Research Article

Digital and Other Poverties: Exploring the Connection in Four East African Countries

Julian Douglas May
jmay@uwc.ac.za
Professor and Director
Institute for Social Development
University of the Western Cape
Modderdam East Road
Cape Town 7530
South Africa
+27 (0)21 959 2911

Abstract

Although improved access to ICT has been put forward as a possible pathway from poverty, the mechanisms by which this takes place remain unclear. This is due, in part the need to further develop the conceptual and methodological tools necessary for such analysis. This article suggests a way in which indicators of multidimensional poverty can be incorporated into the analysis of access to ICT. Using data from a four countries in East Africa, households without ICT are found to be poorer in all dimensions than those with ICT. A multivariate analysis shows the associations between these dimensions of poverty and ICT access, revealing the importance of human and financial capitals. The use of digital poverty and the inclusion of multidimensional measures of poverty improve the estimation of the predictors of ICT access, and conversely, are likely to be important for future attempts to measure the impact of ICT on poverty reduction.

1. Introduction

There has been a remarkable growth in the use of information and communication technologies (ICT) across the world over the past decade. Writing in 1999, Kirkman commented that half the world's population had never made a telephone call. Within a decade, this had changed dramatically, and instead, more than half the world's population was connected via mobile telephony (ITU, 2008, p. 3). Moreover, despite the persistence of widespread poverty, the use of mobile telephony in Africa countries in the last few years has grown more rapidly than in any other region in the world, suggesting convergence in at least this aspect of development, if not in economic well-being more generally (Chen & Ravallion, 2004; Coyle, 2005; ITU, 2009).

This increase in ICT access has been accompanied by a burgeoning literature on the contribution of ICTs to economic growth, development, and poverty reduction. At the most optimistic, ICTs are described by the African Information Society Initiative (AISI) and others as the means whereby developing countries can use technology to leapfrog development stages or technology barriers to achieve both economic growth and broad-based development (Singh, 1999). Other analysts are cautious about attributing direct benefits to ICTs (Arunachalam, 2002; Bollou & Ngwenyama, 2008). This school of thought is concerned that a one-dimensional push for greater use of ICTs may increase the divide between urban and rural areas, between the rich and the poor, and between generations. Thus, while there may well be a link between ICT and poverty reduction, it is not fully understood. In fact, whatever dimension of welfare change is being considered, the direction of its causal link to ICT is contentious, as is the allocation of the costs and benefits of access to ICT, and the mechanisms through which the connection takes place.

Before these issues can be resolved, better methods are needed for the measurement of relative ICT access and its relationship to other forms of deprivation. This paper contributes to ongoing analysis of the impact of ICT on poverty reduction by developing approaches for the identification and measurement of dimensions of poverty associated with differential access and usage of ICTs. The data used are derived from "Poverty, ICTs in Urban and Rural East Africa" (PICTURE-Africa), a three-year research project funded by the International Centre for Development Research (IDRC), investigating the nexus between different dimensions of poverty and ICT usage in Kenya, Rwanda, Tanzania, and Uganda (May, Dutton, & Mascarenhas, 2010). This study made use of a questionnaire survey of approximately 400 households in each country. The interviews were conducted in 2007, 2008, and again in 2010. As this objective of the present paper is best served by cross-sectional data in which potential problems of sample attrition and measurement error are reduced, only the data from the 2007/2008 wave of interviews are used.

The sampling design involved the purposive selection of census enumerator areas (EAs) as the primary sampling unit, within which households formed the secondary sampling unit and were randomly selected. The purposive selection was based on the identification of the 20 poorest EAs in each country, using data provided by the national statistical offices. At the level of the household, the sample can thus be reasonably described as representative of the poorest regions in the four countries, with the exception of Kenya, in which a bias was introduced by the exclusion of settlements affected by violence in 2007.[1]

2. Background to the Four Countries

There are important differences among the four countries in terms of their socioeconomic and ICT development that must be acknowledged, some of which have been found to be important determinants of ICT access and use (Chinn & Fairlie, 2007). These differences, shown in Table 1, are likely to affect levels of deprivation and ICT access, but should not influence the determinants of usage once a country's fixed effects have been taken in account.

While Rwanda has both a far smaller population and a smaller proportion of its population living in urban areas than the other three countries, it has the highest population density in Africa. Using the HDI, Kenya and Uganda are categorized by United Nations Development Programme (UNDP) as having "medium human development," while Tanzania and Rwanda are categorized as having "low human development." This ranking also applies in terms of another of the UNDP's composite measures of poverty, the HPI-1, and in terms of the US$1 per day poverty line expressed in Purchasing Power Parity (PPP). A number of other differences are apparent, with the most obvious belonging to Rwanda, which fares badly in terms of most measures of well-being, including GDP per capita, adult literacy, and poverty rates, as well as use and access to electricity. As would be anticipated, differences in the ICT indicators are noteworthy, and mostly as expected, Kenya is far better endowed with ICT infrastructure than the other countries and shows the fastest growth in its IDI, a composite measure of ICT status. Still, Tanzania, rather than Rwanda, emerges as being the most deprived country in terms of the composite ICT indicators, despite the prevalence of mobile telephony in this country and its favorable governance index. These indicators conceal a likely ICT bias toward urban areas and a widening digital divide. As Bizimana (2010) observes, 75% of the Internet cafés in Rwanda are located in Kigali, the country's capital city.

3. Digital and Other Poverties

ICTs have been argued to have a broad developmental impact that can potentially bring about a reduction in poverty. Kenny (2002), Flor (2001), and Marker, McNamara, and Wallace (2002) argue that ICTs are powerful tools for empowerment and

1. The sample design and the underlying population structure did result in differences in the percentage of urban households surveyed. Thus, Tanzania has both a larger share of its population living in urban areas and a larger share of its poor EAs located in these areas. The violence in Kenya resulted in the realized sample being disproportionately rural.

Table 1. Socioeconomic Indicators (2007).

Indicators	Kenya	Rwanda	Tanzania	Uganda
Population (in millions) (2005)	35.6	9.2	38.5	28.9
Urban share of population (%)	22.2	18.9	26.4	13.3
Population density (per km^2)	68.6	376.6	46.3	135.4
Human Development Index (HDI)	0.541	0.460	0.530	0.514
Adult literacy rate (% 15 years and above)	73.6	64.9%	72.3%	73.6%
300GDP per capita (PPP US$)	$1,542	$866	$1,208	$1,059
Human Poverty Index-1 (HPI-1)[a]	29.5	32.9	30.0	28.8
Access to electricity (%)	14.0%	3.5%	11.0%	15.0%
Electric power consumption (Kwh per capita)	128	23	80	68
Poverty levels (<PPP US$1 per capita per day)	22.8%	60.3%	52.8%	n/a
Poverty levels (national poverty lines)	52.0%	56.9%	35.7%	37.7%
Gini coefficient	47.7	46.7	34.6	42.6
Ibrahim Governance Index[b]	53.7	48.5	59.2	53.6
Fixed lines (/1,000)	7	2	4	5
Mobiles (/1,000)	302	65	206	136
Hhds with computer (/1,000)	55	3	23	51
Hhds with Internet (/1,000)	22	1	6	1
Internet users (/1,000)	123	21	10	36
ICT Development Index (IDI)[c]	1.62	1.17	1.13	1.21
IDI Rank (of 154 countries)	116	143	145	140
IDI change (2000–2007)	33.9%	18.2%	17.7%	31.5%

Sources: *CIA World Factbook (2009), ITU (2009), MFI (2009), UNDP (2009).*
a. HPI-1 is a composite measure of deprivation used by the UNDP.
b. The Ibrahim Index measures the delivery of public goods and services to citizens by government and nonstate actors.
c. The IDI is calculated by the International Telecommunication Union (ITU). It is a composite index of ICT infrastructure and access, ICT use and intensity of use, and ICT skills and capacity to use ICT.

income generation in developing countries, as well as for increasing access to education and other social services. In an oft-cited example, mobile phone usage among fishers in Kerala has been shown to benefit both producers and consumers through improved information and better functioning markets (Jensen, 2007). Mobile telephones have been found to assist other businesses in the informal economy by helping them attract additional business (Van Dijk & Hacker, 2003). Other studies go further to point out that the role of ICTs is not limited to only promoting growth, but also includes non-income dimensions of development, such as empowerment and security (Gerster & Zimmermann, 2003).

Not all analysts are as sanguine about assuming a positive impact of ICT on poverty reduction. As an example, Arunachalam (2002) argues that ICTs are a necessary but insufficient condition for development and recommends that the focus shift from bridging the digital divide to poverty alleviation. A similar view is held by Kirkman (1999), who notes that, to be useful, any technology must be placed within the local context of capabilities and needs. As Torero and von Braun (2006) conclude in a review paper, ICTs offer an opportunity for poverty reduction, but not a panacea. Rather than being an unqualified benefit to those who are poor, it seems probable that the impact of ICT will be determined by the particular contexts in which these technologies are deployed, the preparedness of the users, and the opportunities that exist for their application. Access to information through ICTs is thus a question not only of connectivity, but also of other deprivations that influence the capability of individuals and communities to access and use these new tools. Indeed, limited access to information and constraints on communication capacity might also represent new dimensions of deprivation, rather than a pathway from poverty (Barrantes, 2007a; Marker et al., 2002).

"Digital poverty" has been coined as a term that begins to take such deprivations into account. Digital poverty has been defined as "the lack of goods and services based on ICTs," and also as a way of taking both connectivity and functionality into account (Barrantes, 2007a, p. 30). Digital poverty thus incorporates a demand dimension (the ICT service cannot be afforded), a capability dimension (the skills to use the service are unavailable), and a supply dimension (the infrastructure to deliver the service is not in place). Finally, the nature and extent of demand for outputs from household livelihood strategies will determine the outcomes that follow, ultimately feeding back to the persistence of digital poverty. Digital poverty (sometimes also referred to as "digital literacy") moves away the dichotomous notion of a "digital divide" in which some have ICT skills and access, while others are deprived of them. Instead, digital poverty can be seen as a continuum, perhaps with a critical threshold akin to a poverty line. While Barrantes (2007a, 2007b) is an influential analyst of digital poverty, other writers have made similar suggestions. In the United States, Wilson, Wallin, and Reiser (2003) discuss the association between social stratification and ICT access, while in Estonia, Pruulmann-Vengerfeldt (2008) talks of "digital stratification" and argues that structural and individual differentiation occurs when accessing ICT. Barja and Gigler (2007, p. 17) provide a theorization of "information and communication poverty," which they suggest refers to "deprivation of the basic capabilities to participate in the information society." This last approach draws attention to the importance of assets and how they are used.

Developing instruments for the measurement of digital poverty is still a wider work in progress. Barrantes (2007a, pp. 6–7) identifies four variables, which she uses to define a digitally poor individual. These are age, as one proxy for human capital; education, as a second human capital proxy; available infrastructure, which includes the physical and institutional structures necessary for the transmission of and access to ICT; and "accomplished functionality," which refers to the uses assigned to the technologies once these are accessed. She then uses these variables to identify four categories of digital poverty or prosperity: extreme digital poverty, in which information is only received; digital poverty, in which information is received and communication is made possible; connected, in which new forms of ICT, such as smart phones and Internet access, are used, but only to receive information or for conventional forms of communication; and digitally wealthy, in which new forms of ICT are actively used for social, legal, economic, and other transactions. Applying this categorization to Peru, Barrantes (2007b, p. 12) classifies households that only have a radio or television as being extremely digitally poor, the digitally poor as also owning a telephone (landline or mobile), the connected as those who may or may not have a telephone, but access the Internet through telecenters, and the digitally wealthy as those who have a computer and Internet connection in their homes. Using a socioeconomic survey undertaken in 2003, Barrantes (ibid., p. 13) finds that the majority of households in Peru (68%) are extremely digitally poor, 8% are digitally poor, 24% are connected (split evenly between those with and without a telephone), and only 0.4% are digitally wealthy. She also finds that the digitally poor are not necessarily the economically poor, and that the two strongest predictors of improved digital poverty status are a household composition that includes fewer children, and better supply-side conditions, including access to electricity and Internet infrastructure. In a preliminary attempt to undertake similar analyses for Mexico, Peru, and Colombia, Gutiérrez and Gamboa (2010) construct indices of digital access and digital literacy, but they stop short of developing a typology of deprivation based on these. Nonetheless, they do report education and income as being important in explaining variation in both of their indices.

An alternate point of departure for an analysis of this ICT/poverty nexus is the sustainable livelihoods (SL) framework, which brings together a multidimensional approach to poverty with the assets and activities adopted by households in order to obtain the resources that they need. The SL framework offers a coherent and widely understood approach, and it can be readily extended to take account of markets, institutions, and technologies (Carney, 1999; Chambers & Conway, 1992; Dorward, Poole, Morrison, Kydd, & Urey, 2003; Hussein, 2002; Moser, 1998). The SL framework has also been shown to have relevance to studies concerned with

Table 2. Proxies of Multidimensional Poverty.

Dimension	Proxy	Unit
Financial	Per capita monthly expenditure normalized to the poverty line	Multiples of the poverty line
Economic	Assets	Index based on the number of durable assets owned by the household plus whether livestock are owned
Physical	Access to services and housing	Index based on number of services and housing attributes
Human	Formal education	Index based on whether at least one resident adult has completed secondary education
Social	Participation in local institutions	Index of group membership and participation in local decision making structures
Digital	Access to, and use of ICT	Index based on the type of ICT used by household members

the impact of ICT (Chapman & Slaymaker, 2002; Marker et al., 2002). Moreover, following other studies that adopt the SL framework, it is possible to make use of the notion of a fivefold asset portfolio developed by Moser (1998) and, in so doing, to take account of a capabilities dimension as recommended by Barja and Gigler (2007).

The data collected by PICTURE-Africa permit the measurement of these five interrelated capitals using proxy indicators for each, with digital poverty introduced as an additional dimension. These dimensions and their proxies are summarized in Table 3.

Despite its recognized limitations, the most widely used measure of poverty refers to the flows of income or expenditure that constitute access to financial capital. For this article, these financial flows are measured using monthly per capita expenditure (PCE), and deprivation is conceptualized as the inability to attain an absolute minimum standard of living using a minimum income line that separates the poor from the nonpoor (Ravallion, 1995). A poverty score is calculated derived from monthly household per capita cash expenditure, plus the imputed value of the consumption of home production, normalized to a poverty line. To adjust for cost-of-living differences in the four countries, all incomes and expenditures have been converted to U.S. dollars in 2005 values, adjusting for Purchasing Power Parity (PPP).[2] Further, due to the methodological differences in calculating the national poverty lines that are used in each country, the international poverty line of PPP$2.50 per capita per day has been used to ensure that the data are comparable when combined. This score ranges from 0.06 (each month, the household spends 6% of what its members require in order to subsist) to the maximum, 21 (each month, the household spends 21 times what its members require to subsist).

Financial flows are structurally dependent upon the availability of economic capital and the stock of productive assets that can be combined and used to generate an income. Deprivation in this form of capital is sometimes referred to as asset, or structural, poverty, and it can result in the persistence of poverty over time or poverty traps, preventing the escape from poverty (Carter & Barrett, 2006; Carter & May, 2001; Reardon & Vosti, 1995). The indicator used will be the number of different assets owned by each household.[3] This ranges between 0 (no assets) and 5 (the maximum possible).

Physical capital reflects access to essential services and housing, and it is largely derived from a basic needs approach to development. The proxy for deprivation in this dimension uses indicators concerning home structures and the services that these structures provide (Alampay, 2006). Following Fiadzo, Houston, and Godwin (2001), as well as De Vos (2005) and other analysts concerned with the

2. The most recent round of PPP price data was collected in 2005 by the International Comparison Program (ICP, 2008). See http://siteresources.worldbank.org/ICPEXT/Resources/ICP_2011.html for details concerning methodology and application.

3. Financial and economic capital are weakly correlated (Pearson's correlation coefficient = 0.344). The assets included are refrigerator, electric or gas stove, lounge suite, motor vehicle, and any large livestock. ICT assets are excluded.

measurement of quality-of-life indicators, principal components and factor analysis are not used to develop this services index. Instead, an approach is adopted that theorizes a structural relationship between the components of each of the unidimensional measures of housing quality. The variables used are selected by assessing their intercorrelations and item-rest correlations, and then by calculating a reliability statistic, Cronbach's α. The higher the α, the higher the correlation between the observed value and the true value. Components that increase α when excluded can be assumed to be measuring other dimensions of deprivation and should dropped from the index. Cronbach's α is also used to assess the reliability of the model, and measures of 0.80 and above are regarded as strong (Arias & De Vos, 1996).[4] In this case $\alpha = 0.674$, which is adequate. This score ranges from 0 (the dwelling is constructed of impermanent materials, and no services are provided) to 4 (the dwelling is constructed of permanent materials, and all services are provided).

Human capital contributes to the reduction many other forms of poverty. Within the context of ICT, deprivation in human capital focuses on skills and knowledge (Alampay, 2006). At the household level, the proxy for this dimension of poverty is the presence of at least one resident household member who has completed secondary education. This is a binary variable; 0 means that no member of the household has a secondary education, and 1 means that at least one adult has completed a secondary education. The educational attainment of each person is used for analysis undertaken at the level of individuals, and the data permit only five categories: no education, completed primary, completed secondary, completed basic tertiary (degrees and diplomas), and completed advanced tertiary (postgraduate qualifications).

Recent literature emphasizes the impact of social capital on the persistence of poverty in developing countries (Baron, Field, & Schuller, 2000; Woolcock & Narayan, 2000). Usually encompassing the social networks and interactions available to individuals, households, and communities, social capital is included by Moser in the fivefold asset portfolio. Although subject to a robust critique (Fine, 2010), and sometimes dismissed as a "slippery concept" (Fine, 2003), for the purposes of this study, the groups to which a randomly selected adult household member belongs, and also their participation in local meetings, are used as proxies, mindful of both the theoretical and empirical constraints associated with this concept.[5] Summing this participation yields a less satisfactory, but still adequate, Cronbach's α of 0.633. This score ranges from 0 (no participation) to 8 (maximum participation).

Barrantes' methodology is followed for the construction of a proxy for digital poverty, with some adaptation, as necessary for the East African context. The "extreme digitally poor" are households that lack access to any form of ICT; that is, they do not have the means to receive voice communication (radio/TV and TV accessories), send voice communication (landline/mobile), send electronic communication (SMS/e-mail), or interactively engage with information (broadband Internet access). The "digitally poor" are able to receive voice information only; the "connected" are those able to receive and send voice communication, and the "digitally wealthy" are those able to send digital communication and interact with digital information.[6] A similar approach is used at the individual level, grouping

4. The components that maximize α are the following: bricks or blocks being used for walls, floors that are cement or cement plus a covering, access to electricity, access to a protected water source, and access to a flush or improved (VIP) toilet.

5. As an example, membership in religious groups is negatively correlated to all other forms of participation, as well as to ICT access, but is highly correlated with financial capital. In this instance, membership is more likely a result of higher incomes, rather than its cause. The same can be said of savings and producer groups, as well as Internet groups which are also correlated with ICT access, the dependent variable of interest to this paper. Other analysts have reached similar conclusions when making use of proxies for social capital (Haddad & Maluccio, 2003; Maluccio, Haddad, & May, 2000), and they have chosen to exclude these categories of membership when constructing social capital proxies. Social capital also overlaps strongly with other concepts concerned with the value of networks, including social exclusion and social connectedness (Coleman, 1988; Saith, 2001). Nonetheless, to remain consistent with the SL approach, I include this proxy for completeness, but exclude membership in religious, savings, and Internet groups which reduce α if included. Robustness checks confirm that including membership of the excluded groups does not change the overall results, but does introduce undesirable collinearities, weakening the models used in this paper.

6. Barrantes' definition of the "digitally wealthy" category is not adopted, since access to landlines and ownership of

Table 3.Descriptive Statistics of the Dimensions of Poverty.[a]

Indicator	Not poor	Poor	ICT access	No ICT access	All
Financial	2.45 *(0.08)*	0.57 *(0.08)*	1.73 *(0.06)*	0.88 *(0.04)*	1.41 *(0.04)*
Economic	1.65 *(0.04)*	1.19 *(0.04)*	1.59 *(0.03)*	1.02 *(0.04)*	1.40 *(0.03)*
Physical	3.72 *(0.05)*	2.46 *(0.05)*	3.41 *(0.05)*	2.29 *(0.05)*	2.33 *(0.05)*
Human	0.63 *(0.02)*	0.40 *(0.02)*	0.67 *(0.01)*	0.49 *(0.01)*	0.51 *(0.01)*
Social	0.51 *(0.03)*	0.35 *(0.02)*	0.49 (0.02)	0.45 (0.02)	0.42 *(0.02)*
0Vulnerability	1.29 *(0.02)*	1.23 *(0.02)*	1.32 (0.02)	1.20 (0.02)	1.25 *(0.02)*
PCE (PPP$)	186.57 *(6.19)*	43.34 *(0.63)*	131.89 (6.29)	66.84 (2.96)	106.89 *(3.33)*
n = 1,508					

a. Due to incomplete expenditure data, the sample size for financial capital and PCE is reduced and n = 1476.

radios, TVs, and TV accessories as ICTs that allow voice communications to be received; land lines and mobiles as ICTs that allow voice communications to be sent; and computers, Internet connections, and e-mail addresses that allow digital interactions.

Finally, the SL framework recognizes the importance of unexpected shocks that might affect both the availability of these capitals and the ways in which they might be used (Chambers, 1995; Davies, 1996). This is included in the discussion, since poor households are especially vulnerable to events that result in a loss of income or assets. The proxy for this dimension is the reciprocal of the number of negative shocks experienced by the household in the two years prior to the survey. Thus, this score ranges from 0.17 (the household experienced six shocks in the previous two years) to 2 (the household experienced no shocks in the previous two years).

The intersection between the measures of multidimensional poverty and the international poverty line, which categorizes households into those receiving above and below PPP$2.50 per person per day is a useful way of showing the descriptive results for each of these proxies, as is household access to new forms of ICT in the form of mobile phones, e-mail accounts, and the Internet. Recall that each dimension is measured as a score, rather than as a percentage of households with the attribute being investigated, with low scores reflecting higher deprivation. Per capita expenditure per month (PCE) in 2005 PPP$ is included in Table 3 for comparison, and the mean and standard error of the mean (in italics) are reported.

Money-metric poverty intersects with all the other indicators of poverty, with those below the poverty line being more likely to have experienced shocks in the 24 months prior to the survey, less likely to belong to groups or participate in decision making, as well has having fewer assets, lower incomes, fewer educated adult household members, and a lower level of service provision. The difference in means is statistically significant at the 99% confidence level between poor and nonpoor for all dimensions other than social groups and vulnerability, and the indicators are weakly correlated, confirming that they represent different dimensions of deprivation and should be separately included in the multivariate analysis of the ICT/poverty nexus that follows.[7] The dimensions also differ between households that have access to mobile phones, e-mail addresses, and the Internet, and those that do not, with the latter group poorer in all dimensions and also marginally more prone to shocks. Once again, these differences are significant at the 99% confidence level, with the exception of social capital and vulnerability, although the latter does meet the 95% confidence level.

computers are extremely limited in East Africa. Further, many mobile telephones can now be used for digital transactions, suggesting a dilution of the importance of a computer and Internet connection at home.

7. Levene's test for equality of variance and the T-test for equality of means confirms that the means and distribution of poor and nonpoor households are statistically different at the 99% confidence level for all indicators other than social capital and vulnerability, the latter of which does not pass Levene's test. Financial and physical capital are moderately correlated (Pearson's correlation = 0.447). All further testing of the descriptive results make use of both Levene's and the T-test, and only confidence levels are reported.

Table 4. ICT Ownership of Households by Country (%).

ICT	Tanzania	Kenya	Rwanda	Uganda	All
Radio	66.7	79.2	73.9	61.2	70.2
TV	23.7	39.1	23.8	9.6	24.0
VCR/DVD	12.0	19.6	16.9	4.3	13.1
Landline	1.8	0.5	2.9	0.8	1.5
Computer	1.8	1.8	9.5	1.3	3.5
Internet connection	0.3	0.8	2.1	0.0	0.8
E-mail address	5.1	16.5	29.2	22.5	18.2
Mobile phone	54.2	67.7	55.7	68.8	61.7
Any ICT	78.8	88.6	81.5	87.4	84.0
Electricity	30.3	32.1	34.8	13.8	27.6
n = 1508					

4. Access to ICT

Attention can now be turned to access to ICTs. Table 4 shows ownership of the forms of ICT for which information was collected in the four countries. The table includes access to electricity either from the grid or a generator.

As might be expected, given the higher incomes and indicators of development, access to most ICTs is highest in Kenya, with some striking exceptions. In the case of Internet connections, computers, landlines, and the use of an e-mail address, households in Rwanda are better endowed than Kenya, suggesting better penetration of newer forms of ICT in this country. Households in Tanzania have the lowest access to ICT, with 21% having no form of ICT at all. Radios are the most commonly owned ICT in all four countries, ranging from almost 80% in Kenya to 61% in Uganda, and they are thus an important mode of communication in the region. This is followed by mobile phone ownership; mobiles are almost as widely available as radios, ranging from 69% of households in Uganda to 54% in Tanzania. Households own an average of 1.9 ICTs, with just 16% owning no form of ICT at all. Finally, access to electricity is low in all countries, with only 14% of households in Uganda having an electricity supply. All differences noted among countries are statistically different at the 95% level of confidence.

These results suggest that that the most frequent combination of ICTs through which information is transmitted is likely to be radio/mobile transfers. They also point to a noteworthy dominance of e-mail access over household Internet connections, probably reflecting the use of telecenters (also reported by Barrantes, 2007b). The very low percentage of households with a landline is indicative of a major constraint to the delivery of privately owned Internet access through conventional technologies common to most countries in Africa. Access to an electricity connection is a further constraint for all forms of ICT.

Access to some ICTs is strongly related to financial poverty status, as well as to geographic location, as is shown in Table 5.

Households whose expenditure lies below the poverty line are less likely to have access to any of the listed ICTs, including comparatively well-established and less costly items, such as radios. Just fewer than half of poor households have at least one phone or SIM card available in the household, compared to 77% of nonpoor households, while 61% own radios, compared to the nonpoor category, in which 81% of households own a radio. No financially poor households own a computer, landline, or have Internet access in their homes. Not surprisingly, households in urban areas are better endowed with ICT assets than rural areas, even in terms of the ubiquitous radio, where 76% of urban households own a radio, compared to 65% of rural households. The gap between the urban and rural in terms mobile phones is noteworthy, with phone ownership in the former being as widespread as radio ownership, but only 50% of rural households

Table 5. ICT Ownership of Households by Financial Poverty Status and Geolocation (%).

ICT	Not poor	Poor	Urban	Rural
Radio	81.4	61.1	76.3	65.3
TV	43.8	6.4	39.3	11.6
VCR/DVD	24.9	2.6	23.4	4.8
Landline	3.2	0.0	2.8	0.4
Computer	7.8	0.0	7.1	0.6
Internet connection	1.7	0.0	1.6	0.1
E-mail address	26.2	11.5	26.6	11.3
Mobile phone	77.2	48.5	75.5	50.1
Any ICT	92.9	76.7	91.1	78.2
Electricity	50.1	8.7	49.5	9.6
n =		1,476		1,508

have access to a mobile phone. Finally, access to an e-mail address in urban areas is worth mentioning at 27% of households. All differences reported are statistically significant at the 99% confidence level.

Overall, the results are indicative of a "digital divide" between urban and rural areas that is striking, given that as high as 31% of the urban group is categorized as being poor. This suggests that spatial location may be a more important influence on access to ICT than financial status. If so, managing this divide would require an innovative combination of conventional (e.g., radio) and new (e.g., mobile) technologies, as well as improved access to infrastructure, including electricity, in addition to solutions for the various constraints relating to affordability.

The data permit a similar descriptive analysis for individual access to mobile phones and e-mail addresses.[8] More than one-third of adults older than 15 years of age for whom information was reported have a mobile/SIM (37%), while only 10.4% were reported to have an e-mail address. Ownership of these forms of ICT access is highly correlated, with 88% of those who have an e-mail account also having a mobile/SIM. The influence of gender on ICT ownership is apparent. Overall, 43% of adult men own a mobile phone, compared to 33% of women, and 13% of men have an e-mail account, compared to 8% of women.[9] Access is also differently affected by age, as is shown in Table 5.

The percentage in each age group that has access to a mobile phone quickly increases after 15 years of age, peaking at just below 60% by 30 years of age. Interestingly, and in contrast to other studies that have shown age to be an important factor in determining access, this peak persists until 55 years of age, and only then drops, showing widespread access to mobile phones throughout most of the individual life cycle. The prevalence of e-mail access is far lower; it peaks in the 25–29 year age group, with around 10% of all other age groups having an e-mail address. However, there are marked gender differences in the ownership of both forms of ICT at all age groups, particularly in respect to mobile phones. A smaller percentage of women have ownership at all age groups, and the fall-off in

8. These data are drawn from the household roster and thus are representative of adults in poor EAs in the four countries. Information was obtained from the main respondent who was asked to report on the ownership status of other household members. These data were provided for 98% of all adults (4,799 out of a possible 4,871 adults), but respondent error is possible and ownership may be underreported, especially in the case of e-mail addresses. The results obtained for mobile phones are similar for those from a subsample of adults who were interviewed directly concerning their ICT access and use, but substantially different for e-mail access. In the case of the latter, 59% of the subsample reported access to a free personal e-mail account, subscription personal e-mail account, or a work account. It should be noted, though, that this subsample refers to those present at the time of the interview and is thus not necessarily representative of all adults.

9. These differences are statistically significant at the 99% confidence level.

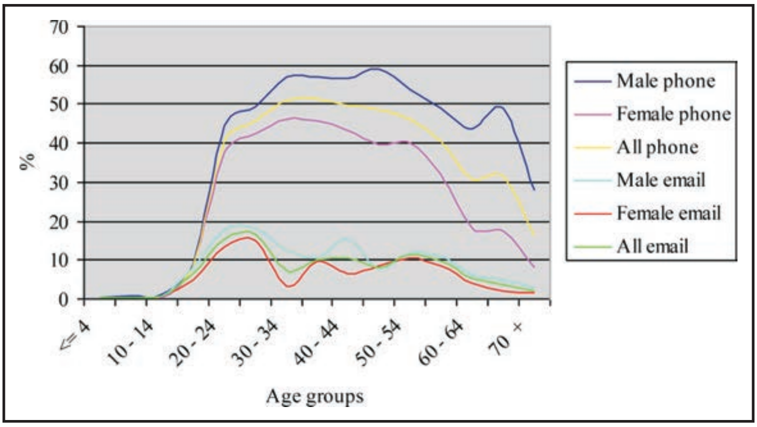

Figure 1. Age/Sex Distribution and Individual ICT Access.

This produces the profile of digital poverty shown in Table 6.

Just over 37% of the total population either have no access to any form of digital ICT, or have access only to ICT assets for the reception of communication (radios/TVs), a proportion almost half of what was found by Barrantes in Peru in 2003. A further 44% are connected and able to send voice communications, while 19% are digitally wealthy and able to interact with the information source. This latter categorization differs from that used by Barrantes, in that I include those who attain this digital wealth by way of telecenter access. If this were to be restricted to Internet access at home, this proportion would fall to less than 1%, as was the case in Peru. Digital poverty is most extreme in Tanzania, followed by Rwanda, although this country also has the highest percentage of its population who are digitally wealthy. This suggests that, in Rwanda, connectedness is rapidly converted into interactive communication, and that digital inequality may be related to financial inequality. All differences reported are statistically significant at the 99% confidence level.

ownership starts at a younger age for women. As a result, while only 18% of women in the cohort 60–64 years of age have a mobile phone/SIM, 44% of men in the same age group have a phone. These differences are statistically different at the 95% confidence level.

Education has been found to be another important factor affecting access to ICT, and both e-mail and mobile access increases dramatically as education increases. Almost 90% of those with tertiary education have a mobile phone or SIM card, and 71% of this group has e-mail access. Although tertiary education appears to be a critical threshold for graduation into e-mail access, it is noteworthy that those who have completed secondary school education are five times more likely to have an e-mail account than those with only primary schooling, and twice as likely to have a mobile phone. Even gaining a primary school education improves the likelihood of gaining access to a mobile phone, and those who have completed primary school are three times more likely to have a mobile than those who have no education at all. These differences are statistically significant at the 99% confidence level, confirming educational attainment as being of critical importance for ICT access.

The analysis presented thus far points to the presence of considerable and differentiated digital poverty in the sampled households. The first step in confirming this is to explore the combinations of ICT access observed in the PICTURE-Africa data following the methodology adopted by Barrantes (2007b).

Digital poverty also varies according to poverty status and geolocation, and

Table 7 shows that households in rural areas are far more likely to have no access to ICT or to be digitally poor, while over one-quarter of those in urban areas are digitally wealthy.

In contrast to the findings of Barrantes (2007b), here, financial poverty overlaps substantially with digital poverty. Only 7% of the financially nonpoor lack any access to ICT, and 78% are connected or are digitally wealthy. In contrast, 51% of the financially poor either have no access to ICT at all or are digitally poor. Although it cannot be argued that financial poverty is a cause or a consequence of digital poverty, it is evident that a strong association exists between these different forms of deprivation in East Africa. Similar patterns are repeated in terms of geographic location, with digital poverty being much higher in rural areas, although the relatively high proportion of connected households in rural

Table 6.
Digital Poverty of Households by Country (%).

Digital Poverty Status	Tanzania	Kenya	Rwanda	Uganda	All
No ICT	21.1	12.0	18.5	12.6	16.0
Digitally poor	24.4	19.6	25.5	17.4	21.4
Connected	48.6	52.9	26.9	48.9	44.0
Digitally wealthy	5.9	15.5	30.1	23.2	18.6
n = 1,508					

Table 7.
Digital Poverty Status of Households by Financial Poverty Status and Geolocation (%).

ICT	Not poor	Poor	Urban	Rural
No ICT	7.0	23.4	9.1	21.6
Digitally poor	14.7	27.4	14.6	27.1
Connected	50.8	38.0	48.8	40.1
Digitally wealthy	27.5	11.3	27.5	11.3
n =		1,473		1,508

areas is noteworthy and indicative of improved ICT penetration, largely emanating from access to mobile telephony. All differences reported are statistically significant at the 99% confidence level.

4.1 Predictors of Access to ICT

Along with control variables such as country, geospatial location, sex of household head, household size, and the reciprocal of the number of shocks experienced in the two years prior to the survey, the dimensions described can now be used as independent or predictor variables in a binary logistic regression to estimate the likelihood of household ICT access. This is defined here as being connected or being digitally wealthy (having a mobile phone, computer, or e-mail address), and the results are shown in Table 8.[10] Two models are presented: The first includes financial poverty as the predictor of interest, and the second includes all the multidimensional measures of deprivation discussed above. Exponentiating the coefficients produces odds ratios (ORs), which are a helpful way of interpreting the results. ORs in bold signify statistical significance at the 99% confidence level.

The first point to note is that including the additional dimensions of deprivation improves the model, evidenced by the increase in the log likelihood ratio, as do the Wald chi^2 and pseudo r^2. This is confirmed by the likelihood ratio test, which confirms that including the four additional dimensions of poverty results in a statistically significant improvement in model fit.[11]

Controlling for the potential confounders, two dimensions are not statistically significant in terms of improving access to mobile phones, the Internet, and e-mail: economic capital and social capital. However, even using the coarse-grained proxy for human capital possible with this data, human capital is almost as important as financial capital; the odds of gaining access to ICT are increased fivefold by a unit increase in the logged poverty score, and four times by a unit increase in access to a household member with secondary education. Improvements in

10. The log of the poverty score (PCE normalized by the poverty line) has been used for the income predictor due to the presence of some extreme values. As there are no households with zero expenditures, no further adjustment is necessary.
11. LR chi^2 (4) = 158.19, Prob > chi^2 = 0.0000.

Table 8. Predictors of Household ICT Access.

	Odds ratio	95% conf. interval		Odds ratio	95% conf. interval	
Predictors	**Model 1**			**Model 2**		
Financial	**14.560**	9.321	22.746	**5.160**	3.108	8.568
Economic				1.116	0.951	1.309
Physical				**1.401**	1.235	1.589
Human				**4.125**	3.078	5.528
Social				1.163	0.936	1.446
Vulnerability	**1.598**	1.304	1.958	**1.519**	1.221	1.891
Urban location	**2.730**	2.053	3.631	**1.910**	1.396	2.614
Household size	**1.453**	1.349	1.565	**1.306**	1.208	1.411
Kenya	**3.015**	2.073	4.384	**3.467**	2.122	5.665
Rwanda	**1.372**	0.973	1.934	1.125	0.768	1.649
Uganda	**4.466**	3.068	6.501	**2.280**	1.518	3.248
Sex of HH head	0.882	0.662	1.176	0.847	0.622	1.152
n	1,470			1,470		
Log likelihood	757.19			−678.09		
Wald chi^2	284.36			366.72		
Prob > chi^2	0.000			0.000		
Pseudo r^2	0.225			0.306		

the quality of housing are also important, increasing the odds of access to these forms of ICT by 1.4. The odds of having ICT in urban areas are almost twice those in rural settlements, while exposure to fewer shocks reduces the odds of ICT access. Excluding the *country-fixed effects,* this does not change the sign or significance of any of the predictors, but it does increase the contribution to the model that is made by variation in financial capital. This reflects the differences in the prevalence of poverty in the four countries reported in Table 1.[12]

The predictors of individual ICT access can be estimated following the same procedure already used at the household level, although individual characteristics of age, sex, formal educational achievement reflecting the number of years of education completed, and individual earnings can be included, in addition to the household measures of poverty already used. The results of the binary logistic regression are shown in Table 9, which considers only adults older than 15 years of age.[13] Three models are shown: The first includes only household financial poverty (household per capita expenditure) and excludes the additional dimensions of poverty and individual earnings, the second includes individual earnings, and the last adds in the proxies for multidimensional poverty. ORs in bold are statistically significant at the 99% confidence level.

Model 1 reveals the impact of purely demographic factors and confirms the importance of gender and education in influencing individual access to ICT. Adult men are 1.4 times more likely than women to have a mobile phone, e-mail address, or Internet access, while an additional unit of education increases the odds of ICT access by 1.2. While age is statistically significant, the overall impact is

12. The Wald chi square for the income predictor more than doubles to 35.380, while the odds ratio increases to 3.2.
13. As there are both zero incomes and extreme values, individual earnings have been logged after adding a small constant ($0.01) to the earnings of all individuals. This prevents the loss of any data in the log transformation by marginally adjusting the origin of the log curve, but not its shape. Since the zeros are known to be true values and do not reflect missing data, this should not introduce error. Further, the square of age is used to manage the known curvilinear relationship between age and income and the similar relationship that has been suggested by Barrantes for age and ICT access.

Table 9. Predictors of Individual ICT Access.

Predictors	Odds ratio	95% conf. interval		Odds ratio	95% conf. interval		Odds ratio	95% conf. interval	
	Model 1			Model 2			Model 3		
Financial	**3.552**	2.866	4.403	3.613	2.881	4.532	**2.584**	1.990	3.357
Economic							1.035	0.957	1.120
Physical							**1.188**	1.107	1.275
Human							1.020	0.842	1.234
Social							1.076	0.958	1.209
Vulnerability	**1.321**	1.182	1.477	**1.344**	1.197	1.508	**1.310**	1.165	1.473
Urban location	**1.946**	1.656	2.286	**2.058**	1.739	2.435	**1.804**	1.504	2.162
Household size	**1.048**	1.021	1.075	**1.072**	1.042	1.103	**1.055**	1.023	1.087
Kenya	**2.076**	1.649	2.613	**2.457**	1.926	3.134	**2.800**	2.157	3.635
Rwanda	**1.717**	1.395	2.115	**1.915**	1.535	2.389	**1.793**	1.434	2.241
Uganda	**2.160**	1.767	2.641	**1.343**	1.080	1.670	**1.353**	1.076	1.700
Sex of HH head	1.002	0.849	1.182	1.009	0.848	1.201	1.017	0.853	1.211
Age	**0.999**	0.998	1.000	**0.999**	0.998	1.000	**0.999**	0.998	1.000
Sex	**1.420**	1.236	1.631	**1.231**	1.064	1.424	**1.260**	1.088	1.459
Ind. HK	**1.222**	1.201	1.244	**1.233**	1.211	1.256	**1.224**	1.198	1.251
Ind. earnings				**1.240**	1.204	1.278	**1.242**	1.205	1.280
n	4,780			4,596			4,596		
Log likelihood	−2495.3			−2289.4			−2275.4		
Wald chi^2	1,025.39			983.56			999.36		
aautoProb > chi^2	0.000			0.000			0.000		
Pseudo r^2	0.211			0.245			0.249		

almost linear, with each additional year resulting in a modest decline in the odds of ICT access. Including individual earnings confirms that part of this gendered result is due to the lower earnings received by women, as well as their lower participation in wage labor or self-employment. Nonetheless, sex remains a statistically significant predictor of ICT access when controlling for earnings, suggesting that factors other than earning power constrain the access of women to ICT. Introducing household-level indicators of multidimensional poverty reveals similar effects on individual access to ICT, as is the case for the household as a whole, but only the proxy for physical poverty is statistically significant. This suggests that individual attributes of education are more important than the presence of educated household members, and that the stock of economic assets possessed by a household has little impact on ICT access. The likelihoods ratio test and Wald chi^2 show that the inclusion of additional dimensions of poverty only modestly improves the strength of the model.[14]

A similar analysis can be performed for households using digital poverty as the dependent variable. In this instance, an ordered (also known as an ordinal) logistic regression is used, as the dependent variable has four or more categories; these can be ordered from digitally poor to connected. The results are shown in Table 10, and as before, ORs in bold signify statistical significance at the 99% level.

The log likelihood ratio, likelihood ratio test, and Wald chi^2 confirm that the predictors do contribute to explaining variation in digital poverty, and that the inclusion of the additional dimensions of poverty

14. LR chi^2 (4) = 28.09, Prob > chi^2 = 0.0000.

Table 10. Predictors of Household Digital Poverty.

	Odds ratio	95% conf. interval		Odds ratio	95% conf. interval	
Predictors	**Model 1**			**Model 2**		
Financial	**13.814**	9.811	19.450	**4.702**	3.194	6.924
Economic				**1.294**	1.144	1.463
Physical				**1.307**	1.192	1.434
Human				**3.616**	2.811	4.649
Social				1.065	0.915	1.239
Vulnerability	**1.445**	1.229	1.700	**1.361**	1.152	1.607
Urban location	**2.313**	1.840	2.909	**1.736**	1.364	2.208
Household size	**1.361**	1.296	1.430	**1.221**	1.161	1.285
aspnumKenya	**2.696**	2.045	3.554	**2.821**	2.042	3.898
Rwanda	**2.461**	1.878	3.224	**2.298**	1.735	3.044
Uganda	**4.740**	3.520	6.383	**2.824**	2.092	3.892
Sex of HH head	0.980	0.776	1.238	1.02	0.802	1.297
Thresholds						
Digitally poor	1.005	0.642	1.368	1.761	1.327	2.186
Connected	2.492	2.121	2.864	3.385	2.937	3.834
Digitally wealthy	5.107	4.669	5.545	6.330	5.802	6.858
n	1,470			1,470		
Log likelihood	−1,624.64			−1,519.69		
Wald chi^2	493.44			657.44		
Prob > chi^2	0.000			0.000		
Pseudo r^2	0.149			0.204		

does strengthen the model.[15] Although the psuedo r^2 statistic does not indicate the proportion of variance for the response variable explained by the predictors, and as such, should be interpreted with caution, the test also suggests that the model retains predictive power using the categorical proxy for digital poverty. The thresholds indicate the estimated cut-offs of the latent variable used to differentiate the digitally poor from the connected and the digitally wealthy when values of the predictor variables are evaluated at zero.

With the exception of social capital and the sex of the household head, the coefficients of the predictors are all significant at the 99% confidence level in both models. In terms of the survey location, changing from rural to urban is expected to result in an increase of 2.3 in the ordered log odds of being in a higher level of digital poverty, but this falls to 1.7 when multidimensional poverty indicators are included, suggesting that location operates through its implications for access to services, economic assets, and education. This can be compared to gaining a household member with a secondary education (a 3.6 increase in the ordered log odds in Model 2) or an extra unit of financial capital (a 4.7 increase in Model 2).

The implication of this analysis is that controlling for location, socioeconomic characteristics, and the other dimensions of poverty, both ICT access and digital poverty are largely determined by access to financial capital and human capital. However, including other dimensions of poverty improves the

15. LR chi^2 (4) = 209.90, Prob > chi^2 = 0.0000.

model fit and shows that each is statistically significant when holding financial and human capital constant.

5. Conclusion

This paper suggests a way in which multidimensional poverty can be taken into account when analyzing the developmental implications of information and communication technologies. Using proxies depicting five dimensions of poverty grounded in the sustainable livelihoods approach, poverty in the poorest areas of four East Africa countries is first measured, and then used as a predictor of access to mobile phones, the Internet, and e-mail. Further, the notion of digital poverty proposed by Barrantes (2007a, 2007b) and others is adapted for low-income countries, measured, and then used as alternative indicator of relative access to ICT.

Proxies for financial capital, based on per capita household expenditure relative to the international poverty line (US$2.50 per person per day), and on human capital, measured by the presence of at least one adult household member who has completed secondary education, are shown to be the most important predictors of ICT access, controlling for relevant confounders, country fixed effects, and the effects of the other dimensions. Comparing models in which only financial capital is included to those in which all dimensions are included reveals that the estimation of ICT access or digital poverty is strengthened by the adoption of a multidimensional notion of poverty. This is true despite the relatively crude measures of these dimensions available for this analysis. Further, using digital poverty rather than simply access to new forms of ICT is shown to be both a feasible indicator of relative ICT access, as well as a means of more clearly revealing the marginal contribution made by each of the dimensions of poverty than can be achieved using a simple binary approach. Analyzing the data using individual access to ICT reveals important gender and age dimensions which would otherwise be lost if analysis were to take place only at the level of the household. Most important, at all age groups, women are around 1.4 times less likely than men to have access to ICT, and this difference cannot be ascribed only to differences in earnings or economic participation.

While the proxies used have been shown to be adequate for the task of predicting access, a number of improvements may be necessary when exploring the impact of ICT on poverty reduction. The proxy for financial capital used in this paper is the product of a laborious expenditure module in which detailed records were obtained using a recall method, and then broken down by the classification of individual consumption according to purpose (COICOP) codes adopted by the United Nations Statistics Division. Beyond the adoption of a diary approach, in which households are repeatedly visited to obtain weekly expenditure data, further refinement is probably unnecessary and possibly only feasible in surveys undertaken by official statistics agencies. Likewise, the estimation of physical capital is grounded in a well-established approach for measuring housing quality that is widely used when generating quality-of-life indicators. However, a more accurate measure of human capital, perhaps including literacy testing, and at least including actual years of completed schooling, would be an advantage. Likewise, valuing assets, rather than simply counting the number of assets owned, should also improve analysis and facilitate the identification of poverty traps associated with ICT. The measure of social capital did not perform well in all of the models, perhaps unsurprising, given the theoretical concerns that have been raised about this concept. Nonetheless, social connectedness is clearly of importance when attempting to value the developmental impact of ICT, and the development of appropriate indicators deserves further attention. An option might be to collect data on the number of contacts made using ICT and user assessments of the quality/importance of these contacts.

While a better understanding of the predictors of ICT access may be interesting in its own right, this analysis is a step toward a more fundamental question: What is the impact of improved access to ICT on poverty reduction? Answering this is not feasible with the cross-sectional data discussed in this paper, but it is apparent that future analysis would be well advised to include a multidimensional approach to poverty, and also to make use of an ordinal scale of ICT access, such as that which is implied by digital poverty. Moreover, such analysis should also attempt to take account of important intrahousehold differences both in terms of ICT access and other household resources that may be confounders. Panel data, such as that collected in the second wave of the PICTURE-Africa study, will allow for further exploration of the impact of ICT, but as argued by this paper, the tools for such analysis require further development and ongoing refinement. ■

References

Alampay, E. A. (2006). Beyond access to ICTs: Measuring capabilities in the information society. *International Journal of Education and Development Using Information and Communication Technology, 2*(3), 4–22.

Arias, E., & De Vos, S. (1996). Using housing items to indicate socioeconomic status: Latin America. *Social Indicators Research, 38*(1), 53–80.

Arunachalam, S. (2002). Reaching the unreached: How can we use information and communication technologies to empower the rural poor in the developing world through enhanced access to relevant information? *Journal of Information Science, 28*(6), 513–522.

Barja, G., & Gigler, B.-S. (2007). The concept of information poverty and how to measure it. In H. Galperin & J. Mariscal (Eds.), *Digital poverty: Latin American and Caribbean perspectives* (pp. 11–28). Ottawa: IDRC.

Baron, S., Field, J., & Schuller, T. (Eds.). (2000). *Social capital: Critical perspectives.* Oxford, UK: Oxford University Press.

Barrantes, R. (2007a). Analysis of ICT demand, in regional dialogue on the information society. In H. Galperin & J. Mariscal (Eds.), *Digital poverty: Latin American and Caribbean perspectives* (pp. 29–54). Ottawa: IDRC.

Barrantes, R. (2007b). *Digital poverty: Concept and measurement, with an application to Peru.* Notre Dame, IN: University of Notre Dame, Kellogg Institute.

Bizimana, C. (2010). *Rwanda baseline report.* Butare, Rwanda: National University of Rwanda.

Bollou, F., & Ngwenyama, O. (2008). Are ICT investments paying off in Africa? An analysis of total factor productivity in six West African countries from 1995 to 2002. *Information Technology for Development, 14*(4), 294–307.

Carney, D. (1999). *Sustainable livelihoods approaches: Progress and possibilities for change.* Toronto: DFID.

Carter, M. R., & Barrett, C. (2006). The economics of poverty traps and persistent poverty: An asset-based approach. *Journal of Development Studies, 42*(2), 178–199.

Carter, M. R., & May, J. D. (2001). One kind of freedom: Poverty dynamics in post-Apartheid South Africa. *World Development, 29*(12), 1987–2006.

Central Intelligence Agency (CIA). (2009). *CIA World Factbook.* Langley, VA: CIA.

Chambers, R. (1995). Poverty and livelihoods: Whose reality counts? *Environment and Urbanization, 7*(1), 173–204.

Chambers, R., & Conway, G. R. (1992). *Sustainable rural livelihoods: Practical concepts for the 21st century.* Brighton, UK: Institute for Development Studies.

Chapman, R., & Slaymaker, T. (2002). *ICTs and rural development: Review of the literature, current intervention and opportunities for action.* (ODI Working Paper 192). London: Overseas Development Institute.

Chen, S., & Ravallion, M. (2004). *How have the world's poorest fared since the early 1980s?* Washington, DC: World Bank.

Chinn, M. D., & Fairlie, R. W. (2007). The determinants of the global digital divide: A cross-country analysis of computer and Internet penetration. *Oxford Economic Papers, 59,* 16–44.

Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology, 44,* S95–S120.

Coyle, D. (2005). Overview. In Vodafone, *Africa: The impact of mobile phones* [Electronic version]. *Vodafone Policy Paper, 2,* 3–9. Retrieved from http://www.vodafone.com/start/misc/public_policy.html (now obsolete link)

Davies, S. (1996). *Adaptable livelihoods: Coping with food insecurity in the Malian Sahel.* London: MacMillan Press.

De Vos, S. (2005). Indicating socioeconomic status among elderly people in developing societies:

An example from Brazil. *Social Indicators Research, 73*(1), 87–108.

Dorward, A., Poole, N., Morrison, J., Kydd, J., & Urey, I. (2003). Markets, institutions and technology: Missing links in livelihoods analysis. *Development Policy Review, 21*(3), 319–332.

Fiadzo, E., Houston, J., & Godwin, D. (2001). Housing quality for poverty and development policy analysis: CWIQ in Ghana. *Social Indicators Research, 53*(2), 137–162.

Fine, B. (2003). Social capital: The World Bank's fungible friend. *Journal of Agrarian Change, 3*(4), 586–603.

Fine, B. (2010). *Theories of social capital: Researchers behaving badly.* London: Pluto.

Flor, A. G. (2001). ICT and poverty: The indisputable link. *Paper presented at the Third Asia Development Forum on Regional Economic Cooperation in Asia and the Pacific.* Retrieved from http://www.fsp.usp.br/acessibilidade/ICTandPoverty-TheIndisputableLink2001.pdf

Gerster, R., & Zimmermann, S. (2003). *Information and communication technologies (ICTs) for poverty reduction in sub-Saharan Africa: A learning study.* Geneva: Gerster Consulting.

Gutiérrez, L. H., & Gamboa, L. F. (2010). Determinants of ICT usage among low-income groups in Colombia, Mexico, and Peru. *The Information Society, 26*(5), 346–363.

Haddad, L., & Maluccio, J. A. (2003). Trust, membership in groups, and household welfare: Evidence from KwaZulu-Natal, South Africa. *Economic Development and Cultural Change, 51*(3), 573–601.

Hussein, K. (2002). *Livelihoods approaches compared: A multi-agency review of current practice.* London: DFID.

International Comparison Program (ICP). (2008). *2005 international comparison program: Tables of final results.* Washington, DC: World Bank.

International Telecommunication Union (ITU). (2008). *Report on the World Summit on the Information Society Stocktaking.* Geneva: ITU.

International Telecommunication Union (ITU). (2009). *Measuring the information society: The ICT development index.* Geneva: ITU.

Jensen, R. (2007). The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector. *The Quarterly Journal of Economics, 121*(3), 879–924.

Kenny, C. (2002). Information and communication technologies for direct poverty alleviation: Costs and benefits. *Development Policy Review, 20*(2), 141–157.

Kirkman, G. (1999). It's more than just being connected. A discussion of some issues of information technology and international development. *Paper presented at the Development ECommerce Workshop.* Retrieved from http://cyber.law.harvard.edu/itg/libpubs/beingconnected.pdf

Maluccio, J. A., Haddad, L., & May, J. (2000). Social capital and household welfare in South Africa 1993–1998. *Journal of Development Studies, 36*(6), 54–81.

Marker, P., McNamara, K., & Wallace, L. (2002). *The significance of information and communication technologies for reducing poverty.* London: DFID. Retrieved from https://www.dfid.gov.uk/Documents/publications/ictpoverty.pdf

May, J., Dutton, V., & Mascarenhas, O. (2010). *Poverty and information and communications technology in urban and rural Eastern Africa (PICTURE–AFRICA): Results from cross-sectional data.* Durban: University of KwaZulu-Natal.

Mo Ibrahim Foundation(MIF). (2009). *The Ibrahim index publication.* Retrieved from http://www.moibrahimfoundation.org/en/section/the-ibrahim-index

Moser, C. O. N. (1998). The asset vulnerability framework: Reassessing urban poverty reduction strategies. *World Development, 26*(1), 1–19.

Pruulmann-Vengerfeldt, P. (2008). Digital stratification: A closer look at the included and excluded in the digital Estonia. In N. Carpentier (Ed.), *Democracy, journalism and technology: New developments in an enlarged Europe* (pp. 169–181). Tartu, Estonia: Tartu University Press.

Ravallion, M. (1995). *Poverty comparisons.* Chur, Switzerland: Harwood.

Reardon, T., & Vosti, S. A. (1995). Links between rural poverty and the environment in development countries: Asset categories and investment poverty. *World Development, 23*(9), 1495–1506.

Saith, R. (2001). *Social exclusion: The concept and application to developing countries.* Oxford: Queen Elizabeth House, University of Oxford.

Singh, J. (1999). *Leapfrogging development? The political economy of telecommunications restructuring.* Albany, NY: State University of New York Press.

Torero, M., & von Braun, J. (2006). *Information and communication technologies for development and poverty reduction: The potential of telecommunications.* Washington, DC: Johns Hopkins University Press and IFPRI.

United Nations Development Programme (UNDP). (2009). *Statistics of the human development report.* United Nations Development Programme. Retrieved from http://hdr.undp.org/en/statistics/

Van Dijk, J., & Hacker, K. (2003). The digital divide as a complex and dynamic phenomenon. *The Information Society, 19*(4), 315–326.

Wilson, K. R., Wallin, J. S., & Reiser, C. (2003). Social stratification and the digital divide. *Social Science Computer Review, 21*(2), 133–143.

Woolcock, M., & Narayan, D. (2000). Social capital: Implications for development theory, research, and policy. *The World Bank Research Observer, 15*(2), 225–249.