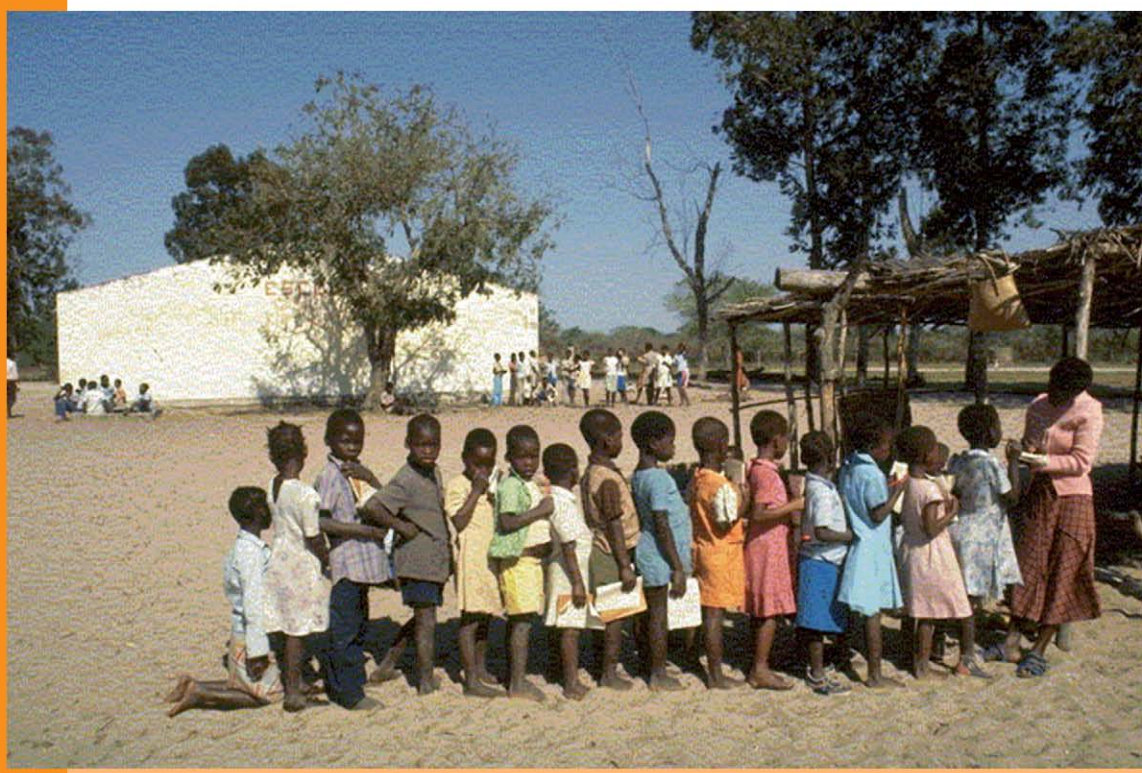
Education for Rural People



Education for Rural People and Food Security

A Cross-Country Analysis

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Foreword to the ERP Publications

Education for Rural People (ERP) is crucial to achieving by 2015 the Millennium Development Goals (MDGs) of eradicating extreme poverty and hunger (No. 1), achieving universal primary education (No. 2), promoting gender equality (No. 3) and ensuring environmental sustainability (No. 7).

The World Food Summit, held in Rome in 1996, highlighted the need to increase access to education for the poor and the members of disadvantaged groups, including rural people, in order to achieve poverty eradication, food security, durable peace and sustainable development. The 2002 World Summit on Sustainable Development (WSSD), held in Johannesburg, also emphasized the role of education. As the majority of the world's poor, illiterate and undernourished live in rural areas, it is a major challenge to ensure their access to quality education. The lack of learning opportunities is directly related to rural poverty. Hence, education and training strategies need to be integrated within sustainable rural development strategies, through plans of action that are multisectoral and interdisciplinary. This means creating new partnerships among policy-makers and practitioners working in agriculture and rural development and those working in education.

To address these challenges, the Directors-General of FAO and UNESCO jointly launched the flagship programme on ERP (http://www.fao.org/sd/erp/) during the World Summit on Sustainable Development. ERP promotes inter-agency collaboration to facilitate targeted and coordinated actions. Moreover, ERP is a flagship to alert donors and other stakeholders of the need for systematic action and investment in education, training and capacity building related to MDGs one, two, three and seven.

FAO is the UN lead agency of the ERP Flagship. It is within this framework, and to provide inspiration for the flagship initiative, that ERP has launched a series of publications with other partners such as the Department of Economics, Università degli Studi Roma Tre. Previous titles prepared in collaboration with the UNESCO International Institute for Educational Planning (IIEP) or other partners, are listed at the end of this book

The ERP publications are co-ordinated at FAO by Lavinia Gasperini.

Acknowledgments

We are grateful to many persons for helping us conduct this research. First of all, we would like to thank Lavinia Gasperini, FAO Senior Agricultural Education Officer (Research and Extension Division) and Coordinator of the ERP initiative, for her useful suggestions and supervision of our work. Next we would like to thank Alessia Naccarato, Researcher at the Department of Economics of the Università degli Studi Roma Tre, who gave us fundamental insights into the quantitative methodology we used in this research. We greatly appreciate the contribution of Elaine Unterhalter, Senior Lecturer at the Institute of Education, University of London, whose insights were fundamental to linking the theoretical framework with the empirical analysis. We are also grateful to all participants of the International Working Group on Education (IWGE) Seminar organized by UNESCO and hosted in Rome by FAO in June 2006 and of the International Conference of the Human Development and Capability Association (HDCA) on "Freedom and Justice", held in Groningen during summer 2006. The comments of rural development experts as well as education experts on earlier drafts of this publication were essential to improving the quality of the research. The editing work done by James H. Williams has been of inestimable value, and we would like to thank him for joining this project with great enthusiasm and professionalism. We would also like to thank the participants of the 28 March 2007 Seminar held at FAO headquarters, where we had the opportunity to discuss the results of this research in depth. Written comments by L. Van Crowder, Senior Extension Systems Officer, Natural Resources Management and Environment Department of FAO, helped us clarify a number of key points. Finally, we would like to thank Eszter Kollàr for her corrections and useful advice on preliminary versions of the paper.

List of Abbreviations

DHS	Demographic and Health Surveys
EFA	Education for All
ERP	Education for Rural People
FAO	Food and Agriculture Organization of the United Nations
HFI	Household Food Insecurity
HNP	Health, Nutrition and Population
ICN	International Conference on Nutrition
IFAD	International Fund for Agricultural Development
ISCED	International Standard Classification of Education
MDGs	Millennium Development Goals
OLS	Ordinary Least Squares
PRSPs	Poverty Reduction Strategy Papers
SD	Standard Deviation
SOFI	State of Food Insecurity
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development

Abstract

Food insecurity is at the heart of the international movement to overcome hunger and poverty. The first Millennium Development Goal (MDG) sets as its target the eradication of extreme poverty and hunger, with a target of halving the incidence of poverty and hunger by 2015. This research contributes to that process, by analysing the connections among rural poverty, hunger and education for rural people. The paper focuses on rural people, because they are among those groups suffering the most from extreme hunger. Using household-level data from the Demographic and Health Surveys (DHS) for 48 low-income countries, the study examines through visual and statistical means the co-variation between hunger and lack of education. The study finds that hunger is highly correlated with educational deprivation. Moreover, the correlations are highest at the primary level, decreasing in strength with higher levels of education. In coherence with the Capability Approach, which stresses education's active role in developing people's capabilities, these results suggest that to fight food insecurity, governments, international organizations and civil society should invest more in the education sector, especially primary education for rural people. Greater investment in quality primary education is likely to make substantive progress possible towards achievement of MDGs 1 and 3, 2.[1] Our results suggest, for example, that if a low-income country such as Mali, among those with the lowest levels of education, could double access to primary education by rural people, it could substantially reduce rural food insecurity, by around 25 percent. Given the concentration of population and poverty in rural areas in most low-income countries, education for rural people can be seen as a key factor for promoting overall national food security. Increasing educational participation will require substantially greater investments of resources and a mobilization of political will at international, national, and local levels. This paper aims at raising awareness primarily among policy makers outside education of the central role of education in fighting hunger and poverty.

[1] MDG 1: "Eradicate extreme poverty and hunger"; MDG 2: "Achieve universal primary education"; MDG 3 "Promote gender equality and empower women". MDG 3 relates to education since the commitment related to it is: "Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015". For the entire list of MDGs, see the following Web site: http://www.un.org/millenniumgoals/

Overview

Food insecurity and poverty in low-income countries are at the heart of the current work of the international community. The first MDG gives priority to halve by 2015 the proportion of people suffering from poverty and hunger. FAO has the mandate to monitor progress towards achievement of this goal. The 2005 State of Food Insecurity (SOFI) report, published by FAO, shows how poverty and hunger are essentially rural phenomena, closely related to the lack of education. Given the strong correlation between poverty, hunger and education, in 2002 FAO launched the Education for Rural People (ERP) partnership programme in collaboration with UNESCO. Up to the present, about 300 partners - international organizations, national governments, academic institutions, civil society, and the media - have joined the programme. This research contributes to the policy work of the ERP partnership.

Main findings

More than 800 million people suffer from food insecurity and lack of education. This paper shows, through quantitative analysis, that education is a key determinant of food insecurity for rural populations in low-income countries. We draw attention to rural people because they are traditionally neglected by national education and development policies. The theoretical foundation for this study is a substantial body of research that documents how education improves people's capacity to diversify assets and activities, increase productivity and income, foster resilience and competitiveness, access information on health and sanitation, strengthen participation, all essential elements in ensuring long-term food security. Here, we analyse the extent to which lack of education is associated with food insecurity in rural areas in low-income countries.

The study found that the correlations between food security and primary education are very high. These correlations decrease progressively with basic (primary + lower secondary school), upper secondary, and tertiary education. These bidirectional relationships are examined through statistical and graphical methods.

Econometric analysis confirmed that primary education is a key determinant of food insecurity in rural areas of low-income countries, even when other factors such as access to water, health, and sanitation are controlled. Based on our model, doubling school attendance rate on the part of primary school age children is associated, on average, with 20 percent or 25 percent decrease in food insecurity. Since the majority of people in low-income countries live in rural areas, and since it is in these areas that the largest proportion of world poverty and hunger exists, education for rural people is a key factor for promoting overall national food security.

Study rationale

In an era of scarce resources, this research helps provide criteria to policy-makers for setting priorities among different sectors of investments, and for priorities for different levels within the education system.

In recent years, the policy and research development agenda has highlighted the inter-relatedness among illiteracy, poverty, food insecurity, and gender inequalities. It is now well understood that poverty is a multi-dimensional phenomenon, not a simple lack of income. Poverty means lack of health, lack of housing, lack of self-esteem, lack of food, lack of hope, lack of empowerment and participation, and lack of education. With the MDGs, the U.N. launched a new strategy based on recognition of the multiple dimensions of poverty and the need to overcome them by interdisciplinary, inter-sectoral work, and interagency collaboration. The core idea behind the Millennium Strategy is the inter-linkages among multiple factors of development, including the relation between lack of education and lack of access to food. The Millennium Strategy and Project provided the policy and operational framework for a change from traditional agricultural production and supply-driven approaches to people-centred sustainable development policies. The multidisciplinary approach to the MDGs permitted a broadening of the focus of poverty and food insecurity reduction efforts to include education and training of all of those who live in the traditionally neglected rural space.

These policy changes culminated in the Millennium Summit and were nurtured by several key development events of the 1990s. At the first International Conference on Nutrition (ICN) held in December 1992, 159 States declared: “we recognize that poverty and the lack of education, which are often the effects of underdevelopment, are the primary causes of hunger and undernutrition” (Article 5 of the World Declaration on Nutrition). In 1996, the World Food Summit (WFS) Plan of Action adopted several commitments which identified education as a key to poverty eradication, durable peace and food security (Commitment 1, Objective 1.4). Commitment Two (Objective 2.1) refers to the need to develop human skills and capacities through basic education and pre- and on the-job training. Objective 2.4 of Commitment Two stresses the need for "promoting access for all, especially the poor and members of vulnerable and disadvantaged groups to basic education" in order to "strengthen their capacity for self-reliance". The Summit calls governments, in partnership with all actors of civil society to "promote access and support for complete primary education" with particular attention to "children in rural areas and to girls". In 1990, Article 3 of the Education for All (EFA) Declaration stressed that an active commitment must be made to removing educational

disparities by focusing on underserved groups specifically including the poor, working children and rural and remote populations. Article 5 of the same Declaration focused on the need to broaden the means and scope of basic education by also focusing on basic skills training for youth and adults including agriculture techniques.

The analytical focus of this research is on the connections between education and food insecurity in rural areas. Seventy percent of the world's poor - defined as those with income of less that 1 dollar per day - live in rural areas (see, for example, World Bank 2003). However, many of the development strategies developed by national governments and donors overlook the rural reality and focus mainly on urban and peri-urban areas.

It was in this context that the ERP strategy was developed. This research has been undertaken under the auspices of the ERP FAO-led partnership, and is co-funded by FAO and the Università degli Studi Roma Tre, Department of Economics, an institutional member. The Department is deeply committed to work in this area, offering a Master's degree programme in Human Development and Food Security and a PhD in Institutions, Environment, and Policies for Economic Development. This collaboration between the Università degli Studi Roma Tre and FAO, Natural Resources Management and Environment Department, aims to strengthen awareness of the importance of investments in basic education for rural people in low-income countries, to help improve overall standards of living and to help meet especially MDGs 1, 2 and 3.

1. Introduction

The 1996 World Food Summit provided the following useful definition of food security: "Food Security exists when all the people, at all times, have the physical and economic access to sufficient, safe, nutritious food for a healthy and active life". This paper focuses on rural people, who are traditionally neglected by national education and development policies. The 2004 State of Food Insecurity Report (FAO 2005, pp. 28-29) highlighted the strong relationship between food insecurity on one hand and illiteracy and lack of education on the other. Data for rural areas in 22 low-income countries show how a high level of undernourishment - used as a proxy of food insecurity - is correlated with a low level of literacy. The current empirical study is intended to take this line of analysis one step further.

The key element of the current research is the construction of an econometric model based exclusively on rural data. Theory provides a strong case for the positive impacts of education on food security. From a broader human development perspective, the impact of education goes far beyond the enhancement of productive skills to be used in the labour world. Education contributes to development in social, institutional, as well as economic spheres. Based on this theory, education is expected to have strong explanatory power in relation to food security in rural areas. The current analysis examines the data to see if the evidence supports the theory.

Section 2 explains the theoretical foundations of the quantitative analysis. Section 3 describes the methodology, data, variables and choice of indicators, and analytic strategy. Section 4 presents results, first of exploratory analyses - graphical and correlational - of the relationships between education for rural people and rural food insecurity. This is followed by multiple regression analyses, which allow the estimation of the effects of educational security on food insecurity, controlling for the effects of other factors likely to be associated with food insecurity. Section 5 summarizes the report, discussing the implications of findings for policy and practice in agriculture, development, and food security.

2. Theoretical Background

Chapter 2 aims to provide the theoretical background for the quantitative analysis. The chapter is structured as follows. Since there is a two-way relationship between education and food security, first we briefly address the causal relationship between food security and education, and then the reverse one, which is the main object of analysis of this paper.

No much work has been produced to study the last direction of the relationship, thus reference is made with respect to different literatures, and focusing on rural people of low-income countries. The recently published report on "Hunger and Learning" (WFP 2006) offers interesting insights.

2.1 Impact of Food Security on Education

The food insecurity-education direction of the relationship has been studied more deeply. In order to explain it in a comprehensive way, it is necessary to differentiate current from future effects of hunger and to distinguish three main phases in the educative process: early childhood (age 0-5), school age (6-17), and adulthood (18 and above).

During early childhood, undernourishment is likely to limit the stimulation a child should receive and to undermine the basic learning capacities of a child. The main negative effects of food insecurity in this stage are visible during the school-age phase (WFP 2006, pp. 41-44).

In school-age, food insecurity causes several damages to children (WFP 2006, pp. 45-46). It can lower school enrolment and attendance, and then it can limit the capacity to concentrate and perform in school. Since schooling is seen as an essential opportunity for learning, these are large impediments to child mental development. Another relevant problem in this stage is that food insecure families face higher opportunity costs in sending children to school because they could earn and provide means of subsistence to the household members. Such opportunity costs are even larger if school fees exist.

Finally, also adults could develop their knowledge, abilities and skills through specific programmes such as literacy training or agricultural extension programmes. Although "By adulthood, an individual's cognitive capacity to learn is already largely established" (WFP 2006, p. 46), these are important learning occasions for both daily life matters and employment and earning opportunities. The main obstacle consists in the larger opportunity costs since at this stage people spend the major part of the day in the workplace. This is true even when classes are organized after working hours (WFP 2006, p. 48).

In terms of policy, both governments and international organizations such as FAO and WFP prevalently intervene during early childhood and school-age stages. In the first case, through iron and micronutrients supplementary diet, and in the second case, mainly through school feeding. School feeding is a typical policy applied to increase children school attendance and concentration in the classroom, by providing them with food at school. This also contributes to lower the opportunity costs of food insecure families, since they have to feed fewer members.

2.2 Impact of Education on Food Security

The aim is to study the influence of education on food security in low-income countries. Since 70 percent of world poor live in rural areas (World Bank 2003) we propose a theoretical model that stresses the *instrumental* role (Sen 1999, pp. 38-40) played by education in tackling food insecurity among rural people.

Although "acclaimed as one of the most powerful engine for reducing hunger and poverty" (FAO 2005, p. 14), the impact of education on food security is often exclusively conceived in economic terms. The same FAO report clarifies that "lack of education undermines productivity, employability and earning capacity, leading directly to poverty and hunger". This reflects the human capital approach, following which education is relevant insofar as it increases personal earnings and productivity, and economic growth at national level (Schultz 1961 and 1971; Becker 1962 and 1993; Psacharopoulos 1973). More specifically, in rural areas, education improves agricultural productivity, leading to food security (e.g. Jamison et al. 1982; Pudasaini 1983; Koffio-Tessio et al. 2005). For example, Jamison et al. (1982, p. 54), on the basis of the results derived from 118 studies conducted in several geographical areas (17 in developing countries and 1 in Japan), estimated that completing the first four years of formal schooling results in a 7.4 percent increase of agricultural productivity.

However, this approach has been criticized because it is very economistic; it only recognizes the instrumental economic role of education (Sen 1997; Woodhall 2001; Robeyns 2006). Education, to the opposite, can have a double "indirect" role: through "economic production" and through "social change". The latter is neglected in the human capital framework. This approach is especially more suitable to the new conceptualization of food security, which goes beyond the simple attention on food supply.[2] Considering both the contributions has relevant policy implications with respect to the type and level of education to focus on.

Using as main conceptual framework the Capability Approach (Alkire 2005), and counting on different kinds of literature, we identify the main mechanisms through

[2] The evolution of the concept of food security will be briefly analysed in chapter 3.11, which draws attention to the indicator of food insecurity adopted for the quantitative analysis.

which rural people with more education are more likely to experience higher levels of food security. The various contributions of education to food security can be viewed in the diagram 1. Here, we explain more in depth some of these channels.

First, the impact of education can occur through *social* and *institutional change* (brown in the diagram). As Mukudi (2003) claims, education has a key role in accessing public *information*, especially concerning health, nutrition, and hygiene because it "can open the mind of people" (Robeyns 2006, p. 3). Acquiring knowledge about how to avoid and face illnesses is essential since people with diseases require more calories to be food secure. Furthermore, it is well known that people need to have, where possible, an adequate and diversified diet in order to build a stronger immune system and avoid morbidity and mortality. Finally, even following right hygienic practices is essential to prevent diseases like diarrhoea. Mass media such as radios are widely spread in African countries, even among poor people living in rural areas; therefore only people with a minimum level of education can properly capture and elaborate that information.[3]

Even more relevant is the role of primary education and literacy in acquiring this type of information from written messages. This argument, indeed, should be extended in an inter-temporal dimension: "parental education […] has been found to invariably influence nutritional outcomes of the children. Children of less educated parents and those of parents with no educational exposure consistently score poorly on nutritional status indices" (Mukudi 2003, p. 246). Moreover, there is a gender aspect that does matter for ensuring long-term food security (red in the diagram). In fact, the specific impact of women's education is higher: girls who attend school and obtain at least the basic skills can even teach right health and hygienic practices to their children once they become mothers. This means that female education should be at the centre of the analysis because it has an additional direct effect on nutritional status. Empirical research, such as that carried out by Glewwe (1997, p. 151) in Morocco, showed that mother's "education improves child health primarily by increasing health knowledge" and that it does not depend prevalently on the subjects studied in class, but on the very general abilities to read, write, reflect, and process information.

Education, then, is fundamental to promote *agency* (Sen 1999). "Agency refers to a person's ability to pursue and realize goals that he or she values and has reason to value" (Alkire 2005), but here it is just interpreted as the ability of rural poor to escape from poverty and hunger with their own means. Who is educated is more likely to find a job, but has also a capacity to use more rationally the resources he or she owns. Educated and informed people are more likely to select valuable objectives in life, such as having stable access to food for their household. Even here there is a gender aspect. Mothers showed to assign a higher value to the well-being of their children, allocating more resources to health, and nutrition (Sen 1999, pp. 195-196). Quoting again Sen (1999,

[3] See among others Schnell-Anzola et al. (2005, pp. 20-21) drawing this conclusion from an empirical study made by Thomas (1999).

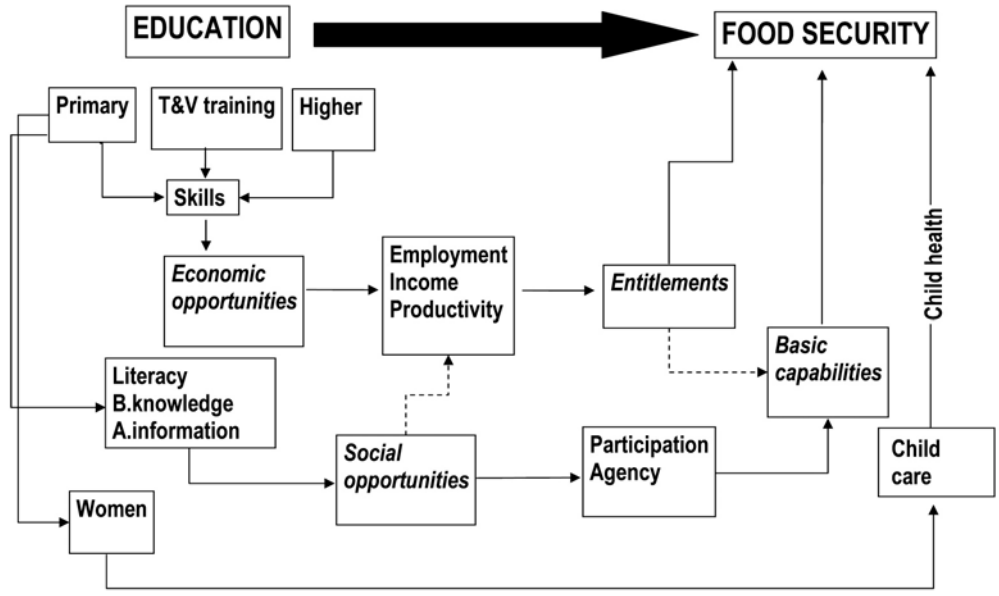
p. 197), "female literacy […] is found to have an unambiguous and statistically significant reducing impact on under-five mortality, even after controlling for male literacy". Therefore, a more active role of women in family is likely to lead to lower mortality rates, which, in low-income countries, are mostly due to malnutrition.

A third "social" benefit of education for food security and well-being in general, is enhanced through an improvement of *social relations*. In rural Africa, for instance, the role of community actions is impressive. Some authors defined "social capital" (Woolcock and Narayan 2000) the social networks in which a person is included, arguing that the larger these nets are the larger the possibility to find assistance in emergency situations. To make an example, many communities organize common meals, systems for a common access to credit, labour division, and public participation to ceremony expenditures. This way the risk, even to become food insecure, is alleviated, making individuals less vulnerable. The next question is: how does education affect social relations? Lanzi (2004, p. 13) speaks about the "positional" value of education, with reference to the ability to relate well to others and to cooperate (OECD 2003), achieved through education, even here conceived in its more general form rather than the specific topics studied in school.

Finally, education provides an *inner* contribution to food security, making people more ambitious and self-confident. Being educated is considered a relevant weapon against feelings like shame and lack of hope, whose overcoming is indispensable to promote food security through the other mechanisms mentioned above.

Education influences food security through the *economic production* channel (green in the diagram). In rural areas, this is typically achieved through the increase of agricultural productivity and efficiency in that sector. That is, by increasing the amount of output per unit of input, and by choosing and allocating in the best way the inputs of production. However, another economic contribution of education to food security was often neglected: the income obtained by crops different from the main one and non-farm activities. Rural non-farm activities were not taken into adequate consideration; instead, they can be a fundamental direct source of food or income, and, even more, a resource for the long-run. In fact, the diversification of income generating activities is essential to reduce vulnerability and recover more rapidly from emergencies like natural disasters.

Diagram 1. Direct and Indirect Contributions of Education to Food Security



More recently, the 2006 World Food Programme publication on "Hunger and Learning" has contributed to systematize the relationship between education and food security. Although not directly referring to a particular approach, it recognizes the multiple benefits of education and learning on household, child, and overall food security. In particular, it makes a temporal distinction of such benefits. Although the quantitative study, which will follow this section, concentrates on the whole (rural) society, without distinguishing by units of analysis (children, mothers, households, etc.), in this part it is important to outline that the impact of education varies depending on the stage of life in which it is acquired: early childhood (0-5), school age (6-17), or adulthood (18 and above).

In the early childhood, lack of proper stimulation undermines child's capacity to learn and be food secure in the future. There are no direct, immediate effects on his or her food security (WFP 2006, pp. 51-53).

School-age is crucial for both current and future dimensions of food security (*availability*, *access*, and *utilization*). In school, children directly learn subjects related to nutrition, health, and hygiene (*utilization* dimension), acquire life-skills, and finally obtain knowledge and skills to use in future working experiences.

During adulthood specific programmes such as extension services in agriculture can increase household food *availability* and income (*access* to food). Moreover, adults have the opportunity to learn certain behaviours connected with food *utilization* that they did not learn previously.

As a conclusion, it is important to point out that this chapter has provided brief but fairly exhaustive examination of linkages between the two phenomena. Due to data constraints and limits related to the modelling of economic and social relationships, the quantitative analysis will be able to reproduce only partly this theoretical framework.

Finally, a wider approach than the human capital approach allows to assess the multiple channels through which an educated and skilled society can reduce food insecurity among rural people of low-income countries. Furthermore, this has important policy implications: the type of education that could be useful for the purpose could go much beyond the simple functional literacy and agricultural extension services. The capability approach, in fact, stresses the importance of education for general children's and adults' development. The empirical analysis will intend to assess also the level of (formal) education countries should invest in for the purpose of alleviating rural food insecurity.

3. Methods

3.1 Dataset and Aggregate Indicators

Household data represent the best source of information on hunger and educational participation. Among the best household surveys in low-income countries is the

DHS, funded in part by USAID.[4] DHS relies primarily on household schedules and questionnaires for women aged 15-49. Women are asked a range of information concerning their household on topics such as nutrition, fertility, prevalence of HIV-AIDS and other diseases, access to media, and educational participation and attainment.

This analysis is carried out on DHS data from rural[5] areas of 48 low-income countries (see Annex 1 for further details on the sample). Data from rural households were aggregated to the country level for analysis. Thus the sample consists of 30 countries from Africa, 10 from Asia, and 8 from Latin America (see Annex 2). DHS administered its surveys in different years, from the late 1980s to 2004. We decided to consider data only from the 10-year period 1995 to 2004, during which time it is assumed the structural relationship between education and food security was sufficiently stable to make analysis meaningful.[6] In those countries where there are multiple years of data, we used the average value.[7] Data were processed using the Stata statistical analysis software package.

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[4] Also the World Bank *Health, Nutrition and Population (HNP) Poverty Data* are based on DHS surveys. Data are available online at the Web site http://www.measuredhs.com/aboutdhs/ Accessed on 27/06/2007.

[5] There is no common definition of rural areas across countries: DHS follows the definition provided by each country. In general terms, rural areas are those with less than a fixed number of residents (e.g. 2,500 in some countries in Sub-Saharan Africa), far from cities, and with poor infrastructure.

[6] Most low-income countries adopted new education policies in the middle 1990s. Criticism of structural adjustment policies of the World Bank and the International Monetary Fund led to adoption of new approaches to development assistance, represented by the use of Poverty Reduction Strategies (PRSPs) and the MDGs. The MDGs represent a new consensus on the need for greater balance among growth and equity, and social and economic investments such as education and health. (See, for example, Stiglitz 2001; Cornia et al. 1987; Psacharopoulos and Woodhall 1985).

[7] For more information on data treatment see Annex 1.

3.1.1 Measures of Outcomes—Rural Food Insecurity

This analysis seeks to understand whether in rural areas of the 48 countries examined food insecurity varies in relation to educational participation. If a strong relationship is found to exist, we will conclude as theory suggests that participation in education for rural people leads to greater rural food security.

To carry out this analysis, a theoretically and empirically sound measure of food security must be constructed. Food security is a multi-faceted phenomenon, and its appropriate measurement varies according to the purpose of analysis and use. A study seeking to predict food crises, for example, would require different measures than a study such as this one which seeks to understand causal relationships among structural factors. Here, we use anthropomorphic, nutritional, and survival data, which point directly to undernourishment, an adequate and reliable measure of human deprivation (see Annex 3 for a more complete theoretical discussion of these issues).

Our outcome consists of three components:

- "Adequate survival status" (Wiesmann 2002), which serves as a proxy for premature death due to malnutrition. We average the infant mortality rate and the under-5 mortality rate.[8]

- A second component reflecting Wiesmann's ideas of both "adequate nutritional status" and "food adequacy". Here, they are expressed by the prevalence of stunting,[9] underweight[10] and wasting.[11] We average the values of the three indicators, weighting by 2/3 the percentage of the rural population with moderate stunting (underweight and wasting), and weighting by 1/3 the percentage of the population with severe stunting (underweight and wasting).

[8] While Wiesmann uses only the variable under-5 mortality rate, here an average value between this variable and the infant mortality rate is used because the causes of very early death can show a different intensity and typology of malnutrition (Wiesmann 2002).

[9] "Stunting" is defined as children with a height-for-age score two or more standard deviations below the mean of a normal distribution of children's height for age. "Severe" refers to children who are three or more standard deviations below the mean; "moderate" refers to children who are between two and three standard deviations below the mean.

[10] "Underweight" refers to weight-for-age indices. "Severe" denotes scores of three or more standard deviations below the mean, while "moderate" refers to scores of two to three standard deviations below the mean.

[11] "Wasting" is defined as children with a weight-for-height score of two or more standard deviations below the mean on an index of children's weight for height. Again, "severe" denotes scores of three or more standard deviations below the mean, while "moderate" refers to scores of two to three standard deviations below the mean.

- Female malnutrition. We use the percentage of rural women whose body mass index is less than an internationally fixed threshold of 18.5.[12]

As the first indicator of household food insecurity (*rurHFI1*), we calculate a simple arithmetical mean of the three components.

This method of calculation assigns equal weight to each of the three measures of deprivation. The case could be made, however, that the more extreme deprivation should be weighted more heavily, as any area of extreme deprivation cannot easily be counterbalanced by a higher score in another area. To allow for this possibility, we calculate a second measure (*rurHFI2*), which gives greater weight to extreme deprivation.[13] (See Annex 3 for the formulas used).

As shown in Table 1, our index of food insecurity is calculated using data on infant and child mortality; stunting (height-for-age indices), wasting (weight-for-height), underweight (weight-for-age); and female malnutrition (BMI).

[12] Many experts do not use this indicator, but we feel it is extremely important to check both the nutritional situation of one of the most disadvantaged groups (women) and, to forecast possible food insecurity problems for the future. Most women will be mothers, and their nutritional status decisively affects the health of their children. Using this variable also provides an element of "stability" over time in food security.

[13] For both theoretical and mathematical explanation see Anand and Sen (2003, pp. 211-218).

Table 1. Components used to construct measures of food insecurity

Indicators of	Variable
Survival	
Rural infant mortality rate (%)	rurinfantmortality
Rural child mortality rate (%)	rurchildmortality
Rural under 5 mortality rate (%)	rurund5mortality
Malnutrition	
Rural severe stunting rate (%)	rursevstg
Rural moderate stunting rate (%)	rurmodstg
Rural severe wasting rate (%)	rursevwstg
Rural moderate wasting rate (%)	rurmodwstg
Rural severe underweight rate (%)	rursevundwght
Rural moderate underweight rate (%)	rurmodundwght
Female Malnutrition	
Percentage of rural women whose BMI is less than 18.5	rurlowbmi

3.1.2 Policy Variables - Educational Participation

DHS captures educational participation by asking questions about school attendance. This is an imperfect measure. While school attendance rates for different age-groups can be considered reasonably good proxies for educational participation, they do not capture all relevant information, leaving out, for example, information on school completion or transition, or on cognitive achievement. There could be situations in which students go to school, attend class, but learn little, not passing to next class or acquiring a sufficient amount of the curriculum. There is also the possibility of overage children biasing the statistics, for example an 18-year old in primary school.[14] To partially compensate for the weakness of school attendance data, we also used the "highest level of school attended" as a percentage of the rural population.

[14] Literacy, which identifies the basic capacities to read and write, could provide complementary information. However literacy data are available only for a very small number of countries.

Table 2. Measures of educational participation

Indicators of	Variable
Attendance	
Attendance rate of rural children, ages 6-10	rurattendance610
Attendance rate of rural children, ages 11-15	rurattendance1115
Attendance rate of rural youth, ages 16-20	rurattendance1620
Attendance rate of rural youth, ages 21-24	rurattendance2124
Highest Level of Education	
Percentage of rural population with no education	rurnoedu
Percentage of rural population with upper secondary or higher education	rurminsecondary
Percentage of rural population with tertiary education	rurtertiary

The variables included in these two groups are used as proxies of access to different levels of education, as follows:

- *Primary Education* corresponds approximately to Level 1 of the International Standard Classification of Education 1997 (ISCED 1997).[15] Primary education is measured here by two variables: 1) the school attendance rate for the rural population in the age-group 6-10; and 2) by the percentage of rural people with no education.

- *Lower Secondary Education* corresponds to Level 2 of ISCED (1997). Here it is measured by the school attendance[16] rate for the rural population ages 11-15.

- *Basic Education*, consisting of primary and lower secondary school, corresponds to ISCED Levels 1 & 2. It is measured by the school attendance rate for the rural population ages 6-15.

[15] The DHS education data do not reflect precisely the ISCED 1997 international standards. The age-groups for school attendance are, instead, the same used by UNICEF. See, for example, UNICEF TransMONEE 2006 Glossary:
http://www.unicef-icdc.org/resources/transmonee/2006/glossary_2006.pdf. Comparability is also complicated by the different structures of education systems in different countries. Most systems are organized roughly according to the ISCED classification. However the length of different cycles can vary across countries. Primary education cycles, for example, vary from 5 to 8 years.

[16] Attendance is used here to refer to enrollment or participation as opposed to daily attendance.

- *Upper Secondary Education* corresponds to ISCED Levels 3 and 4 (upper secondary and post-secondary but not tertiary education). It is measured by school the attendance rate, upper secondary school, for the rural population ages 16-20.

- *Upper Secondary and Higher Education* corresponds to ISCED Levels 3, 4 and 5. It is measured by the proportion of rural people who have attended at least secondary school.

- *Tertiary Education* corresponds to ISCED Level 5. It is measured in two ways: 1) by the attendance rate for the rural population ages 21-24; and 2) by the percentage of the rural population which has attended tertiary education.

3.1.3 Control Variables—Other Factors Affecting Food Security

In order to understand the true effects of education, it is necessary to control for other factors that are also expected to affect food insecurity. Holding those other

factors constant allows us to gauge the relative size of the educational effect, given other relevant factors. These factors relate to sanitation, health, access to potable water, access to media, ownership of assets as a proxy for assets-based poverty, and context (whether or not it is an African country; whether or not there was a conflict at the time of the survey or immediately before).[17]

[17] These factors were included as they were reasonably assumed to have an important relevance on the level of food insecurity at the household level. There was no income data, but one variable related to the ownership of different types of assets. The lack of any of these non-productive assets is here used as a proxy of (assets-based) poverty. Finally, it was decided not to include most of the factors related to physical environment (clime, natural disasters and others) and institutional environment (democracy, political freedom, participation).

Table 3. Control variables

Factor	Variable
Sanitation, Health, Water	
% of rural households without toilet facility	rurnofacility
% of rural children under 5 with diarrhoea[18]	rurhealth
% of rural households with access to potable water	rurwater
Access to Media	
% of rural households with access to radio	rurradio
% of rural households with no basic asset[19]	rurnoasset
Context	
dummy variable for continent[20]	dcontinent
dummy variable for presence of conflict	dconflict

3.2 Analytic Strategy

As noted, the overall purpose of this analysis is to understand the relationship between educational participation in rural areas and food insecurity, independently of other factors associated with food security. We begin with a series of exploratory analyses then move on to econometric analyses using multiple regressions, which allows for more credible causal inferences as well as precise estimation and comparison of effects.[21]

[18] Calculated for the two weeks preceding the survey.
[19] A measure of assets-based poverty.
[20] This dummy variable takes a value of 1 if the country is African, value 0 if is from another continent.
[21] Causality cannot be assumed from the statistical models utilized here, which only examines correlational relationships. However, these models can examine the evidence in support of a theoretical argument. Moreover, with the regression models the researcher is able to examine the "effect" of multiple factors simultaneously, thus enhancing the credibility of inferences.

4. Results

4.1 Exploratory Analysis

Section 4 discusses the results of analysis. The exploratory analysis consisted of four parts, discussed as follows: first, we present descriptive statistics to describe the overall extent of participation in different levels of education in the sample. Next, we present a "dependency analysis", which examines connections between educational participation, measured at different levels, and food insecurity. The next section presents and discusses scatterplots of the two variables, noting important country cases. The final section presents results of correlation analysis, permitting a more precise estimation of the bidirectional relationships examined here.

4.1.1 Descriptive Statistics - Educational Participation

First, it is useful to present a general idea of the extent of educational participation in the sample. Table 4 presents mean, minimum and maximum values for the sample of 48 countries of rural data.[22]

Table 4. Educational participation rates in rural areas in low-income countries (in percents; n=48)

Variable	Mean	Minimum	Maximum
PRIMARY EDUCATION			
Attendance of rural children ages 6-10	60.4	13.4	91.7
Percentage of rural children with no education	38.4	4.1	87.2
LOWER SECONDARY EDUCATION			
Attendance of rural children ages 11-15	67.2	14.3	98.0

[22] Countries were not weighted according to population, consciously, to ensure that more populous countries did not skew the results. As a consequence, however, these figures must be understood as representing the mean country value for rural educational participation rather than the overall average.

BASIC EDUCATION			
Attendance of rural children ages 6-15	63.4	13.7	93.2
UPPER SECONDARY EDUCATION			
Attendance of rural children ages 16-20	28.8	1.4	73.9
UPPER SECONDARY & TERTIARY EDUCATION			
Percentage of rural population who have attended secondary or tertiary education ages 16-24	19.2	1.3	76.7
TERTIARY EDUCATION			
Attendance of rural youth ages 21-24	7.3	0.2	30.6
Percentage of rural population who have attended tertiary education	1.6	0.001	8.8

It is clear from this table that educational participation rates in rural areas vary considerably across levels of education and among countries in the sample.

While a majority of rural children appear to be taking part in primary and basic education, for example, there are country cases where the rates are substantially lower.[23] Upper secondary and tertiary participation rates are substantially lower in all cases. In most low-income countries, it would seem, a majority of rural children do not attend secondary school. Participation is particularly low in tertiary education. Using *rurattendance2124* as a proxy for tertiary education, an average of only 7.3 percent of rural youth between 21 and 24 attend school across the sample of countries, with a minimum of 0.2 percent in Niger and a maximum of 30.6 percent in South Africa. Participation in tertiary education is even lower if measured by *rurtertiary*, ranging from 0.001 percent in Mozambique to 8.84 percent in Jordan.[24]

[23] It must be remembered that attendance does not necessarily entail successful completion or mastery of the curriculum, or even literacy.

[24] These differences can be understood as differences in the variables used as proxies for access to tertiary education. For instance, r*urattendance2124* reflects the percentage of rural people aged 21-24 attending school, while *rurtertiary* is the percentage of total current population in rural areas that has ever taken part

A key policy question for this analysis is whether participation at one level of education is more closely associated with food security than others.

4.1.2 Dependency Analysis

A useful way of studying the relationship between two variables is to cross-classify the data and then build a contingency table or cross-tabulation showing the counts at different levels. Within each variable, countries were divided into five classes, reflecting the different intensity of the phenomenon (see Annex 4 for the values for different countries. Contact the authors for details in the classification of particular variables).

Maps are used to present associations between high levels of education and low levels of food insecurity, and vice versa. A similar analysis was carried out for the 2004 State of Food Insecurity Report (FAO 2005); however, such analysis considers only 22 countries and uses only literacy rates as a proxy of education.

Countries with high levels of association are coded with a specific colour on the world map.

Figures 1 and 2 look at basic education. Figure 1 shows countries where there is low educational participation and high food insecurity, all in rural areas. "High" is defined as countries in the top two of five categories of countries classified as above. "Low" is defined as countries in the bottom two, of five categories. Brown indicates where both conditions apply, that is high food insecurity is coupled with low educational participation. Yellow indicates countries where educational participation is low but where food insecurity is not low. Blue indicates countries where food insecurity is high, but educational participation not in the low levels.

The figure shows a clear relationship between high food insecurity and educational participation in rural areas. Countries with the lowest levels of rural participation in basic education are generally also countries with the highest levels of rural food insecurity.

Several additional points are worth noting. First, high or very high food insecurity is never associated with high levels of basic education. Moreover, of the 48 low-income countries for which data are available, all those included in the map (except for two) are

in tertiary education. An African country, for example, might have a relatively large number of people of tertiary attending age, who are attending some level of school, though not necessarily at the tertiary level. To the extent that some children and youth are overage and attend school at a level below that corresponding to the proper age, these figures overstate participation in higher levels of education, and may understate participation in lower levels.

African. Finally, that no Latin American countries appear on this map. Compared to other low-income countries, they are "food secure".[25]

The question can also be answered in the reverse, by looking at the correspondence between countries with high levels of educational participation in basic education and low levels of food insecurity in rural areas. Figure 2 shows the results of this analysis. Countries in brown are those where the rural food insecurity is in the low or very low categories, and basic educational participation is in the high or very high groupings. Yellow indicates countries where rural areas score in the lowest two categories of food insecurity but not the high or very high categories of basic education. Blue indicates countries where rural access to basic education is in the high or very high groups, whereas food insecurity is not in the low or very low categories. The large prevalence of brown suggests a statistical dependency between high levels of basic education and low levels of food insecurity. Even large countries such as Brazil and Kazakhstan, which have high levels of rural basic education, have low levels of food insecurity, at least as measured here.

Maps portraying the statistical dependency between primary education and food insecurity are quite similar to the results reported here and so are not shown here.

However, the relationship between food insecurity and higher levels of education is worth investigating. Figure 3 presents similar results for countries with lower/lowest rates of secondary participation and higher/highest levels of food insecurity. Brown indicates countries where there is high or very high rural food insecurity, along with low or very low secondary education participation. There would appear to be a general dependency, but not a high correlation.

Figure 4 shows that only in a few countries there is correspondence between low or very low rural food insecurity and high or very high secondary participation (brown area). Instead the map shows a number of South American countries where low food insecurity is coupled with middle or even low levels of secondary participation (countries in blue). Thus, we conclude that there is only a weak statistical dependency between participation in secondary education and food insecurity.

The final set of maps looks at the dependency between food insecurity and tertiary education in rural areas. Figure 5 shows the relationship between low/very low tertiary participation and high/very high food insecurity. The lack of a strong relationship can be seen in the lack of brown. Less than half the countries are marked in brown colour. Only

[25] Brazil and South Africa, for example, are not in the list of the countries with high or very high rural food insecurity. This is an artefact of this country-centred analysis, which looks only at averages for all rural areas of the country. In fact, it is well-known that some provinces in rural Brazil, especially those along the northeast coast, have dramatic numbers of people suffering from hunger. Similar questions might be raised about South Africa, both suggesting directions for future analysis.

in a few African countries is high food insecurity associated with educational deprivation at the level of tertiary schooling.

Figure 6 portrays the relationship between high/very high tertiary participation and low/very low food insecurity in rural areas. As can be seen, countries with high or very high percentages of rural people attending school at tertiary levels are not more likely to have high levels of rural food security. The brown area, which shows countries performing well in both dimensions, includes only two African countries. On the contrary, the area in yellow, which identifies countries with high tertiary participation and middle or even high levels of rural food insecurity, covers almost all the countries noted on the map.

This simple analysis suggests that countries with high levels of participation in basic (and primary) education generally have rural food security, but that the association weakens at higher levels of education. The following sections will verify this initial conclusion with more sophisticated statistical tools.

Figure 1. Correspondence of low/very low 6-15 school attendance rate and high/very high food insecurity (rurHFI1)

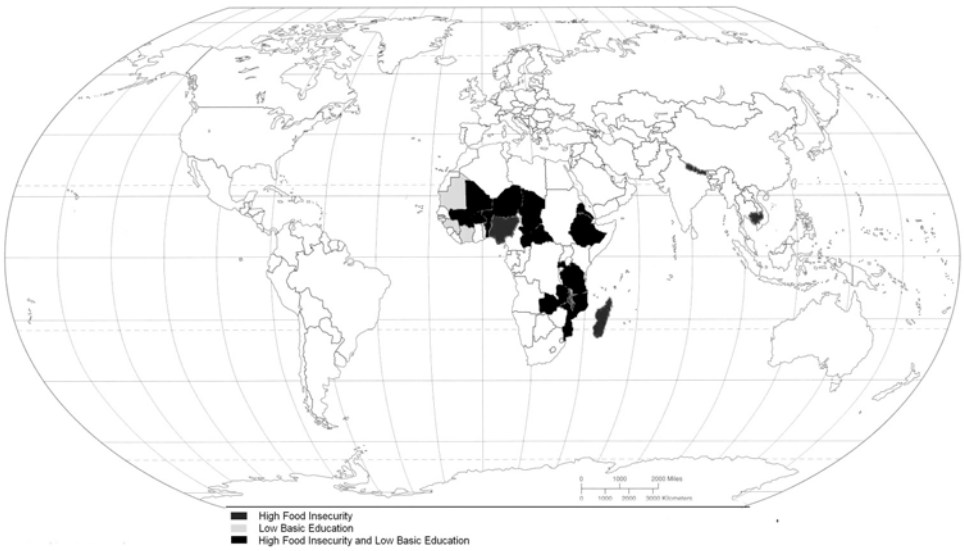


Figure 2. Correspondence of high/very high 6-15 school attendance rate and low/very low food insecurity (rurHFI1)

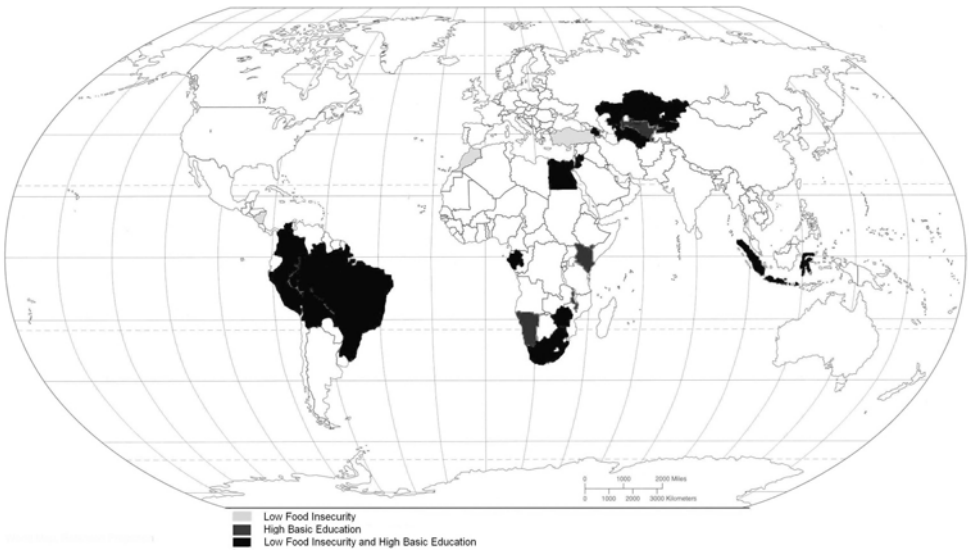


Figure 3. Correspondence of low/very low 16-20 school attendance rate and high/very high food insecurity (rurHFI1)

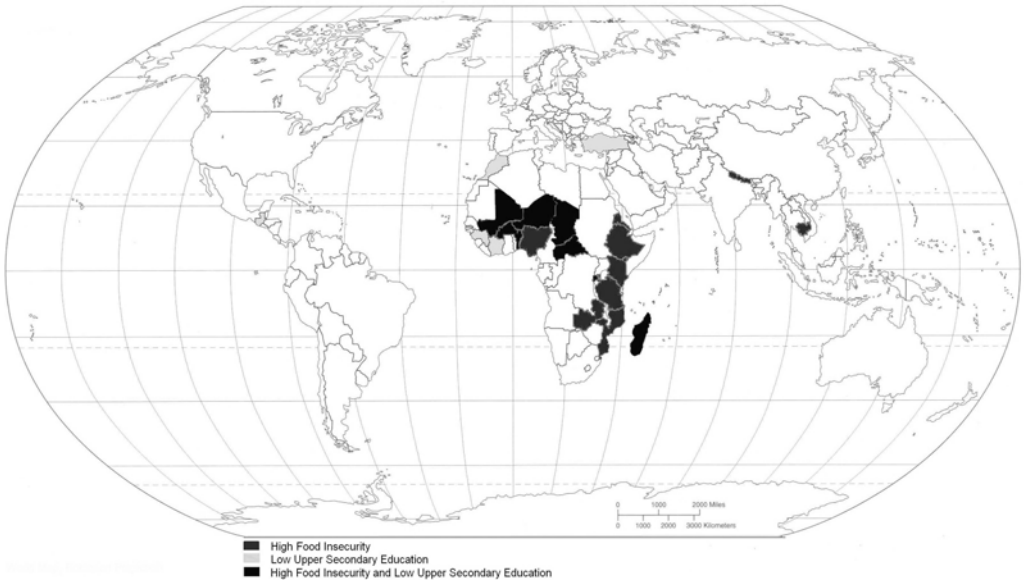


Figure 4. Correspondence of high/very high 16-20 school attendance rate and low/very low food insecurity (rurHFI1)

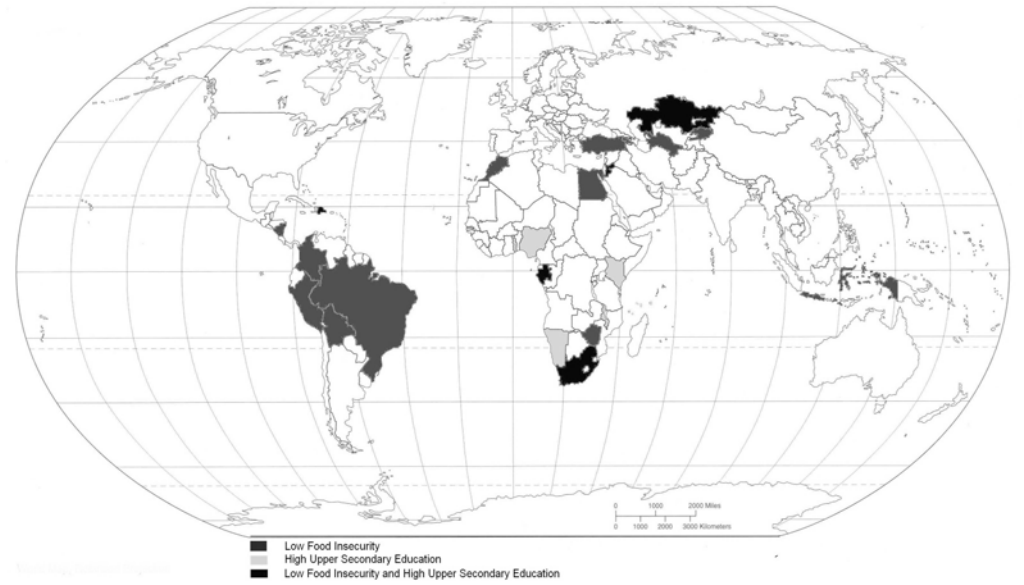


Figure 5. Correspondence of low/very low 21-24 school attendance rate and high/very high food insecurity (rurHFI1)

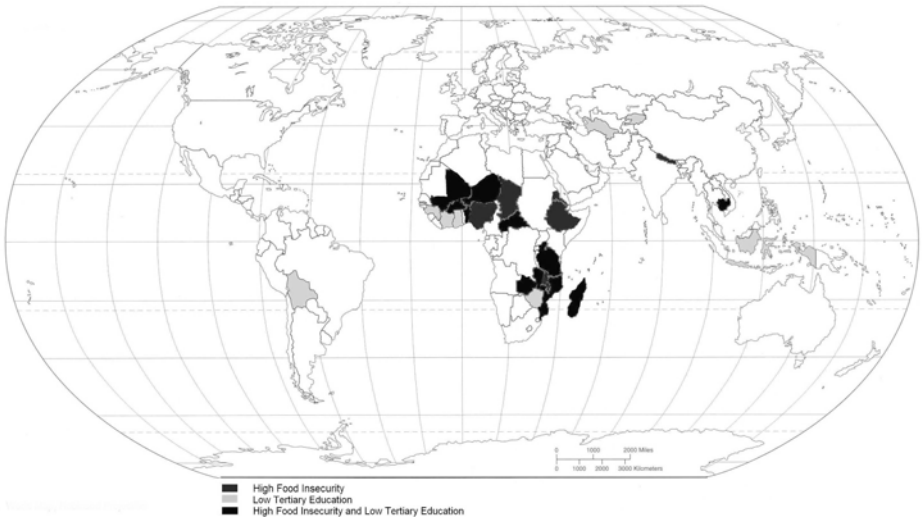
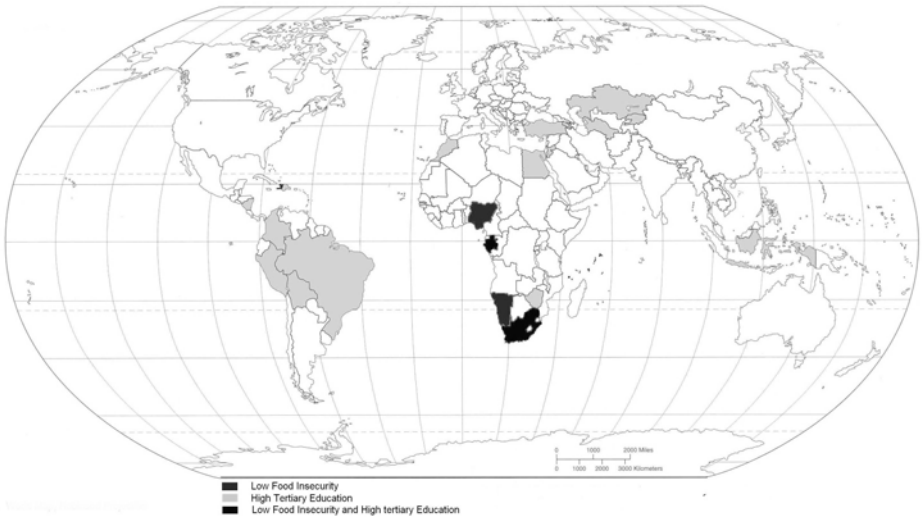


Figure 6. Correspondence of high/very high 21-24 school attendance rate and low/very low food insecurity (rurHFI1)

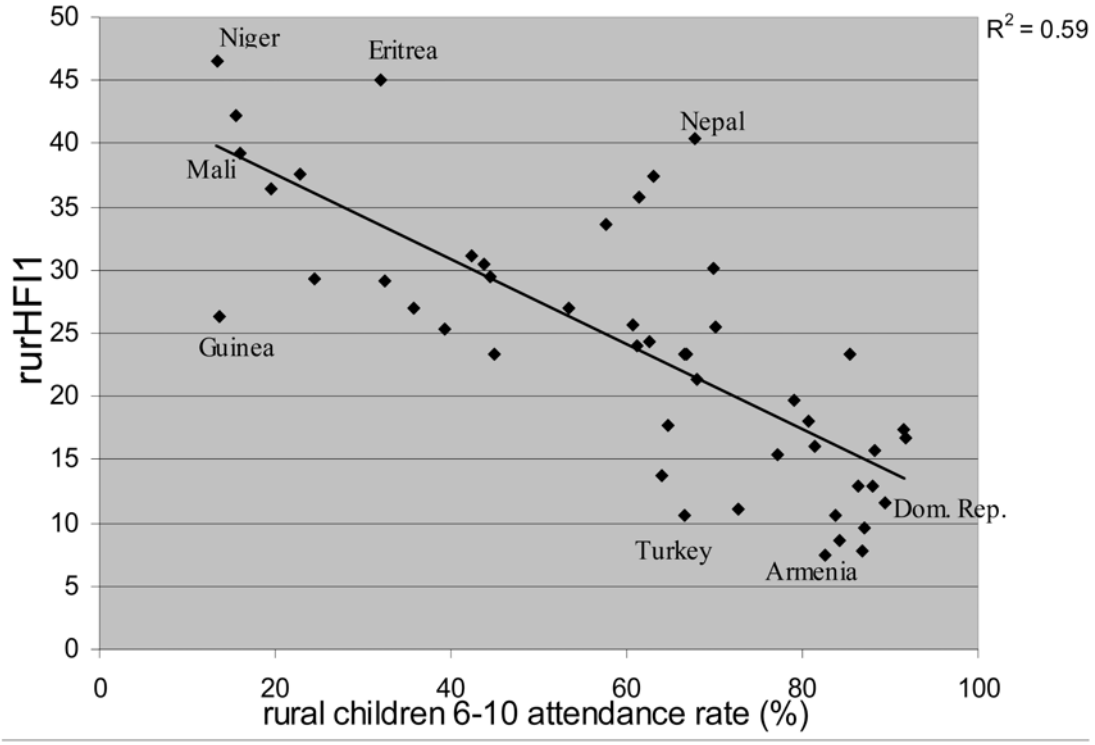


4.1.3 Graphical Tools: Scatterplots

Scatter plots are a useful way to analyse more precisely relationships such as these. We present the distribution of countries with Educational Participation on the x-axis and Food Insecurity 1 (*rurHFI1)* on the y-axis. The black line represents the best fitting line.

Figure 7 graphs the relationship between rural food insecurity (rurHFI1)[26] and the 6-10 year old rural attendance rate.

Figure 7. 6-10 Rural School Attendance Rate and Food Insecurity (rurHFI1)



[26] For purposes of the discussion in this section, *rurHFI1* is used to represent food insecurity. Results are quite similar with *rurHFI2*.

The scatter plot reveals a clear pattern: the greater the rate of school attendance among rural children, the lower the average rural food insecurity. In the upper left corner, countries such as Mali have low access to primary education coupled with high levels of food insecurity. On the other hand, countries such as the Dominican Republic, situated in the bottom-right of the graph, have high levels of participation in primary education and correspondingly low levels of food insecurity.

As noted, the black line represents the best fitting linear relationship between the two variables. To the extent that the data points are clustered close to the line, the 6-10 rural attendance rate is a good predictor of food insecurity.[27] By that criterion, there would appear to be a strong negative correlation between these two variables.

It is useful to note the overall pattern and also to note the exceptions, those countries identified as "outliers", which are further from the line and whose names are displayed. For instance, Turkey is in the middle of the distribution of 6-10 attendance rate, but it has a very low level of food insecurity. In Guinea the school attendance rate is very low, but the level of food insecurity is not as low - relatively speaking - as might be expected. Nepal, on the other hand, has a relatively high rate of school attendance among rural 6-10 year olds, but it is the fourth highest country in terms of food insecurity. Niger has the unenviable record of scoring lowest on both attendance rates of rural 6-10 year olds and rural food insecurity.

The pattern for 6-15 attendance rates was much the same (see Annex 5).

Figure 8 shows the relationship between 11-15 attendance rates and food insecurity.

[27] The R-square statistic shows how well a linear relationship explains variation in the data. It ranges from 0 to 1. In this case, the 6-10 rural attendance rate alone explains almost 60 percent of the variability in food insecurity.

Figure 8. 11-15 Rural School Attendance Rate and Food Insecurity (rurHFI1)

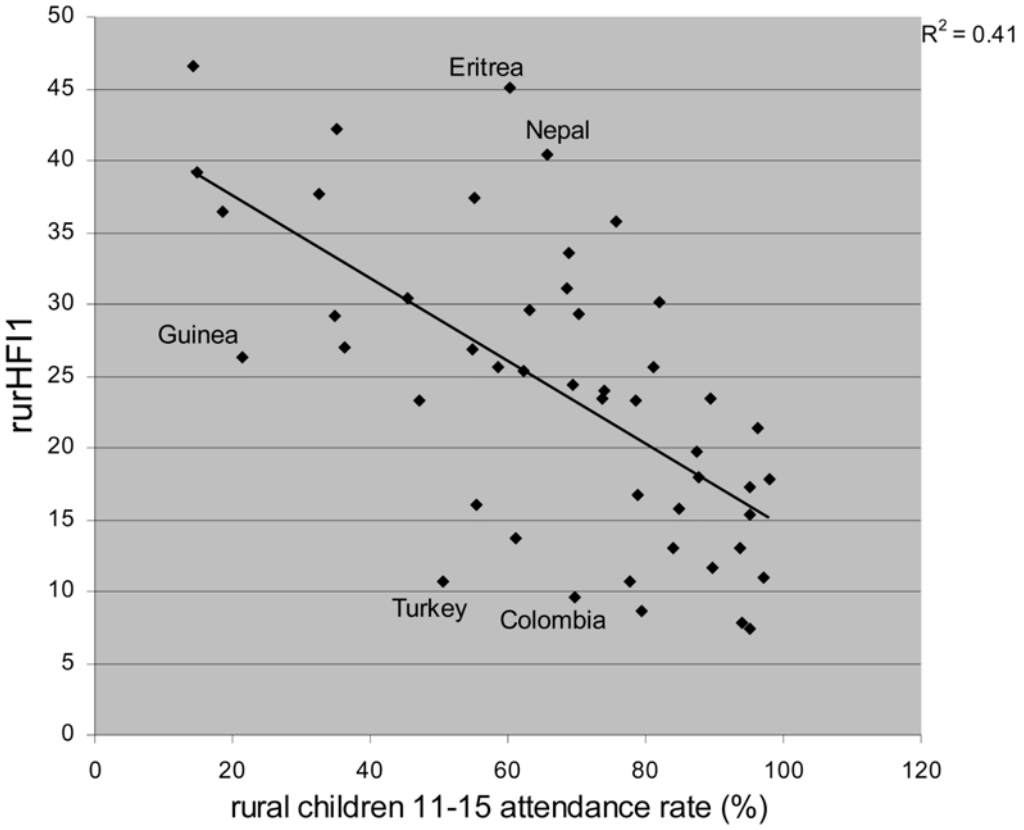
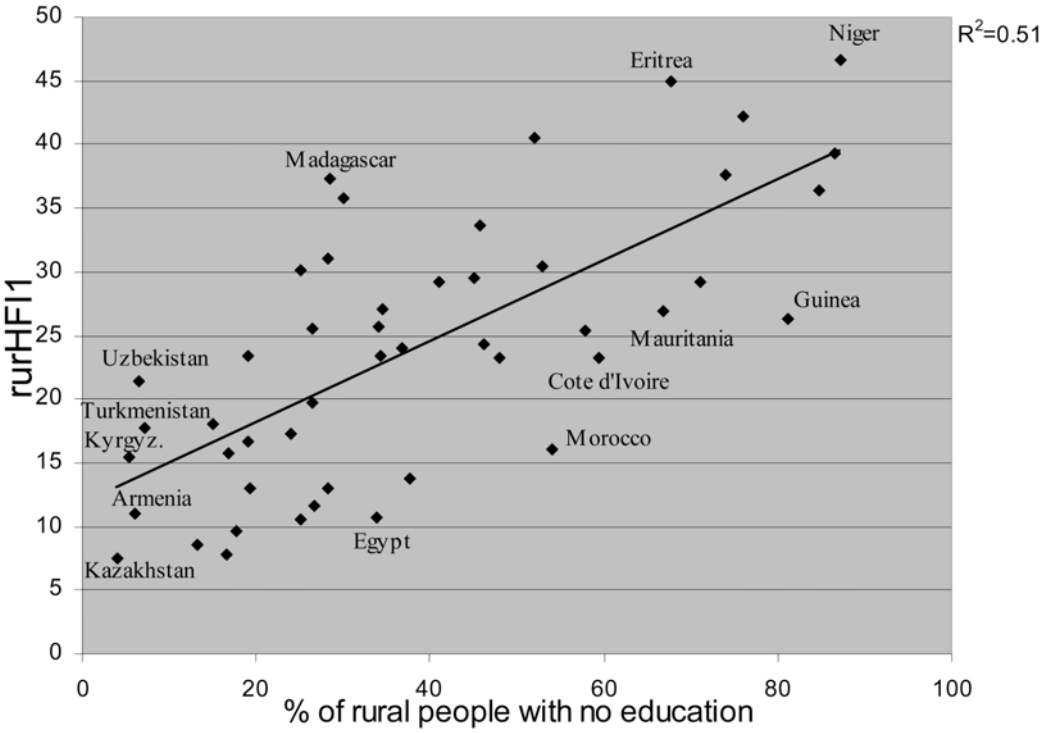


Figure 8 shows a less distinct linear relationship than Figure 7. A number of countries are further from the line. Both the number of outliers and their distance from the line are greater than in the previous case. Colombia represents the clearest case, with its 11-15 attendance rate very close to the overall mean but with a very low proportion of the rural population suffering from food insecurity.

Figure 9 shows the relationship between the percentage of the rural population with no education and food insecurity.

Figure 9. Percent with No Education and Food Insecurity (rurHFI1)

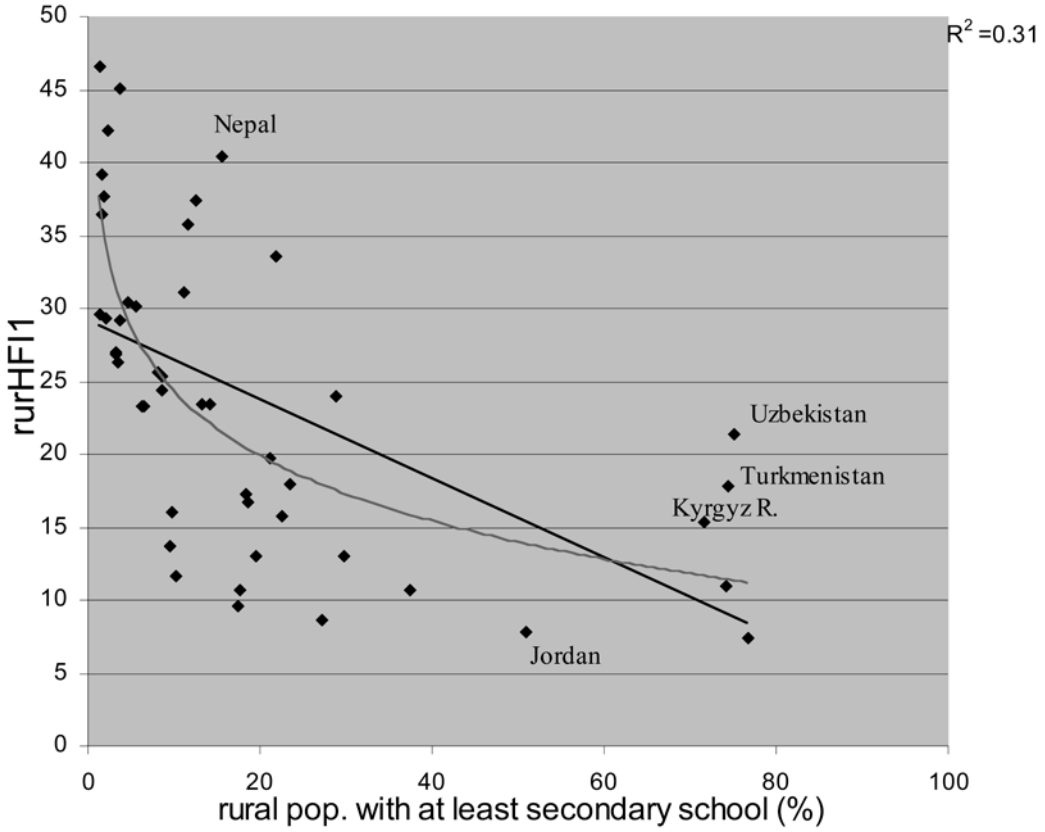


Not surprisingly, the greater the percentage of the rural population with no schooling, the greater the food insecurity. A number of countries fit the pattern, and thus lie close to the fitted line. One group of countries does not. This group scores relatively low on food insecurity relative to their (high or very high) rural populations with no formal education. Given the overall pattern, one would have expected more food insecurity in these countries - Morocco, Guinea, Cote d'Ivoire, Mauritania and Niger.

A second group, countries - Armenia, Kazakhstan, the Kyrgyz Republic, Turkmenistan, and Uzbekistan - though varying in food insecurity show similar and extremely low percentages of their rural populations with no education. This is a consequence no doubt of the well-known massive investments in education made by the states of the former Soviet Union. It would appear that beyond a certain point, variations in educational participation have little to do with food security. This point is illustrated by countries on the other end of educational participation. Again in these African countries, at a certain point in lack of education, differences across countries have little impact on food insecurity.

Figure 10 shows the relationship between food insecurity and percentage of the rural population with secondary or more education.

Figure 10. Percent with at least Secondary and Food Insecurity (rurHFI1)



Here as the analysis shifts to higher levels of education, it becomes clear that the relationship is no longer linear. The trend is better represented by a logarithmic curve. This suggests that higher levels of secondary education are associated with lower levels of food insecurity especially among countries with low overall levels of rural participation in secondary and higher education. The effect diminishes above a certain point, but then would appear to increase sharply for the Central Asian countries noted earlier. Given the small number of cases and their geographical and shared past, we would assume this is more likely an artefact of their particular and recent history than a reflection of the effects of education.

Scatter plots of the relationships between food insecurity and the 6-15 rural attendance rate, 16-20 rural attendance rate, 21-24 rural attendance rate, and tertiary education are presented in Annex 5. These graphs reveal much the same patterns, a close correlation between the educational participation of young students, presumably at lower levels of education, and correspondingly weaker relationships at higher levels of education, among older rural students. Indeed, at the tertiary level, the relationship is not linear at all.

These results suggest that increasing enrolment in primary education might be a way to reduce food insecurity. Of course, given the bidirectional nature of the relationship, this relationship might be understood in reverse, with increasing food security as a way to increase participation in primary education.

4.1.4 Correlation Analysis

Correlation analysis allows us to quantify the relationships we have been examining. We do this with two measures, Pearson's *r* and Spearman's *rho*. Both measures range in value between -1 (perfect negative correlation) and +1 (perfect positive correlation), but they have an intrinsic difference, which can affect the results.[28] Here we discuss results for both correlation coefficients in relation to our first measure of Food Insecurity (*rurHFI1*).

Table 5 presents correlation coefficients between education variables and food insecurity (*rurHFI1*).

[28] Pearson's *r* is a linear correlation coefficient, and is seriously affected by the presence of outliers and non-linearity in the relationship. Spearman's *rho* is defined as a "quasi ordinal" correlation coefficient because it is calculated by applying the Pearson correlation formula to the ranks of the data rather than to the actual value of the data. This is useful because it allows outliers to have less influence that in Pearson's *r*. It is useful to look at them both to assess the linearity of the relationship. If Pearson's *r* is much smaller than Spearman's *rho* applied to the same variables, then one can reasonable conclude that the variables are substantially correlated, but not linearly. When both correlation coefficients show similar values, there is linearity.

Table 5. Correlations between educational participation and food insecurity

	Pearson	Spearman
Attendance Rate 6-10	-0.77	-0.79
Attendance Rate 6-15	-0.74	-0.76
Attendance Rate 11-15	-0.64	-0.64
Attendance Rate 16-20	-0.46	-0.45
Attendance Rate 21-24	-0.18	-0.24
No Education	0.72	0.71
Secondary or More	-0.56	-0.72
Tertiary	-0.55	-0.71

The two coefficients are similar except for percentage of the rural population with secondary or higher education and percentage of the rural population with tertiary education. Except for these two indicators, there appears to be a high degree of linearity.

More importantly in terms of policy is the numerical confirmation of our finding that food insecurity is most highly (though negatively) correlated with the participation of younger children in primary education. By contrast, the correlation between *rurHFI1* and *rurattendance2124* is not statistically significant. Stated more declaratively, we can conclude:

- Countries with high levels of primary schooling in rural areas are more likely to be food secure.
- Countries with high levels of secondary schooling in rural areas are not necessarily more likely to be food secure.
- High levels of rural participation in tertiary education have little to do with food insecurity.

4.2 Econometric Models

Thus far we have examined the two-way relationships between educational participation, measured at different levels, and food insecurity among rural people. In this section, we use multiple regression analysis to develop a series of econometric models to estimate the "effects" of educational participation, again measured at different levels, on food

insecurity. Regression analysis allows us to measure more precisely the effects of predictor variables, in this case educational participation. It also allows us to examine simultaneously the effects of different levels of education on food insecurity and thus to test the notion that the primary level is most closely associated with food insecurity. Regression analysis also permits the inclusion of "control" variables, that is, factors identified in section 3 that are also associated with food insecurity. Controlling for such factors as sanitation or access to clean water allows us to assess the unique contribution of educational participation on food insecurity, independently of other associated factors. This type of analysis also gives us greater confidence in our findings, and it moves us much closer to an understanding of the likely causal relationships.[29]

We ask two questions:

- What is the quantitative impact of education for rural people on rural food insecurity?

- What is the level of education that most affects food insecurity?

To answer these questions, we use Ordinary Least Squares (OLS) regression analysis to develop two models of the effects of education for rural people on rural food insecurity. The first uses all education variables as predictors, in an effort to see which type of education has the greatest "effect" impact on food insecurity. The second model regresses both education and control variables on food insecurity, in order to obtain a more realistic assessment of the independent effects of education. Both models are estimated twice, with each of the two outcome measures *rurHFI1* and *rurHFI2*.[30]

4.2.1 Models with only educational variables

Table 6 presents the results of the first regression estimates, which examined the effects of all education variables, but which included in the final model only those predictors statistically associated with food insecurity independently of the other terms.[31]

[29] Econometrics does not automatically show causality. The quantitative analysis is built on the theoretical framework outlined in Chapter 2. However, since there is no comprehensive literature on this topic, causalities can only partially be modelled. Therefore, in this section we present correlation reinforced by control variables and built on a theoretical foundation. Thus we make the strongest possible case for causality.

[30] We use step-wise regression to end up with final models, reported here, in which all predictors are statistically associated with the outcome, food insecurity. Variables that are not statistically significant are rejected in an iterative process.

[31] The model has the following statistical properties required for credible OLS regression: statistical significance of each coefficient (0.05 level) and of the model as a whole, normality in the distribution of error terms, lack of multi-collinearity, homoskedasticity, linearity of the relationships, correct specification.

Table 6. Models 1.1 and 1.2: Educational determinants of food insecurity in rural areas (n=48)

Model	1.1	1.2
	Food Insecurity 1	Food Insecurity 2
Constant	43.4***	53.7***
	(2.56)	(3.26)
6-10 Attendance Rate	-0.28***	-0.34***
	(0.04)	(0.05)
Percent with at least Secondary Education	-0.12*	-0.16*
	(0.05)	(0.06)
Model Statistics		
Adjusted R-Square	0.62	0.60
F statistic	39.7	36.6
degrees of freedom	2, 45	2, 45
p-value	< .001	< .001

Key: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
(figures in parentheses are standard errors)

Overall model statistics suggest that this combination of independent variables jointly predicts food insecurity (overall p-value < 0.001). These two educational factors, percentage of the rural population with at least secondary education and 6-10 rural attendance rate, explain 64 and 62 percent of the variation in food insecurity (the difference depending on the measure). As expected, both education terms are negatively associated with food insecurity, that is the greater the educational participation, the lower the average food insecurity. Both education terms are statistically significant. The magnitude of the effect of the 6-10 rural attendance rate is more than twice that of percentage of the rural population with at least secondary education. It is interesting that of the education variables included in our analysis, only these two remained statistically significant predictors of food insecurity when examined in conjunction with the others. We can summarize our model as follows:

Model 1.1: Food Insecurity 1 = 43.4 – 0.28 x Percent at least Secondary + – 0.12 x 6-10 Attendance Rate

Model 1.2 differs from 1.1 in using *rurHFI2*, which gives greater weight to extreme deprivation in the indicator of food insecurity. The coefficients of the educational terms are somewhat higher, indicating a greater "effect" of education on food insecurity, measured with greater weight on extreme deprivation.

4.2.2 Models with control variables

In addition to education variables, the seven control variables discussed earlier were included in the step-wise regression. Table 7 reports the models finalized after running appropriate sensitivity analyses and with all the statistical properties required for regression analysis which were reported earlier.[32]

Table 7. Models 2.1 and 2.2: Determinants of food insecurity in rural areas, education and control variables (n=48)

Model	2.1	2.2
	Food Insecurity 1	Food Insecurity 2
Constant	27.5*** (3.72)	34.5*** (5.00)
6-10 Attendance Rate	-0.20*** (0.04))	-0.25*** (0.05)
Percent with No Assets	0.13** (0.04)	0.16* (0.06)
Percent with No Toilet Facilities	0.11*** (0.03)	0.13** (0.03)
Model Statistics		
Adjusted R-Square	0.75	0.71
F-value	48.3	39.1
degrees of freedom	3, 44	3, 44
p-value	< 0.001	< 0.001

[32] Contact the authors for technical details of the results and statistical procedures used.

Key: * p < 0.05, ** p < 0.01, *** p < 0.001
(figures in parentheses are standard errors)

Not surprisingly given the additional predictive information in new variables, Models 2.1 and 2.2 explain more of the variation in food insecurity (75 and 71 percent respectively, as compared to 64 and 62 percent). Again, the 6-10 rural attendance rate remains a significant predictor of food insecurity, especially when greater deprivation is weighted more heavily. Not surprisingly, lack of economic well-being and lack of sanitation are also statistical significant predictors of food insecurity.

Model 2.1: Food Insecurity = 27.5 – 0.20 x 6-10 Rural Attendance Rate + + 0.13 x Percent with No Assets + 0.11 x Percent with No Toilet Facilities

With this model, rural food insecurity can be predicted by:

- *School attendance* of children ages 6 to 10, which is found to be the best predictor of food insecurity

- *Lack of access to toilet facilities*, as a proxy for lack of sanitation, which is the second best predictor of food insecurity

- *Assets-based poverty,* lack of ownership of non-productive assets, as a proxy for an asset based measure of absolute poverty

These results suggest that one of the best ways to reduce food insecurity among rural people may be to promote primary education. Interestingly, primary education was highly correlated with lower levels of food insecurity, whereas most other assets, e.g., percent of rural households with access to radio, were not. It may be that the literacy acquired in primary education is a necessary or strongly facilitating condition for effective use of the messages concerning sanitation, health, and food utilization conveyed by radio. Still, it is interesting that lack of primary education contributes more to food insecurity than the poverty measure, lack of ownership of assets. Finally, as suggested by earlier exploratory analysis, primary education was also a better predictor of food insecurity than basic, secondary, or tertiary education.

Thus, the determinants of rural food insecurity can be expressed as follows:

Model 2.2: Food Insecurity 2 = 34.5 – 0.25 x 6-10 Rural Attendance Rate + + 0.13 x Percent with No Toilet Facilities + 0.16 x Percent with No Assets

The model is quite similar to 2.1. Based on this model, we can conclude that doubling rural children's participation in primary education would produce a reduction by around 25 percent in food insecurity. Of course, these results likely underestimate the true impact of education which has effects at community and national as well as at individual levels.[33]

[33] Another issue to raise regarding the model is the feedback effect: education affects food security, but, in turn, food security could affect education. This risks the generation of biased OLS estimates. However, since there is no empirical literature on this specific field, no econometric tool is available to overcome such a problem.

5. Conclusions

Education is widely recognized as one of the key dimensions of development. MDGs 2 and 3 focus directly on education. In the same way, the EFA initiative, and especially the first World Conference held in Jomtien in 1990 and the successive conference held in Dakar in 2000, concentrate on education, and more specifically, on primary and basic education. Indeed, the World Food Summit in 1996 acknowledged the critical role of education in achieving food security. This research attributes further value to education: Education of rural people, the main group directly involved in food production, processing and commercialization, is a key factor in fighting food insecurity in low-income countries. Recognizing the inter-linkages between rural people deprivations such as lack of education on the one hand, and food insecurity and malnutrition on the other hand, is fundamental to a more comprehensive view of the MDGs.

This research deliberately focused on rural people in low-income countries. Despite their statistical predominance, where they still represent more than 70 percent of the overall population, rural people are usually discriminated against by national policies in many sectors, including education. Although a number of studies have considered the "urban bias" (e.g. Lipton 1977; 1981), only few documents of international organizations consider the vulnerability of rural people. Most national and international studies and statistics are not disaggregated by rural-urban areas, and thus fail to present an accurate picture of the situation of low-income countries. This research suggests that, in rural areas of low-income countries, there is a high correlation between food insecurity and lack of education, especially at lower levels of education. Indeed, of the factors we examined, our measure of rural primary education was by far the best predictor of rural food security.

Perhaps the most relevant result of this research is the finding that primary education more than secondary or tertiary education for rural people contributes to the promotion of rural food security. Of all the educational variables examined in the full econometric model, only primary education remained significant holding controls constant. The analysis suggests that, if a low-income country such as Mali, which is among those with lowest levels of education, managed to double access to primary education, it could substantially reduce the intensity of food insecurity (by 20 percent or 25 percent depending on the indicator).

Finally, since the majority of people in low-income countries live in rural areas (see Annex 2), and since it is in these areas that the largest proportion of world poverty and hunger exists, education for rural people is a key factor for promoting overall national food security.

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Annex 1. Data treatment

Originally, the research focused on 49 low-income countries, 30 from Africa, 11 from Asia, and 8 from Latin America. However, several of these countries displayed missing values for some variables. Thus, before proceeding with the correlation analysis, data needed to be cleaned and missing values imputed.

First, all data were transformed into percentage values to make them uniform and facilitate interpretation.

Secondly, the "donor method", based on cluster analysis, was used to impute missing values. This method involves first identifying variables that are most highly correlated to the one with a missing value. In the second step, these variables, which usually vary between one and four, are used to run a cluster analysis. This cluster analysis makes it possible to identify the observations closer to the missing value. Once a relatively homogeneous cluster is found, the missing value is replaced with the mean of the cluster. In this case, the other countries that are in the cluster are the "donors". Finally, to check the relative correctness of the procedure, attention was paid to the distribution of "donor countries" around the original variable (that one in which one value is missing), the lower the standard deviation, the better the analysis.

This procedure was applied to four countries, Namibia, South Africa, Indonesia, and India. In the first three cases, the missing values were found in variables related to food security, and the results were quite satisfying. By contrast, India, which had missing values for several education variables, presented a set of values for both education and food security variables quite different from the general pattern tracked by the other countries. For this reason, it was difficult to find a cluster in which India was included. Even with a very limited number of clusters built up on the other school attendance rates among rural people, India was always in a 1-country group. The lack of adequate information to fill in the missing values and the relevance of these two variables for the analysis led to the removal of India. As a result, the statistical analysis was carried out on 48 countries.

Annex 2. List of countries and statistics on rural population

Country	Continent	Rural population (%)	Source	Year
Benin	Africa	55.5	IFAD[34]	2003
Burkina Faso	Africa	81.4	UNFPA[35]	most recent
Central Africa	Africa	56.2	UNFPA	most recent
Cameroon	Africa	47.8	IFAD	2004
Chad	Africa	74.2	UNFPA	most recent
Comoros	Africa	64.4	IFAD	2004
Cote D'Ivoire	Africa	54.2	UNFPA	most recent
Egypt	Africa	57.2	IFAD	2003
Eritrea	Africa	80.0	IFAD	2003
Ethiopia	Africa	83.4	IFAD	2003
Gabon	Africa	14.8	UNFPA	most recent
Ghana	Africa	67.4	IFAD	2003
Guinea	Africa	63.5	UNFPA	most recent
Kenya	Africa	63.7	IFAD	2003
Madagascar	Africa	69.2	IFAD	2003
Malawi	Africa	83.3	IFAD	2004
Mali	Africa	67.7	IFAD	2003
Mauritania	Africa	35.7	UNFPA	most recent
Morocco	Africa	41.9	UNFPA	most recent
Mozambique	Africa	64.4	IFAD	2003
Namibia	Africa	66.5	UNFPA	most recent
Niger	Africa	76.7	UNFPA	most recent
Nigeria	Africa	53.4	IFAD	2003
Rwanda	Africa	93.4	IFAD	2003
South Africa	Africa	42.1	UNFPA	most recent
Tanzania	Africa	64.6	IFAD	2003
Togo	Africa	63.7	UNFPA	most recent
Uganda	Africa	84.7	IFAD	2003
Zambia	Africa	59.7	IFAD	2003
Zimbabwe	Africa	64.1	UNFPA	most recent
Armenia	Asia	35.7	IFAD	2004
Cambodia	Asia	80.3	UNFPA	most recent
Indonesia	Asia	55.9	IFAD	2003
Jordan	Asia	20.9	UNFPA	most recent

[34] IFAD statistics. http://www.ruralpovertyportal.org/english/regions/index.htm
[35] UNFPA statistics. http://www.unfpa.org/profile/

Kazakhstan	Asia	44.1	UNFPA	most recent
Kyrgyz Republic	Asia	66.3	UNFPA	most recent
Nepal	Asia	87.1	IFAD	2003
Turkey	Asia	32.7	UNFPA	most recent
Turkmenistan	Asia	54.2	UNFPA	most recent
Uzbekistan	Asia	63.6	UNFPA	most recent
Bolivia	Latin America	35.6	UNFPA	most recent
Brazil	Latin America	17.2	IFAD	2003
Colombia	Latin America	22.6	UNFPA	most recent
Dominican Republic	Latin America	39.9	UNFPA	most recent
Guatemala	Latin America	59.4	IFAD	2003
Haiti	Latin America	61.2	UNFPA	most recent
Nicaragua	Latin America	42.7	IFAD	2003
Peru	Latin America	26.1	IFAD	2003
All surveys (unweighted average)		57.1		
Africa		63.2		
Asia		54.1		
Latin America		38.1		

Annex 3. Development of measures of food security

This section explains the creation of indicators of household food security, which must be justified on a theoretical base. To find an appropriate measure of such a phenomenon, it is necessary to examine the existing literature in light of the available data and purpose of analysis. This paper aims to overcome the limitations of traditional measures of food security, which are based on the national food balance sheets.

In a broad sense, household food security indicators can be divided into 3 main categories:

1. **Food consumption indicators**: number of meals a day, number of calories, household percentage of expenditures on food, dietary diversity, which can be estimated through different ways, according to the specific context and available data.

2. **Anthropometric indicators**: relation height-for-age (stunting), relation weight-for-height (wasting), relation weight-for-age (underweight), female malnutrition (low Body Mass Index), micronutrients deficiency, iron deficiency, iodine deficiency.

3. **Livelihood indicators**: assets owned, feeling of insecurity, price of food, employment, health etc.

The choice of the indicator depends on the purpose of the exercise. When the purpose is to monitor food security in its complexity in order to predict potential food crises arising from one of these factors in one specific nation or region, it is essential to take all the above indicators into account. In contrast, if the objective is to discover the general explanatory capacity of a variable, such as education of rural people, on a phenomenon such as rural household food security, a different analysis can be carried out. Our cross-country model uses several education variables as predictors, while the dependent variable is an aggregate indicator of household food security. This suggests the possibility of using a less detailed indicator, which might even be based on only one category, but which would constitute a good proxy for household food security.

This research is based on DHS household surveys, which are mainly concerned with the nutritional and health statuses of children and women. In such a case, we assume it is possible to use only anthropometric indicators and measures of survival as a proxy of household food security in a structural model for several countries. We assume that in all the countries in which the surveys were carried out the correlation between household food security and anthropometric indicators and measures of survival is high and approximately at the same level.

Additional support for the use of anthropomorphic variables such as the prevalence of stunting or underweight is that they reflect human deprivations, and "since our ultimate

concern is with the nature of the lives that people can lead, there is a case for going straight to the prevalence of undernourishment, rather than to the intake of calories and other nutrients" (Anand and Sen 2003, p. 209).

With this theoretical justification, it is necessary to construct an indicator encompassing a balanced mix of anthropometric, nutritional, and survival variables. The indicator we utilized includes three components:

- "Adequate survival status" (Wiesmann 2002), which serves as a proxy for premature death due to malnutrition. We average the infant mortality rate and the under-5 mortality rate.[36]

- A second component reflecting Wiesmann's ideas of both "adequate nutritional status" and "food adequacy". Here, they are expressed by the prevalence of stunting,[37] underweight[38] and wasting.[39] We average the values of the three indicators, weighting by 2/3 the percentage of the rural population with moderate stunting (underweight and wasting), and weighting by 1/3 the percentage of the population with severe stunting (underweight or wasting).

- Female malnutrition. We use the percentage of rural women whose body mass index is less than an internationally fixed threshold of 18.5.

Calculating a simple arithmetical mean of the three components, which we define as F_a, F_b, and F_c, we obtain an indicator of household food insecurity. The name of the variable is *rurHFI1* and it is obtained through the following formula:

$$\mathbf{rurHFI1 = 1/3\ F_a + 1/3\ F_b + 1/3\ F_c},$$

which is a specific case with $\alpha=1$ of the general formula:

[36] Again, Wiesmann uses only the variable under-5 mortality rate, while here an average value between this variable and the infant mortality rate is used because the causes of very early death can show a different intensity and typology of malnutrition (Wiesmann 2002).

[37] "Stunting" is defined as children with a height-for-age score two or more standard deviations below the mean of a normal distribution of children's height for age. "Severe" refers to children who are three or more standard deviations below the mean; "moderate" refers to children who are between two and three standard deviations below the mean.

[38] "Underweight" refers to weight-for-age indices. "Severe" denotes scores of three or more standard deviations below the mean, while "moderate" refers to scores of two to three standard deviations below the mean.

[39] "Wasting" is defined as children with a weight-for-height score of two or more standard deviations below the mean on an index of children's weight for height. Again, "severe" denotes scores of three or more standard deviations below the mean, while "moderate" refers to scores of two to three standard deviations below the mean.

$$\mathbf{rurHFI = (1/3\ F_a^{\alpha} + 1/3\ F_b^{\alpha} + 1/3\ F_c^{\alpha})^{1/\alpha}.}$$

Keeping the weight of each sub-indicator equal to one third, that is assuming that each of them has the same relative value *ceteris paribus*, this formula varies according to the value of alpha. With alpha equal to one, the index is a simple arithmetic mean of the three components. This implies that, for example, a high value of F_a can be counterbalanced by a low value of F_c. However, since each component reflects a deprivation, it is not unreasonable to claim that the *relative impact* of each one on the total analysed phenomenon is likely to increase as the absolute level of that deprivation rises. An example might clarify the meaning of "relative impact".

Considering only one sub-indicator such as F_a and three different levels of it: F_{a1}, $F_{a2,}$ and F_{a3}, with $F_{a3} = kF_{a2} = 2kF_{a1}$, a higher relative impact means that the same absolute variation of the sub-indicator F_a has a higher impact on household food insecurity if the starting level is higher, as formalized here below:

$$\frac{HFI(Fa2) - HFI(Fa1)}{Fa2 - Fa1} < \frac{HFI(Fa3) - HFI(Fa1)}{Fa3 - Fa1}$$

The empirical analysis can incorporate such an argument by selecting a value of alpha higher than 1. In this analysis, we also calculated the outcome using an alpha of 2, in order to gauge the effects when greater relevance given to extreme deprivation.[40] With alpha greater than 1 there is not perfect substitutability between the sub-indicators. A high value of one sub-indicator cannot be totally counterbalanced by a low one of another.

The formula for alpha = 2 is:

$$\mathbf{rurHFI2 = (1/3\ F_a^{2} + 1/3\ F_b^{2} + 1/3\ F_c^{2})^{1/2}.}$$

Thus, *rurHFI1* and *rurHFI2* are the two indicators of food insecurity utilized in the analysis.

[40] For both theoretical and mathematical explanation see Anand and Sen (2003, pp. 211-218).

Annex 4. Classification of countries by categories for dependency analysis

Country	rurattendance 6-15	rurattendance 16-20	rurattendance 21-24	rurHFI1
Armenia	high	middle	low	very low
Benin	low	low	low	high
Bolivia	high	middle	low	low
Brazil	high	middle	middle	low
Burkina Faso	very low	very low	very low	high
Central Africa	low	low	low	high
Cambodia	middle	middle	low	high
Cameroon	middle	middle	middle	middle
Chad	very low	low	middle	high
Colombia	high	middle	middle	low
Comoros	low	high	high	middle
Cote d'Ivoire	low	low	low	middle
Dominican R.	high	high	middle	low
Egypt	high	middle	middle	low
Eritrea	low	middle	middle	very high
Ethiopia	very low	middle	middle	very high
Gabon	very high	high	high	low
Ghana	middle	middle	low	middle
Guatemala	middle	low	middle	middle
Guinea	very low	low	low	middle
Haiti	middle	high	high	middle
Indonesia	high	middle	low	low
Jordan	very high	high	middle	very low
Kazakhstan	high	high	middle	low
Kenya	high	high	middle	middle
Kyrgyz Rep	high	middle	low	low
Madagascar	middle	low	low	high
Malawi	high	high	middle	high
Mali	very low	very low	low	high
Mauritania	low	Middle	middle	middle
Morocco	middle	Low	middle	low
Mozambique	low	Middle	low	high
Namibia	high	High	high	middle
Nepal	middle	Middle	middle	high
Nicaragua	middle	Middle	middle	low
Niger	very low	very low	very low	very high
Nigeria	middle	High	high	high
Peru	high	Middle	middle	low

Rwanda	low	very low	very low	high
South Africa	high	very high	very high	low
Tanzania	low	Middle	low	high
Togo	middle	High	middle	middle
Turkey	middle	Low	middle	low
Turkmenistan	high	Middle	low	low
Uganda	middle	Middle	middle	middle
Uzbekistan	high	Middle	middle	middle
Zambia	low	Middle	low	high
Zimbabwe	high	Middle	low	low

Annex 5. Additional tables & figures

Table A-1. Correlations between educational participation and food insecurity (*rurHFI2*)

	Pearson	Spearman
Attendance Rate 6-10	-0.75	-0.77
Attendance Rate 6-15	-0.73	-0.75
Attendance Rate 11-15	-0.64	-0.64
Attendance Rate 16-20	-0.47	-0.45
Attendance Rate 21-24	-0.20	-0.21
No Education	0.69	0.70
Secondary or More	-0.57	-0.70
Tertiary	-0.55	-0.69

Figure A-1. 6-15 Rural School Attendance Rate and Food Insecurity (rurHFI1)

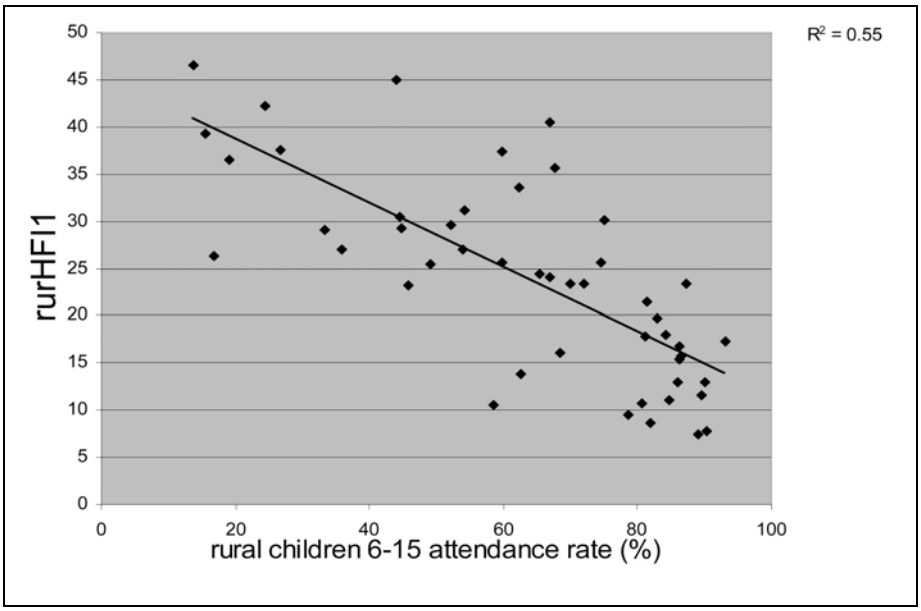


Figure A-2. 16-20 Rural School Attendance Rate and Food Insecurity (rurHFI1)

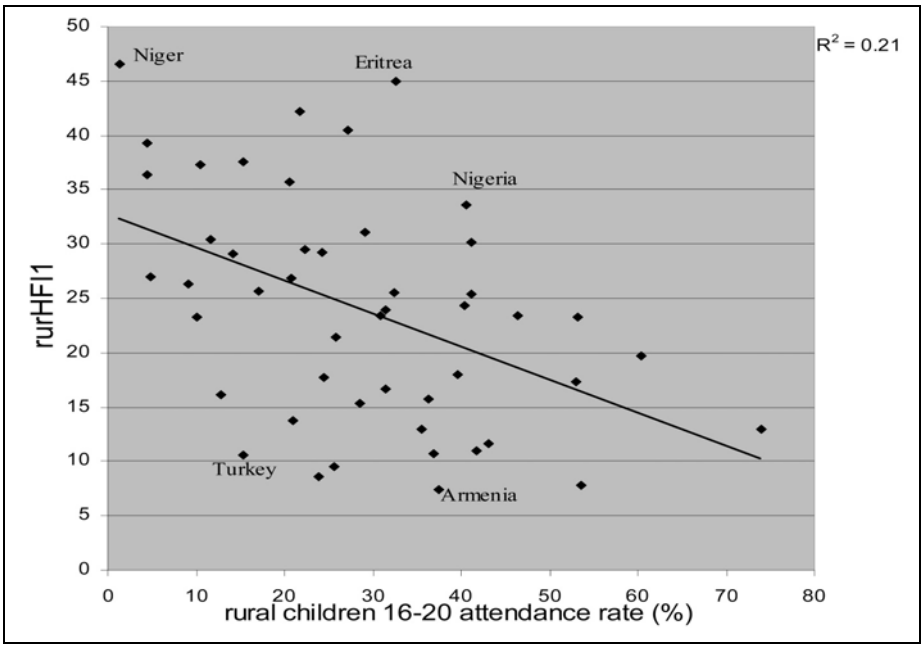


Figure A-3. 21-24 Rural School Attendance Rate and Food Insecurity (rurHFI1)

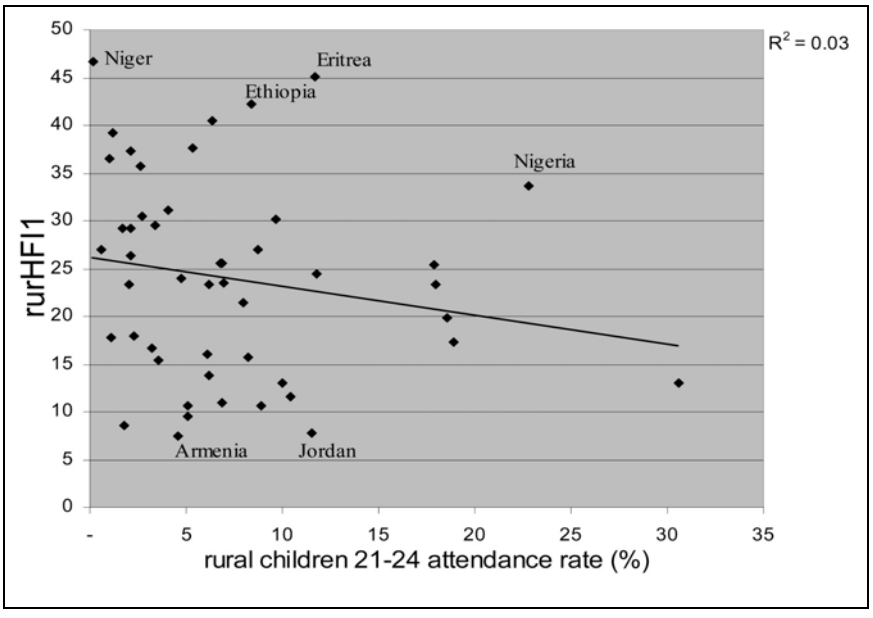
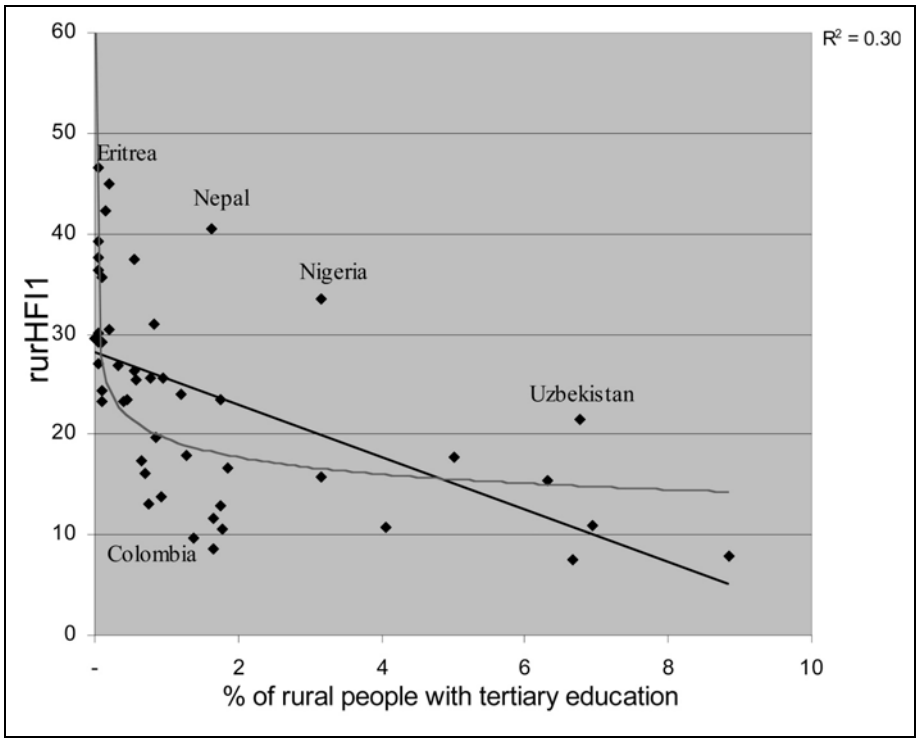


Figure A-4. Percent with Tertiary and Food Insecurity (rurHFI1)



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2. *Education for rural development. Towards new policy responses.* by Atchoarena, D. & Gasperini, L. Rome and Paris 2003 (also available at ftp://ftp.fao.org/docrep/fao/006/ad423e/ad423e00.pdf)

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