.083
	Asset ownership	0.004	0.019	0.001
	Dimension contribution	0.349	0.354	0.349

further investigate the drivers of these differences, and assess the contribution of irrigation in reducing poverty, a two-stage IV probit model is estimated. The results of the second stage[1] (outcomes equation) are presented in Table 12. It is observed a slight difference in the prevalence of multidimensional poverty among the four districts covered by the study. Poverty incidence seems to be less in the district of Malanville, than the districts of Garou, Guene, and Tombouctou. However, the difference is significant only for the district of Tombouctou. This implies that, compared to the district of Malanville, being in the district of Tombouctou increases the

Table 12: Two stage IV probit model estimates for poverty.

Dependent variable: Poverty: 1 for poor, and 0 for non-poor				
Variables	Coef	Prob	dy / dx	Prob
Age (year)				
20 – 35	−0.288	0.437	−0.037	0.435
36 – 59	−0.588*	0.082	−0.0766*	0.077
60 and more	–	–	–	–
Gender (1=Male, 0 = Female)	−0.681**	0.000	−0.088***	0.000
Marital status (1 = Married, 0 = Otherwise)	−0.068	0.729	−0.008	0.728
Farm size (ha)	−0.366***	0.005	−0.047***	0.004
Off farm income (in CFA)	−0.006***	0.004	−0.0008***	0.004
Access to credit (1= Yes, 0 = No)	−6.724***	0.000	−0.876***	0.000
Use of improved seed (1= Yes, 0 = No)	−3.960**	0.029	−0.515**	0.028
Access to extension services (1= Yes, 0 = No)	−1.539	0.263	−0.200	0.263
Fertilizer (kg/ha)	−0.004	0.135	−0.0005	0.132
Herbicide (Liter/ha)	0.130	0.684	0.169	0.684
Market participation (proportion of rice sold)	−0.007*	0.059	−0.001*	0.057
Adoption of irrigation (1= Yes, 0 = No)	−0.089***	0.001	−0.011***	0.001
Districts location (reference: District of Malanville)				
Garou	−2.526	0.222	−0.329	0.219
Guene	−0.635	0.776	−0.082	0.776
Tombouctou	−9.822***	0.000	−1.279***	0.000
Extension visit × Location (reference: Malanville)				
Garou	1.778**	0.038	0.231**	0.035
Guene	3.90***	0.000	0.508***	0.000
Tombouctou	1.648*	0.069	0.214*	0.067
Use of improved seed × Location (reference: Malanville)				
Garou	−3.063***	0.003	−0.399***	0.003
Guene	2.940***	0.001	0.383***	0.001
Tombouctou	0.677	0.498	0.088	0.499
Access to credit × Location (reference: Malanville)				
Garou	4.391***	0.000	0.572***	0.000
Guene	−1.005	0.485	−0.131	0.487
Tombouctou	5.279***	0.000	0.687***	0.000
Fertilizer × Location (reference: Malanville)				
Garou	0.0006	0.928	0.00008	0.928
Guene	−0.005	0.341	−0.0007	0.343
Tombouctou	0.010**	0.012	0.001**	0.011
Herbicide × Location (reference: Malanville)				
Garou	0.582***	0.009	0.075**	0.010
Guene	−0.088	0.745	−0.011	0.745
Tombouctou	−0.01	957	−0.001	0.957
Adoption of irrigation × Access to extension services	1.675*	0.083	0.218*	0.084
Adoption of irrigation × Use of improved seed	−5.325***	0.005	−0.693***	0.005
Adoption of irrigation × Fertilizer	0.010*	0.093	0.001*	0.092
Adoption of irrigation × Access to credit	2.981***	0.001	0.388***	0.001
Adoption of irrigation × Herbicide	0.100	0.609	0.013	0.611
Access to extension services × Fertilizer	−0.005	0.135	−0.0006	0.136
Access to extension services × Use of improved seed	0.644	0.316	0.083	0.318
Access to extension services × Access to credit	0.741	0.184	0.096	0.189
Access to extension services × Herbicide	−0.345**	0.030	−0.045**	0.031
Fertilizer × Access to credit	0.001	0.726	0.0001	0.727
Fertilizer × Use of improved seed	−0.002	0.657	−0.0002	0.657
Fertilizer × Herbicide	0.0005	0.468	0.00007	0.468
Use of improved seed × Access to credit	2.325***	0.002	0.303***	0.002
Use of improved seed × Herbicide	−0.086	0.655	−0.011	0.655
Herbicide ×Access to credit	–	–	–	–
Constant	11.786***	0.000		
Log likelihood	−161.63			
$\chi 2$	1691.23***			
N	690			

Note: *** significant at 1%, ** significant at 5%, and * significant at 10% ; dy / dx: marginal effect probability of being multidimensionally poor. In other words, farmers in the district of Malanville are better off than those in the other districts. The explanation is that as a municipality centre, the district of Malanville may benefit more in term of accessibility to basic services and infrastructures (school, hospital, roads, financial institutions, and market opportunities among other). Also, the presence of irrigation scheme in this district is an opportunity for poverty reduction through increase in productivity and income. As shown in Table 12, the variable use of irrigation has a negative and significant effect on poverty. The marginal effect indicates that use of irrigation decreases the likelihood of being poor by 11% suggesting that involvement in irrigation system increases the likelihood of a farmer to move out of poverty. This is in line with findings from a number of studies (Bhattarai and Narayanamoorthy 2003; Hussain and Wijerathma 2004; Huang et al. 2006; Dillon 2008, Dillon 2011a, 2011b; Adeoti 2009; Gebregziabher, Namara, and Holden 2009; Nkhata, Jumbe, and Mwabumba 2014) that have shown the importance of irrigation for poverty reduction. The main argument is that adoption of irrigation contributes to productivity improvement which may lead to high income and poverty reduction.

Our findings also reveal that irrigation alone cannot reduce poverty. Other than use of irrigation, a number of other variables returned significant signs in the model estimates. The likelihood of a farmer within the age of 36–59 years being multidimensional poor decreases by 7.6%. Theoretically, age is expected to be associated with experience, higher productivity, accumulation of resources, and social capital among other that might contribute to decrease the probability of being poor. Similar results have been found by Bogale (2011) and Adeoti (2014). Men are less likely to be poor than women. Empirical evidence of gender disparity of multidimensional poverty has been reported by Bastos et al. (2009) and Mahoozi (2015). Compared to woman, being a man decrease the probability of being poor by 8.8%. This result finds its explanation from the fact that women in rural area lack access to productive resources (land and other agricultural inputs). We also found a negative and significant effect of farm size on the probability of being poor. This suggests that if farm size increases by 1% the probability of being poor would decrease by 4.7%. Off-farm income is also important in reducing poverty among rice farmers in the municipality of Malanville. A 1% increase in off-farm income would decrease the probability of being poor by 0.08%. This suggests that farmers with high off-farm income are likely to be non-poor. The development of irrigation schemes can offer opportunities for off-farm activities through increased demand for inputs and supply of outputs (Hussain and Hanjra 2004; Nonvide 2018). Diagne et al. (2013) argue that irrigation cannot be introduced in a vacuum without encouraging surrounding service sectors.

Farmers that have access to credit and improved seed were more likely to be non-poor compared to those who did not. Access to credit and use of improved seed decrease the probability of being poor respectively by 87.6%, and 51.5%. The return from the use of farm inputs is different among the four districts considered in the study. Compared to the district of Malanville, the return from the use of improved seed is smaller in the district of Garou and higher in the district of Guene, while no significant effect was found for the district of Tombouctou. Higher return was found for access to extension services in the district of Malanville compared to the districts of Garou, Guene, and Tombouctou. The return from access to credit is higher for the districts of Garou and Tombouctou. In term of return from fertilizer used, this is higher in the district of Tombouctou and no significant difference was found for the districts of Garou and Guene compared to the district of Malanville.

As expected, the variable market participation returns a negative and significant sign. A 1% increase in the proportion of rice sold would decrease the probability of being poor by 0.1%. This suggests that access to market is key for poverty reduction in the municipality of Malanville. Better access to market is key to driving rural farmers from poverty track (Shiferaw et al. 2011; Fisher et al. 2012). In Benin, several marketing channels exist for irrigation rice producers, however, the State remains the major buyers. Rice producers could also sell their rice in the urban markets or export to the bordering countries including Burkina Faso, Niger, Nigeria and Togo.

Interaction terms were also included in the model. This shows the effect of a change in one variable on the partial effect of the other variable (Buis 2010; Greene 2010). Results indicate positive and significant effect only for the interaction between use of irrigation and access to extension services, use of irrigation and fertilizer, use of irrigation and access to credit, and use of improved seed and access to credit. These results suggest that the impact of involvement in irrigation is going to be higher for farmers who have access to extension services and also for those who have access to credit, fertilizer and improved seed than those who did not. Negative sign was found for the interaction between access to extension services and herbicide. This implies that the effect of involvement in irrigation system is smaller for those who had access to extension services but did not apply herbicide.

Conclusions and policy implications

Interest in support for irrigation development find its foundation from past studies that have shown the importance of irrigation as viable tool for poverty reduction. The main argument is that use of irrigation contributes to achieve high yield which may lead to high income and poverty reduction. This study has investigated the effect of irrigation on poverty among rice farmers in the municipality of Malanville, Benin. It explored the complex nature of poverty through the monetary and multidimensional aspects. The latter refers to the number of deprivations experienced by the farmers. A descriptive statistic reveals that incidence of both monetary and multidimensional poverty were still high among rice farmers, especially for dry land rice farmers. An interesting lesson from this study is that weighting structure proposed for the dimensions of poverty by farmers during focus group discussions and that of key informants were found not significantly different from the equal weighting used in Alkire and Foster's framework. To assess the impact of involvement in irrigation on poverty, we employed a two-stage IV probit model to account for endogeneity of involvement in irrigation system. The results indicate that the use of irrigation contributes to decrease the probability of being poor. Besides, we find that farm size, off-farm work and access to market are crucial for driving farmers from poverty. We also find that access to credit and use of improved seed contribute to reduce poverty.

Our findings have a practical policy implication. Our findings justify the need for irrigation development targeting to implement poverty reduction policies in rural area. We also suggest the promotion of improved seed in order to increase farm productivity. Facilitation of access to credit is another policy option that can be adopted. Access to credit helps farmers to secure farm inputs and avoid delay in farm activities. It would also enable farmers to increase farm size. For a greater impact of irrigation, there is a need to improve market access for farmers. Good policies should be the target of the poorest of the poor in rice farming communities.

Disclosure statement

No potential conflict of interest was reported by the author.

Note

1. We did not report results from the first stage (estimates of probability of using irrigation) since this is not the focus of this paper. Interested readers can consult Nonvide (2017).

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