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**Measurement and Analysis of
Multidimensional
Well-being in Rwanda**

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Preface

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East Africa Research Papers is intended to serve as an outlet for publishing theoretical, methodological and applied research covering various aspects of the East African economies, especially those related to regional economic integration, national and regional economic development and openness, movement of goods, capital and labor, as well as studies on industry, agriculture, services sector and governance and institutions. In particular, submission of studies analyzing state-of-the-art research in areas of labor, technology, education, health, well-being, transport, energy, resources extraction, population and its movements, tourism, as well as development infrastructure and related issues and discussion of their implications and possible alternative policies are welcome.

The objective is to increase research capacity and quality, to promote research and collaboration in research, to share gained insights into important policy issues and to acquire a balanced viewpoint of economics and financial policymaking which enables us to identify the economic problems accurately and to come up with optimal and effective guidelines for decision makers. Another important aim of the series is to facilitate communication with development cooperation agencies, external research institutes, individual researchers and policymakers in the East Africa region.

Research disseminated through this series may include views on economic policy and development, but the series will not take any institutional policy positions. Thus, any opinions expressed in this series will be those of the author(s) and not necessarily the Research Papers Series.

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Measurement and Analysis of Multidimensional Well-being in Rwanda

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Abstract

The well-being of families and their children is given high priority in development goals. Children's well-being in Africa is important since the growing number of children is the greatest resource of this continent. Rwanda was one of the first countries that ratified the Convention on the Rights of the Child. The country, despite its very low GDP per capita, also has one of the best child well-being indicators in Africa. In the recent past the country has also had two important achievements: protection of children by establishing the National Commission for Children and launching a Strategy for National Child Care Reform. The measures aim to protect children's rights and integrate children into families that are supported to provide needed care to them. These achievements are largely the result of strong laws and policies many of which have been developed with support from UNICEF. Investments in children's well-being will help in addressing many persistent difficulties that society may have to face in the future. What happens during the early years is of crucial importance for every child's development. This period offers great opportunities, but children are also vulnerable to negative influences. The objective of this research is to estimate multidimensional well-being of children and their families in Rwanda. The aim is to compute an overall well-being index decomposed into its underlying main components. The households are ranked by the level of well-being and by various household and community characteristics. The results shed light on the state and changes in the well-being of children and their families in Rwanda indicating which provinces and districts offer relatively better conditions for them. This can serve as a model for public policies aimed at improving general well-being in the country.

Keywords: Well-being; multidimensional index; sustainable development; Rwanda;

JEL Classification Codes: D13; D63; H53; I131; I138; J13;

1. Introduction

Many children around the world do not have natural human rights due to various reasons including families' income status, the political situation, lack of safety nets, war, religion, ethnicity, gender discrimination and disabilities (Peters and Mullis, 1997; Santos Pais 1999; Ridge, 2002; Gregg et al., 2005; Mayhew, 2005; Sobolewski and Amato, 2005). They do not receive enough food, care and opportunities to attend school and learn new skills. As a result they do not reach their full human potential (Sen, 2000; Attree, 2004). Family support, good nutrition, consistent care and encouragement to learn in the early years of life help children perform better in school, be healthier, have an active and productive participation in society, be more creative and have higher earnings in the future (Duncan and Brooks-Gunn, 2000; Bradshaw, 2002; Kamerman et al., 2003; Bargain and Donni, 2007). This issue is even more important for children in poverty. The number of children under the age of 5 who die of hunger is increasing; 7.6 million of them die each year, while others who survive (over 200 million children) usually do not reach their full potential. As a result, their societies have problems of low labor productivity, development and welfare. The early years of a child's development are of crucial importance since this is a period of growth and also of vulnerability to adverse conditions (UNICEF, 2013).

In Africa, children's well-being is of great importance since children are the greatest resource of this continent. According to key statistics provided by the United Nations Children's Fund (UNICEF, 2014), by 2050, one in every three births and almost one in every three children under 18 will be African. The number of stunted children has increased by one-third in Africa, while other regions have halved the number of stunted children. Although mortality rates among children under-5 have decreased by 45 per cent, still half of the world's 6.6 million under-5 annual deaths occur in Africa. Statistics confirm that Africa has over 300 million out of school children. They fail to complete full primary education and hence fail to master basic literacy and numeracy skills. Between 2010 and 2025, the child population in sub-Saharan Africa will increase by 130 million. This region will also be the single region with the greatest number of children under 18 from around 2030 (UNICEF, 2014). Africa's population is estimated to quadruple by 2100 (United Nations, 2015). Kayizzi-Mugerwa et al. (2017) suggest inclusive growth in Africa to cope with poverty.

Rwanda is one of the first countries that ratified the Convention on the Rights of the Child (CRC). The country, despite its very low gross domestic product (GDP) per capita, has one of the best child well-being indicators on the continent. Recently Rwanda also had two important achievements in the area of children's protection. First, it established the National Commission for Children which protects children's rights. Second, it launched a Strategy for National Child Care Reform, which aims to integrate children into families that are supported to provide needed care to these children. These successes are largely the result of strong laws and policies many of which have been developed with support from UNICEF. UNICEF is among the Government of Rwanda's key partners in preventing and responding to violence, abuse, exploitation and neglect, with a particular focus on the most vulnerable, including children without parental care and children with different forms of disabilities. This cooperation helps Rwanda and its vulnerable population to create an environment to

protect children's rights, provide them opportunities for normal growth and for developing their potential.

Despite the progress made by the government and other stakeholders in improving children's living standards in Rwanda, serious challenges still remain. One of the most important problems is the low rate of primary school completion. Further, students who complete primary school often do not have the skills that they need for successful employment in the future. According to a mini survey conducted by 'Rwanda Today' in Kigali, many children still beg on the streets because they have been abandoned. Many Rwandan children are struggling to deal with the effects of war and genocide, especially those born during the 1994 mayhem. In addition, many children face poverty in families while domestic violence has denied others a chance to be raised in proper homes. Some parents have neglected their children for various reasons. These children are now orphans and as part of the daily struggle many of them end up in petty crimes and drug and substance abuse.

These problems in Rwanda will lead to loss in adult productivity and persistent difficulties in the future. What happens during the early years is of crucial importance for every child's development. It is a period of great opportunity, but also of vulnerability to negative influences. On the other hand, the need to promote children's well-being is widely accepted as a moral imperative. Hence, the objective of this research is to estimate the multidimensional well-being of children and their families in Rwanda. Its aim is to compute an overall well-being index and decompose it into its underlying main components. The families are ranked by level of well-being across household, district and community characteristics. The results shed light on the state and changes in children's well-being in Rwanda indicating which provinces and districts have relatively better conditions for them. This can serve as a model for the general development of the well-being of children and their families in Rwanda.

The rest of this study is organized as follows. Section 2 provides a literature review which is followed by an introduction to the method of measurement in Section 3. The area of study, Rwanda, and the data are presented in Section 4. Section 5 discusses the empirical results and Section 6 gives a conclusion.

2. Literature Review

Literature on well-being in general and on related areas of economic research including capabilities, human development, freedom, poverty, happiness, sustainability, income distribution and social status and their direct association with well-being in income theory and practice has developed rapidly. The literature is divided into subjective and objective aspects (Alatartseva and Barysheva, 2015) referring to internal and external levels of well-being. Each level consists of 4 key contextual attributes that together constitute well-being. They include: (i) one's existence in accordance with their natural essence, (ii) an innate understanding of what is good for oneself, and the presence of the ability and willingness to achieve it, (iii) one's the ability to realize their human potential and plan for life, and (iv) the creation of a society and empowering people to fulfill the above stated positions, and

increase activity and awareness. This study covers many dimensions of objective well-being in general and those of children in particular. This section covers a review of literature found in journals, handbooks and other academic books (see, for example, Bronfenbrenner and Morris, 1998; Sen, 1985, 1999; Ridge, 2002; Kakwani and Silber, 2006, 2007; Senik, 2010; Truyts, 2010; MacKerron, 2012; Alartartseva and Barysheva, 2015; Arndt and Tarp, 2016; Qasim, 2016).

Literature on children's well-being has also developed very fast and as a result of theories, methods and their applications using increasingly available detailed household level data, numerous studies address this important issue. Research examples include Attree (2004) who provides a systematic review of the quantitative evidence on growing up in disadvantageous conditions. Bargain and Donni (2007) emphasize the theory of targeting children to influence their productivity and well-being, while Gregg et al. (2005) investigate the effects of mothers' decisions of returning to work on child development. The issues of measurement, decomposition of well-being and the underlying indicators are investigated by Brooks and Hanafin (2005). Kamerman et al. (2003) discuss social policies, family types and child outcomes. Land (2007) studies the foundation for child development. Stevens et al. (2005) focus on reinforcing the importance of family for successful child outcomes.

Most studies dealing with a measurement and analysis of child well-being use data from developed countries. Heshmati et al. (2008) investigated child well-being in middle and high income countries. Sarriera et al. (2015) examined the relationship between children's perceptions of available material resources and their subjective well-being in eight developed and developing countries. Sachs (2016) discusses subjective well-being over life. Brandolini (2007) computed multidimensional well-being indices focusing on income and health inequalities in the four advanced and largest European economies. Stiglitz et al. (2009) in viewing that well-being is a multi-dimensional phenomenon based on key dimensions that should be simultaneously taken into account. The dimension include: material living standards, health, education, personal activities including work, political voice and governance, social connections and relationships, environment and uncertainty. Maasoumi and Hu (2015) derive weights and substitution degree in multidimensional well-being of social groups in China. The well-being dimensions include: income, assets, house, health and education. Bradshaw (2002) estimated the relationship between child poverty and child outcomes and Bradshaw et al. (1993, 2006, and 2007) computed the index of child well-being in OECD and in the European Union. Jäntti and Bradbury (1999) studied child poverty in industrialized nations. Kamerman et al. (2003) studied the effects of social policies and family types on child outcomes in OECD countries.

Finally, UNICEF (2007) provides an overview of child well-being in 'rich' countries. Individual country case studies of child well-being include Beresford et al. (2005), Gregg et al. (2005) and Mayhew (2005) in the case of UK, Lippman (2004) and Berger et al. (2005) in the case of USA and Hanafin and Brooks (2005) in the case of Ireland.

Heshmati et al. (2008) analyzed the UNICEF Innocenti database and present three composite indices (two parametric and one non-parametric) of children's well-being in middle and high income countries. These indices are composed of six well-being components including

material, health and safety; educational; family and peer relationships; behaviors and risks; and subjective well-being. Each of the components is generated from a number of well-being indicators. They conclude that the Scandinavian countries performed quite well in comparison to other regions in and outside Europe. Their empirical results show that the UK performed extremely poorly in child well-being and the Russian Federation occupied the lowest rank in all the three indices. In addition, the authors provide guidelines on how to empirically link well-being to factors such as inequalities, poverty and growth.

Despite an urgent need for comprehensive child well-being studies covering developing countries only a few such studies have been done. Limited data availability and advanced research capacity explain the poor research in this field. However, the initiation of the millennium development goals and systematic data collection by the World Bank have led to changed conditions in the last two decades. Some cross-country studies have been done since then, while other single country studies too have been carried out. Among the few general studies are those by Ben-Arieh (1997) and Ben-Arieh and Wintersberger (2007) who study indicators of children's well-being to measure and monitor the state of children. Roelen et al. (2017) investigate the role of social protection in improving child well-being and childcare in sub-Saharan Africa. Sarriera et al. (2015) examine the relationship between children's perceptions of available material resources and their subjective well-being in eight developed and developing countries. Other studies focusing on developing countries include Akresh et al. (2011), Caserta et al. (2016), Ssewamala et al. (2010) and UNICEF (2013 and 2014). These are discussed in more detail later.

With regard to developing countries Roelen et al. (2017) studied the impact of social protection on loss of parental care and quality of care and well-being in sub-Saharan Africa. They investigated large-scale nationally implemented cash transfer and public works programs in South Africa, Ghana and Rwanda. According to the results of their study social protection will prevent the loss of parental care thereby providing much needed financial support to kinship or foster care providers. They also found that social protection could improve the quality of care and child well-being for all children in the studied societies.

A few studies have also been done on children's living conditions in Rwanda. In a study based on Rwandan data, Akresh et al. (2011) examined the impact of Rwanda's distinct shocks (defined as localized crop failure and armed conflict) on children's health status. According to their study, in both poor and non-poor households the boys and girls who were born during the conflict in regions experiencing fighting were negatively affected. On the other hand, only girls were negatively affected by crop failure and this impact was even worse for girls in poor households.

Caserta et al. (2016) studied the effects of various living environments for children (including child-headed households, orphanages, street children and foster homes), the quality of care and demographic factors on orphan children's psychosocial well-being in Rwanda. They conclude that children in orphanages exhibited higher levels of emotional well-being and lower levels of mental distress and risk-taking behavior than other non-orphan children. Decision-making abilities were the highest among child-headed households, while they were the lowest among those in orphanages. Demographic factors (such as age and sex) along with the quality of care (such as meal availability and length of

time spent in a particular living environment) were also important predictors of psychosocial well-being among the studied children.

Ssewamala et al. (2010) examined the effect of economic assets on sexual risk-taking intentions among school-going AIDS-orphaned adolescents in rural Uganda. According to the results of this study, in Uganda which is a country devastated by poverty and disease (including HIV/AIDS), having access to economic assets played an important role in influencing adolescents' sexual risk-taking intentions. The findings of this study have implications for the care and support of orphaned adolescents, especially in poor African countries devastated by poverty and sexually transmitted diseases.

Other studies indicate that Africa has become a better place for children as compared to five years ago. Despite its relatively low GDP per capita, the Child Friendliness Index ranked Rwanda at number six among Africa's 52 countries, having moved up five places from its 11th position in 2008. Rwanda has an impressive achievement – it has achieved most of the millennium development goals' (MDGS) targets by the 2015 deadline. Improving access to education is one of the biggest successes of the country. Rwanda has the highest primary school enrollment rates in Africa.

Sarriera et al. (2014) examined the relationship between children's perceptions of their available material resources and their subjective well-being. They found that children in Uganda had limited access to material resources and the lowest average of well-being among children from the sample countries studied.¹ Together with Algeria and South Africa, Uganda also had the strongest associations between well-being and access to material resources. Even with access to all the material resources evaluated, well-being scores were lower in South Korea. Children from Israel, Brazil, Spain and England had similar levels of satisfaction and well-being in looking at material resources and children's subjective well-being in eight countries. The preliminary results underscore the importance of assessing material well-being in children and highlighting the role that material resources play in influencing children's subjective well-being, especially in cases of children experiencing severe resource deprivation.

3. Measurement of the Well-being Index

A principal component analysis (PCA) is a variable dimension reduction method. PCA tries to identify the patterns of the data. It also directs the data by highlighting similarities and differences between related variables. It is used when researchers need to determine the minimum number of factors that will explain the maximum variance in the data. The indicators that form the principal components are highly correlated within a component, but they are not correlated across the components. The method helps reduce the dimensions in the data thereby limiting the many alternative ways to rank the units of observation.

Classical PCA originated in Pearson (1901) and was further developed in Hotelling (1933); this is widely used in political economy, macroeconomics, finance and many other fields. It

¹ The sample countries include: Algeria, Brazil, England, Israel, Spain, South Africa, South Korea, and Uganda.

is useful when one has obtained data on a number of variables and believes that there is some redundancy in these variables. In this case, redundancy means that some of the variables are correlated with one another, possibly because they measure the same construct. Hence, it should be possible to reduce the observed variables into a smaller number of principal components (artificial variables) that will account for most of the variances in the observed variables (Jolliffe, 2002). Estimation of the eigenvalues of the sample covariance matrix is the key step towards PCA to reduce the dimensions of the data.

The method is described in Xiao et al. (2017) as (using their notations): Assume that the m -dimensional output Y is represented as $Y=g(X)$, where X is a vector of n -dimensional inputs. The inputs are assumed to be independent of each other and are characterized by the probability density function $f(x)$. PCA is a multivariate statistical method that can be performed through the eigenvalue decomposition of the covariance matrix of outputs Y . PCA transforms the original variables into a set of new orthogonal variables, the first few of which with the largest variance contain the most information.

The procedure involves a number of steps. First, outputs Y are centered by subtracting the mean vector and denote the centered outputs (Y^C) as:

$$(1) \quad Y^C = Y - \mu_Y$$

Second, perform the eigenvalue decomposition of the covariance matrix as:

$$(2) \quad \Sigma_Y = \Gamma \Lambda \Gamma^T$$

where Λ is the diagonal eigenvalue matrix and Γ is a matrix of normalized eigenvectors associated with the eigenvalues.

Third, the centered outputs Y^C are transformed into independent variables H through:

$$(3) \quad H = Y^C \Gamma$$

where H contains the principal components which are orthogonal to each other. Y^C can also be expressed as:

$$(4) \quad Y^C = H \Gamma'$$

Thus, the original outputs Y can be expanded by the mutually orthogonal principal components in H by:

$$(5) \quad Y = \mu_Y + H \Gamma'$$

Usually, the first of the K principals contain the most variance if the original outputs are selected, then Y can approximately be expressed as:

$$(6) \quad Y = \mu_Y + H_K \Gamma_K'$$

where H_K and Γ_K contain the first K principal components of H and the first K eigenvectors of Γ .

Well-being indices are computed non-parametrically assuming the components' weights used in their aggregation on an ad-hoc basis or parametrically where the weights are estimated. Each approach has their benefits in the form of not assuming the weights rather than estimating them and limitations in the form of an assumption of a functional form and choice of computation method. The performance of the two composite indices' approaches are compared by Heshmati et al. (2008) in the context of child well-being and in Heshmati and Oh (2006) in the context of the development strategy.

Kang (2002) conducted a sensitivity analysis of the composite environmental index while Decancq and Lugo (2008) discuss how to set weights in multidimensional indices of well-being. The robustness of composite indicators in the context of national science and technology policy were investigated by Grupp and Moguee (2004). Noorbakhsh (1998) also investigates alternative development indices.

These studies together shed light on the strengths and weaknesses of the indices and on how to improve upon their performance in measuring children's well-being. Xiao et al. (2017) propose new kinds of sensitivity indices based on PCA to measure the effects of input variables on multivariate outputs. Existing sensitivity indices focus on the variance of principal components representing a magnitude of uncertainty in the corresponding coordinate axes. Our research employs a weighted average of the principal components with eigenvalues greater than 1 where the share of the variance explained by the components is used as weights in the aggregation.

4. Data

The data used in our study consists of household surveys in Rwanda. Rwanda is located in Central/Eastern Africa and is bordered by the Democratic Republic of the Congo to the west, Uganda to the north, Tanzania to the east and Burundi to the south. With an area of 26,338 square kilometers, Rwanda is the world's 149th largest country and the fourth smallest on the African mainland. The country has five provinces -- Kigali City, Southern, Western, Northern and Eastern provinces which were ascertained by borders in 2006. The Eastern Province and Kigali with an area of 9,458 km² and 730 km² are the largest and smallest provinces respectively. The five provinces of Rwanda are divided into 30 districts.² These 30 districts are further sub-divided into 418 administrative sectors. Different administrative sectors are sub-divided into cells, which in turn are divided into villages.³

A 3-year period population growth in Rwanda according to the National Institute of Statistics of Rwanda (NISR) was about 7.0 per cent in 2015 (11.3 million persons in 2015 as compared to 10.5 million persons in 2012). A majority of the people live in rural areas and the population is young, with a density among the highest in Africa. NISR (2014) recorded that

² The districts are Nyarugenge, Gasabo, Kicukiro, Nyanza, Gisagara, Nyaruguru, Huye, Nyamagabe, Ruhango, Muhanga, Kamonyi, Karongi, Rutsiro, Rubavu, Nyabihu, Ngororero, Rusizi, Rulindo, Gakenke, Musanze, Burera, Gicumbi, Rwamagana, Nyagatare, Gatsibo, Kayonza, Kirehe, Ngoma, Bugeser and Nyamasheke.

³ Central Intelligence Agency (CIA) provides a country profile of Rwanda covering various socioeconomic characteristics of the country. at: <https://www.cia.gov/library/publications/the-world-factbook/geos/rw.html>.

in 2012, 43.3 per cent of the population was aged 15 years and under and 53.4 per cent was aged between 16 and 64 years. Therefore, Rwanda is considered a young country in Africa. Rwanda's population density is amongst the highest in Africa at 445 inhabitants per square kilometer. Meanwhile the Southern and Western provinces are the most populated provinces in the country.

The data for the household surveys covered 14,810 household observations in Rwanda in 2006, 2009 and 2012. There were 2,711, 5,351 and 6,748 yearly observations respectively. In our study the overall family well-being index is composed of seven well-being components: household, community, education, housing, nutrition, farming and economics. Each of these components is in turn generated from a number of well-being indicators. The farming and economics components are a part of the family well-being index while the remaining five components are related to children's well-being. Data availability and previous studies such as those by Stevens et al. (2005), Bradshaw et al. (2007), Heshmati et al. (2008), Ssewamala et al. (2010), Akresh et al. (2011), Sattiera et al. (2015), Caserta et al. (2016) and Roelen et al. (2017) influenced the modeling and determined the composition of the index. Summary statistics of data grouped component-wise is presented in Table 1.

Insert Table 1 about here

The first index component represents households; this consists of four indicators: gender, age, and marital state of the household head and the number of spouses. Household represents how optimal the environment is for a child to grow up in. The second index component is labeled as community and is constructed using six indicators including the number of inhabitants per square kilometer; urban, rural and semi-urban areas; and population structures in 2002 and 2012. Community and its provision of services and safety is an extension of the household environment. The third component is associated with education consisting of six indicators among others: literacy, education in years, primary and secondary education of the head, number of children in the household attending school and distance to the road. This component captures availability and facilitation of education. Education and its access and quality are drivers of well-being that define the education component.

The next component is related to housing and is built by using nine indicators covering material for the roof and floor, number of rooms, number of people in the household, source of lighting, main source of drinking water, payment for drinking water and distance to the main water source. High quality and standard of housing increase children's well-being. Nutrition is the fifth index component that is composed of five nutrition-related indicators among others: owning a vegetable garden, number of animals, number of crops, number of banana trees owned by the household and number of banana trees used for making beer owned by the household. The latter has an indirect income effect. Nutrition affects students' growth, health and educational outcomes.

The sixth component captures farming and is composed of four indicators: percentage of farmland cultivated on marshland in a district, altitude, number of animals and number of crops. Farming provides conditions for children's improved welfare and well-being. It may also imply engagement of children in farming activities as child labor. Economics is the last

index component that captures the number of income generating activities undertaken by the household, total income from all income generating activities, producing cash crops, distance to the market, distance to the road, members of the extended family sending back money and having access to credit. Farming and economics influence the welfare of children in a very similar way. The overall composite index of well-being includes 41 indicators forming these seven index components.

5. An Analysis of the Results

5.1 Principal Component Analysis

The principal component analysis of different well-being components and the overall composite index estimated for children and their families are presented in Table 2. Only the eigenvalues which are bigger than 1 were used in computing the different components of the index. The different components were estimated separately and their principal components with eigenvalues exceeding 1 were aggregated using the share of variance that they explain. Traditional researchers rank units only by the first principal component. Our approach is superior as it allowed us to fully utilize information from all principal components with eigenvalues larger than 1. This applies to the overall composite children and family indices as well where full information from various indicators was used for estimating and drawing inferences about the multidimensionality of well-being. As an example the household weighted index was computed using two principal components and the share of the variance that they explained was obtained.⁴ The weighted index was normalized, where the households with minimum and maximum values attained index values of 0 and 1.⁵

Insert Table 2 about here

In order to explain the index components in more detail, we first consider the household component; only two of the principal components are bigger than 1. Number of eigenvalues bigger than 1 and share of variance explained by these principal components are: households (2, 0.60), community (2, 0.73), education (2, 0.49), housing (4, 0.60), nutrition (2, 0.53), farming (2, 0.51) and economic (3, 0.51). In the case of the overall well-being index 14 principal components are bigger than 1 and together they explain 57 per cent of the total variations (14, 0.57). The corresponding figures for children's well-being are (10, 0.55). In the case of family well-being, the contribution of the principal components to the explanation of the variance is reduced from 8 per cent by the first component and 3 per cent by the last component. The corresponding figures for the children's well-being are 10 per cent and 4 per cent respectively.

Now we explain the differences and relationships between the different index components and the composite indices for children and their families. The correlation matrix for the seven well-being components, year, composite children and family indices and income per capita are reported in Table 3. With the exception of a few cases all pair-wise relations are

⁴ The household weighted index is obtained as: $H=(PC1 \times 0.38 + PC2 \times 0.22) / 0.60$.

⁵ The normalized index is obtained as: $H_n = (H_{obs} - H_{min}) / (H_{max} - H_{min})$. The H variables are observed, minimum and maximum in sample values.

statistically significant at the 1 per cent level of significance. Concerning year and other components, only education and household are positively correlated with year while other components are negatively correlated with time. In general, we expected a positive improvement in well-being over time. The negative correlation indicates a declining level of the well-being component over time. A high negative association is found among housing and year (-0.738), between economics and year (-0.589) and between farming and year (-0.458). Farming and nutrition are highly and positively correlated (0.612). The correlation between household and housing (-0.132), community and education (-0.021) and also between education and housing (-0.111) are significant and negative. The correlation between economics and other components is statistically significant and positive, but low. The relationship between household and farming shows that these two components are positively and significantly correlated (0.257).

Insert Table 3 about here

With the exception of farming (-0.046), there are positive correlations between the children and family well-being indices and their individual components. The size of the correlation coefficient varies in the range of 0.01 and 0.527. It approximately reflects individual component's contribution share to the overall well-being index. The correlation coefficient between children and family well-being indices is 0.455. The two indices differ by economics and farming components. Unlike expectations, the income per capita variable is negatively (-0.246) correlated with time suggesting a deterioration of income per capita over time. Income is positively correlated with child well-being (0.038) but negatively correlated (-0.224) with family well-being. Again the negative relationship is unexpected. A measurement error might explain this pattern. It should be noted that these correlation coefficients are pair-wise correlations and as such unconditional on other components. Conditional correlations in the form of a regression analysis are presented later.

5.2 Variations in levels of well-being indices by characteristics

Variations in the levels of different well-being components and the overall composite indices can be analyzed by household and environmental characteristics. In this section we analyze heterogeneity by comparing the average levels of the well-being components of different districts, provinces and areas over time. In Part A of Table 4, Nyagatare has the highest family index value while Ngoma has the highest children's index and income per capita. Ruizi enjoys the highest housing standards and Nyabihu the highest nutrition component of well-being. The highest farming index level belongs to Rubavu. Gicumbi performs well in community and education. In total the five highest ranked districts are Nyagatare, Kayonza, Kirebe, Gatsibo and Nyanza, while the five lowest districts are Gicumbi, Rusizi, Nyaruguru, Burera and Nyahibu.

Insert Table 4 about here

According to Part B of Table 4 the highest/lowest contributing components to a province's rank in different well-being indices are: household (Northern/Eastern), community (Eastern/Northern), education (Southern/Eastern), housing standard (Eastern/Southern),

nutrition (Eastern/Western), farming (Southern/Western) and finally the economics component (Eastern/Southern). In sum, the Eastern Province enjoys the highest family well-being, while the Northern Province has the lowest level of family well-being. The highest and lowest children's well-being are assigned to Western and Southern provinces.

The districts are classified into three groups by different areas as urban, semi-urban and rural. According to Table 4 Part C, in urban areas, education, housing and the overall composite indices are the highest. Also the highest income index belongs to urban areas. On the other hand, the lowest numbers of household, community, nutrition and farming indices belong to urban areas. In rural areas, household, community, nutrition, farming and economics indices are the highest and housing and overall composite indices are the lowest. The lowest education, economic and income indices belongs to semi-urban areas. The largest difference is in the children's well-being index where urban areas enjoy the highest level, while rural areas the lowest level.

Part D of Table 4 presents different indices by the periods of study. The three periods differ by three years each. According to this table the number of community, housing, nutrition and economics indices decreased over time. Only household, education and farming indices increased in 2009 as compared to 2006 and then these indices decreased again in 2012. The maximum amount of income index (0.155) was in 2009 while the minimum value (0.021) is associated with 2012. The aggregate family index fluctuated over time. It decreased from 0.253 in 2006 to 0.136 in 2009 and then increased to 0.280 in 2012. The children's index had an increasing trend from 0.208 to 0.267 and 0.274. In sum, the development in children's well-being from 2006 to 2012 was positive but the development in family well-being index was not smooth. In mid-period, 2009, the development in the family index tended to be negative.

Part E of Table 4 shows the sample mean and the dispersion around mean of the indices and their components. The largest variations relative to mean values are those attributed to housing and economics and the lowest to household and community components. Dispersion in child well-being was smaller than the corresponding dispersion for family well-being.

Figure 1 shows the levels of different components and aggregate family well-being. The housing and community components are the main sources of variations in family well-being among districts. Figure 2 shows the different components and their aggregate well-being of children by districts. Again housing and community are the main contributors to the differences in children's well-being among the districts. Contributions of education and the housing standard components are very similar across districts.

Insert Figure 1 and 2 about here

5.3 Change in indices and their components by characteristics

A correlation matrix of the percentage annual changes in different index components, the overall composite indices and income are presented in Table 5. A large number of the pair-wise correlation coefficients are positive and significantly different from zero. The largest pair-wise correlations are those between changes in household and nutrition (0.188),

household and education (0.154), nutrition and education (0.105), and in particular in changes between nutrition and education (0,591) over time.

Insert Table 5 about here

Table 5 further shows that education, nutrition, farming and economics are the main contributors to changes in family well-being. The corresponding segments for changes in children's well-being over time are household, education, housing and nutrition. As expected the changes in the children and family well-being indices are highly correlated (0.556).

Table 6 presents percentage changes per annum in different index components. According to this table average percentage changes in all indices are positive and they vary between 0.001 (community index) to 0.400 (income index). The percentage change in the nutrition index is 0.123 with minimum of -0.329 and maximum of censored extreme observation of 2.000. Censoring is conducted to eliminate the influence of a few outlier observations as a way to avoid distortions in the distribution of households. Changes in housing and education indices are almost the same. Maximum changes in all the indices (except for income) are the censored value 2.000. Maximum amount of dispersion belongs to the income index (0.074) and minimum to the community index (0.002) indicating that this index did not change much.

Like Table 4 which shows the levels of the indices, changes in the indices in Table 6 are composed of four parts, representing percentage yearly changes in all indices by district, province, area and survey years. Part A of Table 6 shows that the districts differ in performance or percentage changes in respective well-being index components. The range of changes in individual components and well-being indices also differ across districts. The largest percentage changes are those of nutrition and farming. These greatly influence the ranks of Musanze, Nyagatare, Ruizi, Nyabihu and Burera to have the five highest changes in family well-being, while Nyanza, Kirebe, Gicumbi, Rutsiro and Nyamasheke are among the districts with five lowest family well-being indices. The ranks of the districts are not very closely related to changes in income per capita of the families.

Part B of Table 6 shows large variations in percentage changes in the nutrition and farming components as well as in income per capita, while the corresponding variations for the remaining components are low. Like levels, the Eastern Province enjoyed a high change rate or growth in well-being over time. The Northern Province had the highest changes in community and education indices and the lowest changes in housing and nutrition indices. The community index did not change much in different provinces.

Part C of Table 6 indicates that urban districts are superior to semi-urban and rural areas in case of income per capita and family well-being. The same applies to the main contributing well-being components of nutrition and farming, but it does not necessarily apply to other individual well-being components. It is worth mentioning here that heterogeneity in both the indices and their components is very large by location area. We did not find a clear one-to-one relationship between the well-being indices and their underlying components.

Part D of Table 6 shows low changes in 2009 in the indices as compared to 2012. It suggests that the high levels of indices and their components are associated with low annual

percentage changes in the well-being indices – that is a negative relationship between level and percentage changes. We note that most of the changes in the different indices (household, housing, nutrition and farming) happened in 2012. As other parts of this table indicate, the community component did not change much over time. Unlike the two well-being indices, changes in the per capita income index increased over time. This suggests that income is not the main contributor to well-being when well-being is defined multidimensionally.

Figure 3 shows the annual percentage changes in different components and aggregate changes in family well-being. Among the districts, growth in nutrition and farming were the main sources of variations in family well-being. Figure 4 shows changes in the different components and the aggregate well-being of children by districts. Again housing and community are the main contributors to the differences in changes in children's well-being among the districts. The contribution of education is very similar across districts.

Insert Figure 3 and 4 about here

5.4 Determinants of income and well-being

Using the principal component analysis we identified various indicators that contributed to well-being in Rwanda. The well-being index was further decomposed into its underlying main components. In addition we distinguished between well-being of children and their families. We investigated the differences in both levels and percentage changes over time in well-being indices and their components amongst different districts, provinces and location areas in Rwanda and their temporal patterns over time. This included income per capita which is a common uni-dimensional measure of well-being. The income measure was compared with the previous well-being measures which are multidimensional.

PCA helped us reduce the dimensionality of well-being to a few specific components and composite indices of children and their families. In this section we estimate models of income and well-being using a regression analysis to identify their determinants and estimate the effects on levels of per capita income and well-being. The estimation results from the ordinary least squares regression of income per capita on different components of well-being and other determinants such as provincial location, area and time periods are reported in Table 7A. Since there might be a two-way causal relationship between income and well-being, family and children's well-being are also regressed on income and other determinants. Alternatively, an estimation of the income and well-being index as a system of two equations accounts for endogeneity and simultaneity issues. The two sets of well-being models differ by economic and farming components of well-being.

The estimation results in Table 7A are heteroscedasticity consistent following the White test method. In each case four models were specified, estimated and tested. The model specifications differed by generalization of the basic model with the overall index as the determinant, different well-being components and added control variables including time, location, area and province characteristics. The decomposition of the overall index into

underlying components was used to study the impact of various indices on Rwanda's family and children's well-being.

Insert Table 7A about here

In Model A1 which is our basic model in the per capita income, family well-being was the only determinant of level of income. An increase in well-being led to an increased income. This is consistent with the fact that families with higher well-being are more educated and healthier and as such are more productive in terms of their earning capacity. A disaggregation of family well-being in Model A2 led to both positive and negative effects on the level of income. The housing and farming components were negative, while the others were positively related to income. A disaggregation of well-being increased R^2 performance of the model from 0.009 to 0.136. Adding control variables to each of two models labeled as Models A3 and A4 further increased R^2 performance of the income model from 0.047 to 0.160. A specification test suggested that the most general Model A4 was the accepted model specification. All included explanatory variables were statistically significant at less than the 1 per cent level of significance with the exception of one province dummy (Eastern) which was not significantly different from the Southern Province that served as the reference province.

The estimation results from models with determinants of family well-being are reported in Table 7B. The models were estimated by OLS with heteroscedastic consistent standard errors. In Model B1 which is our basic family well-being model, per capita income was the only determinant of level of family well-being. An increase in income increased family well-being. This is consistent with our expectation that a higher income increases a family's welfare and well-being. Adding the control variables representing time, province and area locations to Model B2 suggests they had very positive effects on the performance of the model. R^2 increased from 0.009 to 0.370. Inclusion of the components of the family well-being (Model B3) showed their contributions to well-being. Housing and farming negatively affected family well-being. However, the effect of the housing component was not significant. Finally a generalization of family well-being to include income and well-being components and control variables (Model B4) led to improved performance of the model where R^2 increased to 0.793. A specification test of the models suggested that the most general Model B4 was the accepted model specification. With the exception of two variables, income and the Eastern Province dummy, the remaining explanatory variables were statistically significant at the less than 1 per cent level of significance. Income effect was only weakly significant.

Insert Table 7B about here

Estimation results from models with determinants of children's well-being are reported in Table 7C. The key difference between Models 7B and 7C is that in Model 7C child well-being was primarily effected by only child related components. The models were again estimated by OLS with heteroscedastic consistent standard errors. In the simplest Model C1 which is the basic model per capita income served as the only determinant of the level of children's well-being. An increase in income increased children's well-being. This is consistent with our expectation that a higher income will increase children's well-being.

Similar to the family well-being model's specifications we added the different control variables to Model C2 which showed very positive effects on the performance of the model. R^2 increased from 0.002 to 0.124. Again, inclusion of the children's well-being indicators (Model C3) showed evidence of their positive contributions to children's well-being. The effects of the household and education components were the highest. Finally a generalization of the model to include the control variables in Model C4 led to further improvements in the fit of the model. The performance of the model measured in R^2 increased to 0.662. A specification test of the models suggested that the most general Model C4 was the accepted model specification. All included explanatory variables were statistically significant at less than the 1 per cent level of significance.

Insert Table 7C about here

According to Models 7B and 7C the different well-being components' effects on well-being were positive and significant. The time effect differed among the two models suggesting different development of children and family well-being. On the other hand, farming had a negative effect on the well-being of families. Results from Models 7B and 7C suggest that 2009 had negative effects on family well-being, but 2012 had positive effects. This is interpreted to mean that family well-being has progressed over time in Rwanda. The area and province effects in Models B4 and C4 showed similar positive effects on children and family well-being.

6. Summary and Conclusion

Rwanda is a low income country even by African standards. Despite its limited resources the Government of Rwanda in cooperation with NGOs has been able to give high priority to well-being of families and their children. The country, despite its very low GDP per capita, has succeeded in having one of the best child well-being indicators in Africa. Recently Rwanda fulfilled two important achievements in the protection of children. These reform measures aim to protect children's rights and integrate children into families that provide needed care to them. The success in child welfare is positively influenced by policies developed with support from UNICEF.

This research aimed to estimate multidimensional well-being of children and their families in Rwanda. Composite indices of well-being decomposed into their underlying components were estimated using the principal component analysis method and stratified household surveys. The households were then ranked by level of well-being and by various household, district and community characteristics. The results shed light on both the level and changes in well-being of children and their families. They allow identification of provinces and districts with relatively better living condition for children and families. This can serve as a model for public policies aimed at improving the general development of well-being and its specific components in Rwanda.

In this research we identified various indicators contributing to the well-being of households in Rwanda. A composite index of well-being was also constructed. The aggregate well-being index was further decomposed into several main components including household,

community, education, housing standard, nutrition, farming and economics. A grouping of the components allowed us to distinguish between well-being of children and their families. The measure of well-being is household specific and as such it allowed us to investigate the differences in both levels and percentage changes in well-being indices and their components amongst different districts, provinces and areas in Rwanda and their development over time. The two well-being indices are multidimensional and were compared with the commonly used unidimensional measure defined as income per capita.

The principal component analysis helps reduce the dimensionality of well-being to a few specific components. In computing the index for individual households the different principal components with eigenvalues larger than 1 were aggregated using the share of the total variance in the data explained by the different components. This method allowed us to use all information in computing the composite indices of children and their families. The two indices differed by economics and farming components. The selection of well-being components and aggregate indices were determined by data availability and maximum use of data from an economics point of view. Thus, there is room for significant improvements in the indices' definitions and their measurements.

Variations in the levels and percentage annual changes in different well-being components and composite indices were analyzed by location characteristics of households such as district, province and area over time. The analysis showed evidence of significant heterogeneity in various components and by different dimensions of household characteristics. There is clear evidence that some provinces, districts and areas remained high or low ranked. The index components' levels and changes over time were found to be different by characteristics. Different districts and provinces were found to be endowed with different conditions to promote the well-being of residing households. Any public policy measure to enhance well-being must account for both common and unique locality conditions of households.

In addition to the principal component analysis-based estimated indices to rank households by various characteristics as a complement we also estimated several models of income and well-being using a regression analysis. The objective was to identify their determinants and estimate their effects on levels of per capita income and well-being. This approach helped us establish the correlation or the best causality between the indices and their determinants. The estimation results from ordinary least squares regression of the income per capita on different components of well-being and other determinants such as provincial location, area and time periods were reported. Since there might be a two-way causal relationship between income and well-being, family and children's well-being were also regressed on income and other determinants. The two sets of well-being models differed by the economics and farming components of well-being.

The estimation result from a regression of income per capita as a unidimensional measure of well-being and the principal component analysis based multidimensional indices of children and their families' well-being regressed on various control variables helped identify important characteristics and their effects on well-being. The basic model's specifications were generalized and tested to identify and use the finally accepted model specification in the analysis of the factors influencing well-being in Rwanda. The results show evidence of

heterogeneity in effects and the necessity of designing public policies that are adapted to local conditions.

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Table 1. Summary statistics of means of data (N=14,810)

| Variable | Description | Mean | Std Dev | Minimum | Maximum |
|---------------------|---|------------|-----------|---------|---------|
| <u>A. household</u> | | | | | |
| dfemale | Equals 1 if the head is female | 0.231 | 0.421 | 0 | 1 |
| agehead | Age of hh head | 44.381 | 14.811 | 15 | 103 |
| mshead | Marital state of head, equals 1 if the head is married | 0.589 | 0.492 | 0 | 1 |
| spousnr | Number of spouses | 1.042 | 0.270 | 0 | 5 |
| <u>B. community</u> | | | | | |
| popdens | Number of inhabitants per square kilometer | 634.070 | 762.026 | 1.9 | 13,009 |
| urban | Dummy urban area | 0.048 | 0.213 | 0 | 1 |
| rural | Dummy rural area | 0.872 | 0.334 | 0 | 1 |
| semiurb | Semi-urban area | 0.080 | 0.271 | 0 | 1 |
| pop2002 | Population in 2002 | 20,383.050 | 5,353.609 | 9,225 | 51,461 |
| pop2012 | Population in 2012 | 26,564.180 | 8,446.499 | 10,384 | 58,847 |
| <u>C. Education</u> | | | | | |
| lithead | Hh head can read and write a simple message | 0.826 | 0.783 | 0 | 9 |
| eduhead | Head's education in years | 3.187 | 1.802 | 0 | 10 |
| eduha | Equals one if head has completed primary | 0.266 | 0.442 | 0 | 1 |
| eduhb | Equals one if head has completed secondary | 0.015 | 0.122 | 0 | 1 |
| schoola | Number of children in hh that are attending school | 1.197 | 1.214 | 0 | 7 |
| distroad | Distance to road | 3,760.419 | 3,524.973 | 0 | 21,925 |
| <u>D. Housing</u> | | | | | |
| mroof | Metal shee 1; Clay tiles 2; Other spe 3; Straw/That 4; Wood/bambo 5; | 3.294 | 2.291 | 0 | 8 |
| mfloor | Earth/Mud 1; Cement con 2; bricks 3; Other spe 4; Hardened 5; Clay tiles 6, | 1.601 | 0.658 | 0 | 8 |
| rooms | Numbers of rooms | 2.491 | 2.158 | 0 | 99 |
| hhsizer | Number of people in the hh | 2.440 | 1.283 | 0 | 12 |

| | | | | | |
|---------|--|--------|---------|---|-------|
| electra | Equals 1 if the source of lightning is electricity base is kerosene, candles, battery or no lightning | 0.051 | 0.220 | 0 | 1 |
| electrb | Equals one if the fuel used for cooking is gas or electricity base is wood, charcoal, kerosene or other fuel | 0.006 | 0.080 | 0 | 1 |
| watera | Equals 1 if the main source of drinking water is public tap base is pond, lake, borehole, rain water or spring | 0.491 | 0.500 | 0 | 1 |
| waterb | Equals 1 if the hh pays for water | 0.232 | 0.422 | 0 | 1 |
| waterc | Distance to main water source in minutes | 28.822 | 126.887 | 0 | 6,000 |

E. Nutrition

| | | | | | |
|----------|---|--------|---------|---|-------|
| vegetd | Equals 1 if hh owns a vegetable garden | 0.564 | 0.496 | 0 | 1 |
| nranimal | Number of animals | 2.994 | 5.688 | 0 | 203 |
| nrcrops | Number of crops | 3.373 | 1.730 | 0 | 10 |
| bantrnr | Number of banana trees owned by the hh | 22.056 | 112.847 | 0 | 3,500 |
| bantrbnr | Number of banana trees used for making beer owned by the hh | 31.237 | 116.929 | 0 | 4,000 |

F. Farming

| | | | | | |
|----------|---|-----------|---------|-----|-------|
| marshlan | Percentage of farmland cultivated on marshlands in district | 0.530 | 0.499 | 0 | 1 |
| altitude | Altitude in meters | 1,747.481 | 281.373 | 955 | 2,739 |
| nranimal | Number of animals | 2.994 | 5.688 | 0 | 203 |
| nrcrops | Number of crops | 3.373 | 1.730 | 0 | 10 |

G. Economics

| | | | | | |
|----------|---|-------------|-------------|---|-----------|
| nrincome | Number of income generating activities undertaken by hh | 1.766 | 0.685 | 0 | 10 |
| tincome | Total income from all income generating | 179,793.200 | 236,125.300 | 0 | 7,200,000 |

| | | | | | |
|----------|--|-----------|-----------|---|--------|
| | (four primary) activities | | | | |
| | Equals one if the hh is a producer of cash crops (Tea, Coffee, Sugar) | 0.059 | 0.236 | 0 | 1 |
| cashcrop | | | | | |
| distmark | Distance to market | 77.226 | 61.950 | 0 | 1,200 |
| distroad | Distance to road | 3,760.419 | 3,524.973 | 0 | 21,925 |
| | Equals one if the extended family member sends back money | 0.052 | 0.222 | 0 | 1 |
| worksend | | | | | |
| credd | Equals one if the hh has access to credit | 0.264 | 0.440 | 0 | 1 |

Note: household (hh)

Table 2. Principal component analysis (individual components, children and family composite indices), n=14,810 obs

| Variable | Eigenvalue | Proportion | Cumulative | Variable | Eigenvalue | Proportion | Cumulative |
|--|------------|------------|------------|---|------------|------------|------------|
| <u>I. Individual index components:</u> | | | | <u>II. Overall composite index:</u> | | | |
| <u>A. Household</u> | | | | <u>Composite family wellbeing index</u> | | | |
| PC1 | 1.90 | 0.38 | | PC1 | 3.38 | 0.08 | |
| PC2 | 1.12 | 0.22 | 0.60 | PC2 | 2.85 | 0.07 | |
| <u>B. Community</u> | | | | PC3 | 2.13 | 0.05 | |
| PC1 | 1.90 | 0.47 | | PC4 | 1.89 | 0.05 | |
| PC2 | 1.03 | 0.25 | 0.73 | PC5 | 1.77 | 0.04 | |
| <u>C. Education</u> | | | | PC6 | 1.60 | 0.04 | |
| PC1 | 1.94 | 0.32 | | PC7 | 1.37 | 0.03 | |
| PC2 | 1.04 | 0.17 | 0.49 | PC8 | 1.28 | 0.03 | |
| <u>D. Housing</u> | | | | PC9 | 1.24 | 0.03 | |
| PC1 | 1.68 | 0.19 | | PC10 | 1.20 | 0.03 | |
| PC2 | 1.49 | 0.17 | | PC11 | 1.13 | 0.03 | |
| PC3 | 1.25 | 0.14 | | PC12 | 1.05 | 0.03 | |
| PC4 | 1.01 | 0.11 | 0.60 | PC13 | 1.04 | 0.03 | |
| <u>E. Nutrition</u> | | | | PC14 | 1.03 | 0.03 | 0.57 |
| PC1 | 1.57 | 0.31 | | <u>Composite children wellbeing index</u> | | | |
| PC2 | 1.12 | 0.22 | 0.53 | PC1 | 2.70 | 0.10 | |
| <u>F. Farming</u> | | | | PC2 | 2.36 | 0.08 | |
| PC1 | 1.59 | 0.26 | | PC3 | 1.95 | 0.07 | |
| PC2 | 1.48 | 0.25 | 0.51 | PC4 | 1.51 | 0.05 | |
| <u>G. Economic</u> | | | | PC5 | 1.36 | 0.05 | |
| PC1 | 1.36 | 0.19 | | PC6 | 1.27 | 0.04 | |
| PC2 | 1.19 | 0.17 | | PC7 | 1.13 | 0.04 | |
| PC3 | 1.01 | 0.14 | 0.51 | PC8 | 1.09 | 0.04 | |
| | | | | PC9 | 1.05 | 0.04 | |
| | | | | PC10 | 1.01 | 0.04 | 0.55 |

Table 3. Correlation matrix among index components, n=14,810 obs

| | Year | Household | Community | Education | Housing | Nutrition | Farming | Economic | Family | Children | Income |
|--------------------|--------|-----------|-----------|-----------|---------|-----------|---------|----------|--------|----------|--------|
| Year | 1.000 | | | | | | | | | | |
| Household | 0.041 | 1.000 | | | | | | | | | |
| | 0.001 | | | | | | | | | | |
| Community | -0.144 | -0.010 | 1.000 | | | | | | | | |
| | 0.001 | 0.227 | | | | | | | | | |
| Education | 0.132 | 0.228 | -0.021 | 1.000 | | | | | | | |
| | 0.001 | 0.001 | 0.009 | | | | | | | | |
| Housing | -0.738 | -0.132 | 0.183 | -0.111 | 1.000 | | | | | | |
| | 0.001 | 0.001 | 0.001 | 0.001 | | | | | | | |
| Nutrition | -0.286 | 0.196 | 0.049 | 0.059 | 0.148 | 1.000 | | | | | |
| | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | | | | | | |
| Farming | -0.458 | 0.257 | -0.011 | 0.036 | 0.052 | 0.612 | 1.000 | | | | |
| | 0.001 | 0.001 | 0.175 | 0.001 | 0.001 | 0.001 | | | | | |
| Economic | -0.589 | 0.084 | 0.096 | 0.020 | 0.371 | 0.327 | 0.463 | 1.000 | | | |
| | 0.001 | 0.001 | 0.001 | 0.014 | 0.001 | 0.001 | 0.001 | | | | |
| Family wellbeing | 0.235 | 0.049 | 0.271 | 0.220 | 0.106 | 0.391 | -0.191 | 0.010 | 1.000 | | |
| | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.236 | | | |
| Children wellbeing | 0.197 | 0.527 | 0.094 | 0.384 | 0.062 | 0.214 | -0.046 | 0.000 | 0.455 | 1.000 | |
| | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.952 | 0.001 | | |
| Income | -0.246 | 0.088 | 0.055 | 0.149 | -0.031 | 0.193 | 0.425 | 0.481 | -0.224 | 0.038 | 1.000 |
| | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | |

Table 4. Summary of all indices by district, province, area and year, sorted by family index, sorted by change in family index, n=14,810 obs

| | House hold | Community | Education | Housing | Nutrition | Farming | Economic | Family wb | Children wb | Income |
|-------------|------------|-----------|-----------|---------|-----------|---------|----------|-----------|-------------|--------|
| A. District | | | | | | | | | | |
| Musanze | 0.063 | 0.002 | 0.061 | 0.081 | 0.178 | 0.195 | 0.057 | 0.069 | 0.047 | 0.376 |
| Nyagatare | 0.051 | 0.004 | 0.082 | 0.093 | 0.172 | 0.133 | 0.038 | 0.067 | 0.058 | 0.422 |
| Rusizi | 0.050 | 0.001 | 0.069 | 0.117 | 0.190 | 0.149 | 0.048 | 0.063 | 0.053 | 0.387 |
| Nyabihu | 0.057 | 0.000 | 0.061 | 0.073 | 0.200 | 0.212 | 0.043 | 0.062 | 0.056 | 0.258 |
| Burera | 0.051 | 0.003 | 0.065 | 0.068 | 0.111 | 0.086 | 0.044 | 0.060 | 0.056 | 0.418 |
| Rubavu | 0.056 | 0.002 | 0.068 | 0.078 | 0.189 | 0.230 | 0.054 | 0.055 | 0.029 | 0.311 |
| Ngoma | 0.060 | 0.000 | 0.066 | 0.094 | 0.132 | 0.117 | 0.071 | 0.055 | 0.081 | 0.522 |
| Karongi | 0.059 | 0.001 | 0.066 | 0.060 | 0.129 | 0.053 | 0.062 | 0.052 | 0.053 | 0.394 |
| Rwamagana | 0.056 | 0.001 | 0.053 | 0.074 | 0.139 | 0.100 | 0.044 | 0.050 | 0.054 | 0.468 |
| Bugesera | 0.056 | 0.001 | 0.060 | 0.076 | 0.143 | 0.091 | 0.054 | 0.049 | 0.068 | 0.496 |
| Nyaruguru | 0.050 | 0.001 | 0.067 | 0.070 | 0.101 | 0.048 | 0.058 | 0.043 | 0.049 | 0.351 |
| Huye | 0.059 | 0.001 | 0.058 | 0.078 | 0.129 | 0.053 | 0.064 | 0.043 | 0.064 | 0.379 |
| Nyamagabe | 0.054 | 0.002 | 0.081 | 0.066 | 0.111 | 0.061 | 0.058 | 0.042 | 0.053 | 0.503 |
| Gakenke | 0.052 | 0.000 | 0.083 | 0.061 | 0.079 | 0.009 | 0.059 | 0.041 | 0.047 | 0.470 |
| Kamonyi | 0.051 | 0.001 | 0.055 | 0.072 | 0.100 | 0.068 | 0.081 | 0.038 | 0.054 | 0.493 |
| Ngororero | 0.064 | 0.000 | 0.088 | 0.042 | 0.107 | 0.053 | 0.045 | 0.038 | 0.052 | 0.473 |
| Rulindo | 0.059 | 0.000 | 0.089 | 0.066 | 0.093 | 0.047 | 0.046 | 0.037 | 0.042 | 0.398 |
| Ruhango | 0.060 | 0.001 | 0.063 | 0.075 | 0.128 | 0.056 | 0.054 | 0.035 | 0.072 | 0.352 |
| Gisagara | 0.065 | 0.001 | 0.066 | 0.071 | 0.120 | 0.058 | 0.027 | 0.033 | 0.058 | 0.342 |
| Gatsibo | 0.057 | 0.003 | 0.078 | 0.091 | 0.100 | 0.057 | 0.059 | 0.033 | 0.055 | 0.477 |
| Muhanga | 0.055 | 0.000 | 0.062 | 0.076 | 0.071 | 0.023 | 0.064 | 0.032 | 0.043 | 0.401 |
| Kayanza | 0.065 | 0.000 | 0.079 | 0.078 | 0.094 | 0.101 | 0.047 | 0.032 | 0.053 | 0.429 |
| Nyanza | 0.052 | 0.002 | 0.065 | 0.051 | 0.127 | 0.145 | 0.049 | 0.031 | 0.057 | 0.240 |
| Kirehe | 0.064 | 0.000 | 0.074 | 0.063 | 0.095 | 0.081 | 0.026 | 0.031 | 0.051 | 0.314 |
| Gicumbi | 0.047 | 0.010 | 0.103 | 0.066 | 0.086 | 0.037 | 0.046 | 0.029 | 0.044 | 0.326 |
| Rutsiro | 0.048 | 0.000 | 0.099 | 0.056 | 0.110 | 0.042 | 0.059 | 0.028 | 0.043 | 0.373 |
| Nyamasheke | 0.061 | 0.000 | 0.063 | 0.090 | 0.075 | 0.048 | 0.048 | 0.027 | 0.039 | 0.414 |
| B. Province | | | | | | | | | | |
| Southern | 0.400 | 0.321 | 0.356 | 0.219 | 0.128 | 0.424 | 0.223 | 0.219 | 0.241 | 0.064 |
| Western | 0.411 | 0.328 | 0.350 | 0.267 | 0.114 | 0.388 | 0.234 | 0.212 | 0.273 | 0.072 |
| Northern | 0.415 | 0.281 | 0.346 | 0.227 | 0.118 | 0.398 | 0.236 | 0.199 | 0.272 | 0.073 |
| Eastern | 0.385 | 0.396 | 0.333 | 0.311 | 0.138 | 0.402 | 0.254 | 0.254 | 0.257 | 0.068 |
| C. Area | | | | | | | | | | |
| Urban | 0.380 | 0.299 | 0.373 | 0.342 | 0.106 | 0.313 | 0.216 | 0.249 | 0.357 | 0.075 |
| Semi-urban | 0.391 | 0.327 | 0.339 | 0.267 | 0.123 | 0.388 | 0.211 | 0.235 | 0.280 | 0.061 |
| Rural | 0.404 | 0.338 | 0.346 | 0.253 | 0.126 | 0.410 | 0.240 | 0.220 | 0.252 | 0.069 |
| D. Year | | | | | | | | | | |
| 2006 | 0.331 | 0.366 | 0.283 | 0.603 | 0.154 | 0.421 | 0.339 | 0.253 | 0.208 | 0.043 |
| 2009 | 0.461 | 0.338 | 0.370 | 0.207 | 0.138 | 0.538 | 0.298 | 0.136 | 0.267 | 0.150 |
| 2012 | 0.383 | 0.321 | 0.353 | 0.161 | 0.103 | 0.290 | 0.147 | 0.280 | 0.274 | 0.015 |
| E. Sample | | | | | | | | | | |
| Mean | 0.402 | 0.335 | 0.346 | 0.259 | 0.125 | 0.404 | 0.237 | 0.223 | 0.259 | 0.069 |
| Std Dev | 0.148 | 0.111 | 0.149 | 0.194 | 0.072 | 0.160 | 0.134 | 0.115 | 0.109 | 0.106 |

Table 5. Correlation matrix of changes in index components, n=14,810 obs

| | Household | Community | Education | housing | Nutrition | Farming | Economic | Family | Children | Income |
|------------------|-----------|-----------|-----------|---------|-----------|---------|----------|--------|----------|--------|
| Household | 1.000 | | | | | | | | | |
| Community | 0.012 | 1.000 | | | | | | | | |
| | 0.172 | | | | | | | | | |
| Education | 0.154 | 0.016 | 1.000 | | | | | | | |
| | 0.001 | 0.072 | | | | | | | | |
| Housing | 0.101 | 0.033 | 0.036 | 1.000 | | | | | | |
| | 0.001 | 0.000 | 0.001 | | | | | | | |
| Nutrition | 0.188 | -0.003 | 0.105 | 0.001 | 1.000 | | | | | |
| | 0.001 | 0.731 | 0.001 | 0.922 | | | | | | |
| Farming | 0.123 | -0.009 | 0.036 | -0.004 | 0.591 | 1.000 | | | | |
| | 0.001 | 0.341 | 0.001 | 0.674 | 0.001 | | | | | |
| Economic | 0.031 | 0.011 | 0.069 | 0.049 | 0.097 | 0.091 | 1.000 | | | |
| | 0.001 | 0.222 | 0.001 | 0.001 | 0.001 | 0.001 | | | | |
| Family wellbeing | 0.244 | 0.065 | 0.385 | 0.081 | 0.581 | 0.392 | 0.342 | 1.000 | | |
| | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | | | |
| Child wellbeing | 0.492 | 0.010 | 0.332 | 0.266 | 0.271 | 0.052 | 0.097 | 0.556 | 1.000 | |
| | 0.001 | 0.281 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | | |
| Income | -0.133 | -0.006 | 0.048 | -0.009 | 0.028 | 0.004 | 0.262 | 0.103 | -0.037 | 1.000 |
| | 0.001 | 0.478 | 0.001 | 0.325 | 0.002 | 0.623 | 0.001 | 0.001 | 0.001 | |

Table 6. Summary of percentage changes in all indices by district, province, area and year, n=14,810 obs

| | House hold | Comm unity | Educat ion | Housi ng | Nutriti on | Farmi ng | Econo mic | Famil y wb | Childr en wb | incom e |
|-------------|------------|------------|------------|----------|------------|----------|-----------|------------|--------------|---------|
| A. District | | | | | | | | | | |
| Nyanza | 0.052 | 0.002 | 0.065 | 0.051 | 0.127 | 0.145 | 0.049 | 0.031 | 0.057 | 0.240 |
| Gisagara | 0.065 | 0.001 | 0.066 | 0.071 | 0.120 | 0.058 | 0.027 | 0.033 | 0.058 | 0.342 |
| Nyaruguru | 0.050 | 0.001 | 0.067 | 0.070 | 0.101 | 0.048 | 0.058 | 0.043 | 0.049 | 0.351 |
| Huye | 0.059 | 0.001 | 0.058 | 0.078 | 0.129 | 0.053 | 0.064 | 0.043 | 0.064 | 0.379 |
| Nyamagabe | 0.054 | 0.002 | 0.081 | 0.066 | 0.111 | 0.061 | 0.058 | 0.042 | 0.053 | 0.503 |
| Ruhango | 0.060 | 0.001 | 0.063 | 0.075 | 0.128 | 0.056 | 0.054 | 0.035 | 0.072 | 0.352 |
| Muhanga | 0.055 | 0.000 | 0.062 | 0.076 | 0.071 | 0.023 | 0.064 | 0.032 | 0.043 | 0.401 |
| Kamonyi | 0.051 | 0.001 | 0.055 | 0.072 | 0.100 | 0.068 | 0.081 | 0.038 | 0.054 | 0.493 |
| Karongi | 0.059 | 0.001 | 0.066 | 0.060 | 0.129 | 0.053 | 0.062 | 0.052 | 0.053 | 0.394 |
| Rutsiro | 0.048 | 0.000 | 0.099 | 0.056 | 0.110 | 0.042 | 0.059 | 0.028 | 0.043 | 0.373 |
| Rubavu | 0.056 | 0.002 | 0.068 | 0.078 | 0.189 | 0.230 | 0.054 | 0.055 | 0.029 | 0.311 |
| Nyabihu | 0.057 | 0.000 | 0.061 | 0.073 | 0.200 | 0.212 | 0.043 | 0.062 | 0.056 | 0.258 |
| Ngororero | 0.064 | 0.000 | 0.088 | 0.042 | 0.107 | 0.053 | 0.045 | 0.038 | 0.052 | 0.473 |
| Rusizi | 0.050 | 0.001 | 0.069 | 0.117 | 0.190 | 0.149 | 0.048 | 0.063 | 0.053 | 0.387 |
| Nyamasheke | 0.061 | 0.000 | 0.063 | 0.090 | 0.075 | 0.048 | 0.048 | 0.027 | 0.039 | 0.414 |
| Rulindo | 0.059 | 0.000 | 0.089 | 0.066 | 0.093 | 0.047 | 0.046 | 0.037 | 0.042 | 0.398 |
| Gakenke | 0.052 | 0.000 | 0.083 | 0.061 | 0.079 | 0.009 | 0.059 | 0.041 | 0.047 | 0.470 |
| Musanze | 0.063 | 0.002 | 0.061 | 0.081 | 0.178 | 0.195 | 0.057 | 0.069 | 0.047 | 0.376 |
| Burera | 0.051 | 0.003 | 0.065 | 0.068 | 0.111 | 0.086 | 0.044 | 0.060 | 0.056 | 0.418 |
| Gicumbi | 0.047 | 0.010 | 0.103 | 0.066 | 0.086 | 0.037 | 0.046 | 0.029 | 0.044 | 0.326 |
| Rwamagana | 0.056 | 0.001 | 0.053 | 0.074 | 0.139 | 0.100 | 0.044 | 0.050 | 0.054 | 0.468 |
| Nyagatare | 0.051 | 0.004 | 0.082 | 0.093 | 0.172 | 0.133 | 0.038 | 0.067 | 0.058 | 0.422 |
| Gatsibo | 0.057 | 0.003 | 0.078 | 0.091 | 0.100 | 0.057 | 0.059 | 0.033 | 0.055 | 0.477 |
| Kayanza | 0.065 | 0.000 | 0.079 | 0.078 | 0.094 | 0.101 | 0.047 | 0.032 | 0.053 | 0.429 |
| Kirehe | 0.064 | 0.000 | 0.074 | 0.063 | 0.095 | 0.081 | 0.026 | 0.031 | 0.051 | 0.314 |
| Ngoma | 0.060 | 0.000 | 0.066 | 0.094 | 0.132 | 0.117 | 0.071 | 0.055 | 0.081 | 0.522 |
| Bugesera | 0.056 | 0.001 | 0.060 | 0.076 | 0.143 | 0.091 | 0.054 | 0.049 | 0.068 | 0.496 |
| B. Province | | | | | | | | | | |
| Southern | 0.056 | 0.001 | 0.065 | 0.070 | 0.111 | 0.063 | 0.057 | 0.037 | 0.056 | 0.384 |
| Western | 0.056 | 0.001 | 0.073 | 0.074 | 0.142 | 0.110 | 0.051 | 0.046 | 0.047 | 0.375 |
| Northern | 0.054 | 0.003 | 0.080 | 0.068 | 0.109 | 0.075 | 0.051 | 0.047 | 0.047 | 0.397 |
| Eastern | 0.059 | 0.001 | 0.071 | 0.081 | 0.125 | 0.097 | 0.049 | 0.045 | 0.060 | 0.447 |
| C. Area | | | | | | | | | | |
| Urban | 0.058 | -0.003 | 0.066 | 0.082 | 0.216 | 0.205 | 0.065 | 0.052 | 0.045 | 0.452 |
| Semi-urban | 0.060 | 0.007 | 0.074 | 0.066 | 0.137 | 0.126 | 0.071 | 0.043 | 0.035 | 0.375 |
| Rural | 0.056 | 0.001 | 0.072 | 0.074 | 0.116 | 0.077 | 0.050 | 0.043 | 0.055 | 0.399 |
| D. Year | | | | | | | | | | |
| 2009 | 0.039 | 0.002 | 0.093 | 0.070 | 0.104 | 0.056 | 0.053 | 0.051 | 0.060 | 0.385 |
| 2012 | 0.070 | 0.001 | 0.054 | 0.077 | 0.136 | 0.110 | 0.051 | 0.037 | 0.047 | 0.411 |
| E. Sample | | | | | | | | | | |
| Mean | 0.056 | 0.001 | 0.071 | 0.074 | 0.123 | 0.087 | 0.052 | 0.044 | 0.053 | 0.400 |
| Std Dev | 0.005 | 0.002 | 0.013 | 0.015 | 0.036 | 0.057 | 0.012 | 0.013 | 0.010 | 0.074 |

Table 7A. Determinants of per capita income, n=14,810 obs

| | Model A1 | | Model A2 | | Model A3 | | Model A4 | |
|-----------|----------|---------|----------|---------|----------|---------|----------|---------|
| | Coeff | Std Err |
| Intercept | 9.727a | 0.024 | 9.554a | 0.051 | 9.484a | 0.063 | 8.737a | 0.101 |
| Household | | | -1.562a | 0.072 | | | -1.848a | 0.074 |
| Community | | | 0.556a | 0.098 | | | 0.704a | 0.100 |
| Education | | | 0.963a | 0.066 | | | 0.735a | 0.066 |
| Housing | | | -0.782a | 0.059 | | | 0.448a | 0.097 |
| Nutrition | | | 1.745a | 0.167 | | | 2.156a | 0.192 |
| Farming | | | -0.751a | 0.091 | | | -0.513a | 0.126 |
| Economic | | | 3.367a | 0.095 | | | 3.640a | 0.107 |
| d2009 | | | | | 0.453a | 0.033 | 0.776a | 0.050 |
| d2012 | | | | | -0.177a | 0.029 | 0.899a | 0.060 |
| Family | 1.032a | 0.096 | | | 2.441a | 0.114 | | |
| Suburban | | | | | -0.273a | 0.060 | -0.256a | 0.056 |
| Rural | | | | | -0.270a | 0.050 | -0.380a | 0.047 |
| Western | | | | | 0.192a | 0.027 | 0.223a | 0.026 |
| Northern | | | | | 0.136a | 0.031 | 0.141a | 0.029 |
| Eastern | | | | | 0.100a | 0.029 | 0.024 | 0.028 |
| F-value | 130.360 | | 333.520 | | 92.720 | | 202.790 | |
| R2 adj | 0.009 | | 0.136 | | 0.047 | | 0.160 | |

Notes: Significant at less than 1% (a) and 5% (b) levels of significance. Urban area, Southern province and 2006 are references. Standard errors are corrected for heteroscedasticity.

Table 7B. Determinants of family wellbeing, n=14,810 obs

| | Model B1 | | Model B2 | | Model B3 | | Model B4 | |
|-----------|----------|---------|----------|---------|----------|---------|----------|---------|
| | Coeff | Std Err |
| Intercept | 0.138a | 0.008 | 0.133a | 0.008 | 0.103a | 0.007 | -0.122a | 0.007 |
| Household | | | | | 0.026a | 0.005 | 0.063a | 0.003 |
| Community | | | | | 0.234a | 0.009 | 0.307a | 0.007 |
| Education | | | | | 0.150a | 0.006 | 0.152a | 0.005 |
| Housing | | | | | -0.004 | 0.004 | 0.075a | 0.006 |
| Nutrition | | | | | 1.245a | 0.017 | 0.794a | 0.017 |
| Farming | | | | | -0.506a | 0.008 | -0.032a | 0.008 |
| Economic | | | | | 0.043a | 0.008 | 0.223a | 0.006 |
| d2009 | | | -0.113a | 0.002 | | | -0.074a | 0.003 |
| d2012 | | | 0.033a | 0.003 | | | 0.140a | 0.003 |
| Income | 0.008a | 0.001 | 0.013a | 0.001 | 0.002a | 0.001 | 0.001b | 0.000 |
| Suburban | | | -0.011b | 0.005 | | | -0.023a | 0.003 |
| Rural | | | -0.022a | 0.004 | | | -0.047a | 0.002 |
| Western | | | -0.007a | 0.002 | | | 0.006a | 0.001 |
| Northern | | | -0.014a | 0.002 | | | 0.007a | 0.001 |
| Eastern | | | 0.029a | 0.002 | | | -0.001 | 0.001 |
| | | | | | | | | |
| F-value | 130.360 | | 1088.500 | | 2198.180 | | 3773.350 | |
| R2 adj | 0.009 | | 0.370 | | 0.543 | | 0.793 | |

Notes: Significant at less than 1% (a) and 5% (b) levels of significance. Urban area, Southern province and 2006 are references. Standard errors are corrected for heteroscedasticity.

Table 7C. Determinants of children wellbeing, n=14,810 obs

| | Model C1 | | Model C2 | | Model C3 | | Model C4 | |
|-----------|----------|---------|----------|---------|----------|---------|----------|---------|
| | Coeff | Std Err |
| Intercept | 0.225a | 0.007 | 0.262a | 0.008 | -0.051a | 0.007 | -0.237a | 0.009 |
| Household | | | | | 0.345a | 0.005 | 0.309a | 0.004 |
| Community | | | | | 0.073a | 0.010 | 0.118a | 0.008 |
| Education | | | | | 0.207a | 0.006 | 0.150a | 0.004 |
| Housing | | | | | 0.072a | 0.005 | 0.429a | 0.011 |
| Nutrition | | | | | 0.117a | 0.015 | 0.371a | 0.011 |
| d2009 | | | 0.065a | 0.002 | | | 0.186a | 0.005 |
| d2012 | | | 0.072a | 0.002 | | | 0.256a | 0.006 |
| Income | 0.003a | 0.001 | 0.002a | 0.001 | 0.004a | 0.001 | 0.002a | 0.000 |
| Suburban | | | -0.080a | 0.005 | | | -0.062a | 0.003 |
| Rural | | | -0.115a | 0.005 | | | -0.100a | 0.003 |
| Western | | | 0.041a | 0.002 | | | 0.033a | 0.001 |
| Northern | | | 0.035a | 0.002 | | | 0.037a | 0.002 |
| Eastern | | | 0.031a | 0.002 | | | 0.004a | 0.001 |
| | | | | | | | | |
| F-value | 24.420 | | 363.060 | | 1577.300 | | 2229.720 | |
| R2 adj | 0.002 | | 0.124 | | 0.390 | | 0.662 | |

Notes: Significant at less than 1% (a) and 5% (b) levels of significance. Urban area, Southern province and 2006 are references. Standard errors are corrected for heteroscedasticity.

Figure 1. Family wellbeing level by districts.

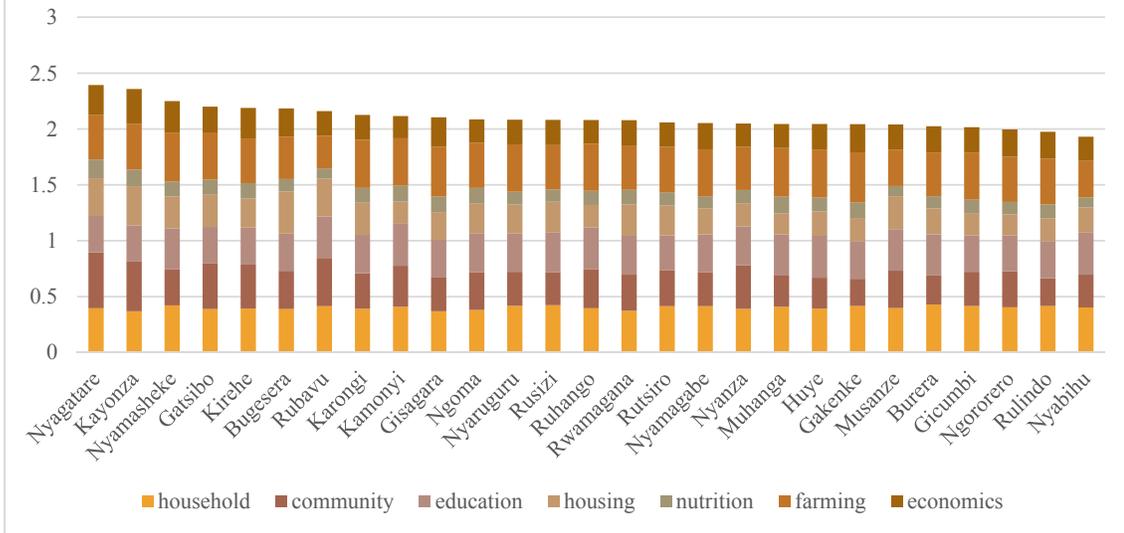


Figure 2. Children wellbeing level by districts.

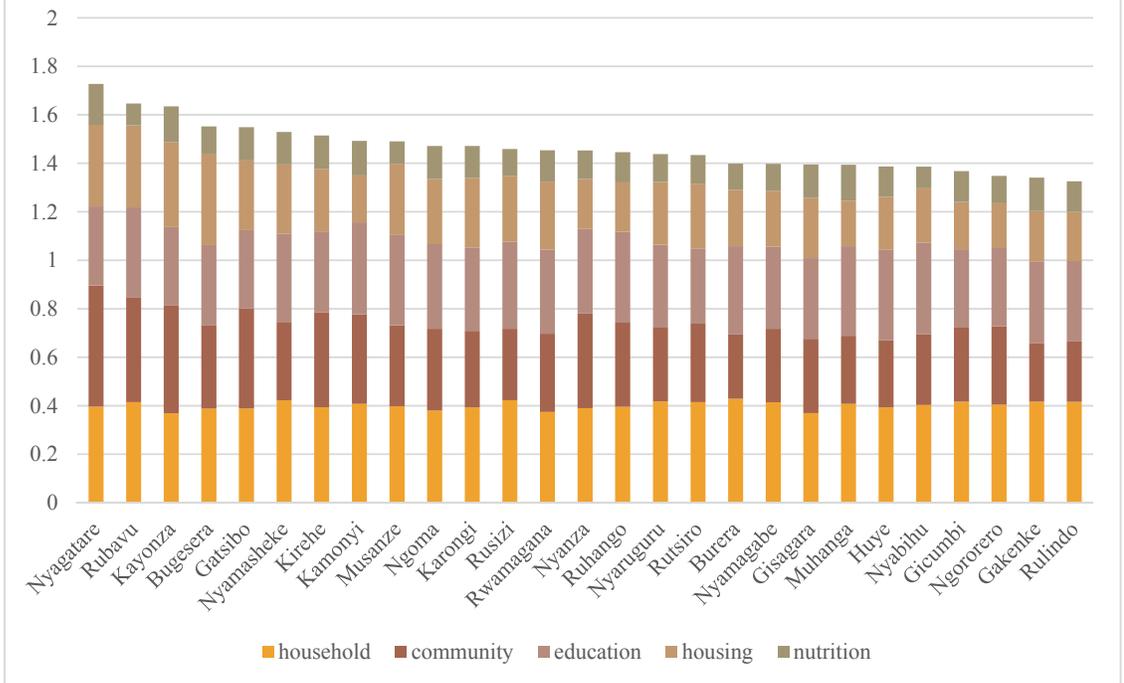


Figure 3. Sum och annual changes in family wellbeing components across districts.

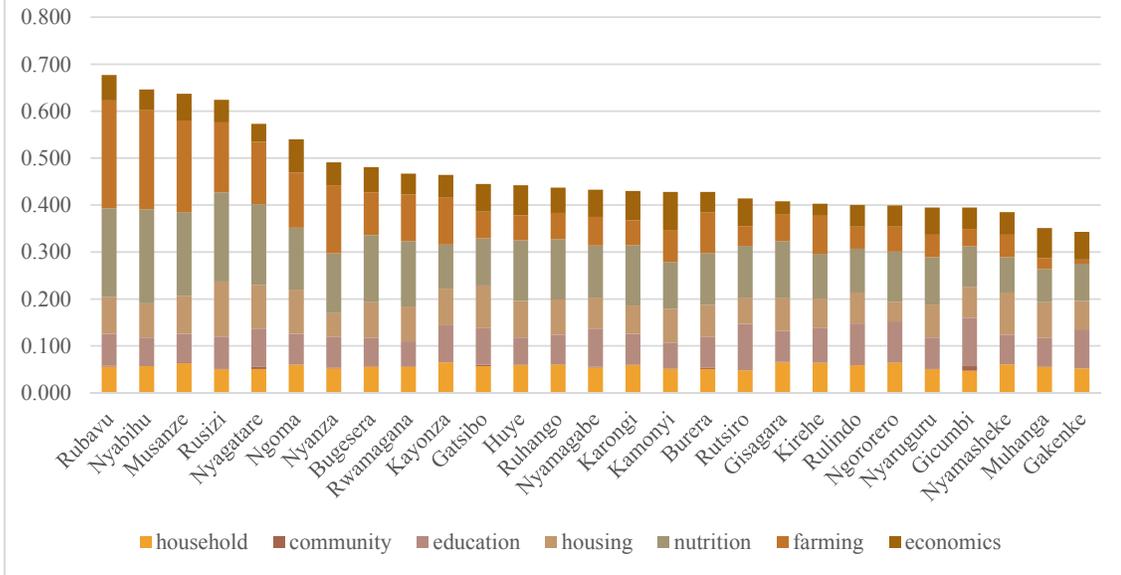


Figure 4. Sum of annual changes in childrens wellbeing components across districts.

