Digital and other poverties:
Exploring the connection in four East African countries

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1 Introduction

There has been a remarkable growth in the use of information communication technologies (ICT) across the world over the past decade. Writing in 1999, Kirkman (1999) commented that half the world's population had never made a telephone call. By 2008 this had changed dramatically and instead over half the world's population was now connected via mobile telephony (WISIS, 2008). Indeed, despite the persistence of wide-spread poverty, the use of mobile telephony in African 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 and Ravallion 2004; Coyle 2005; ITU 2009).

This phenomenal 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 over development stages or technology barriers to achieve both economic growth and broad-based development (Singh 1999). Other analysts are more cautious about attributing direct benefits to ICT (Nulens and van Audenhove 1999; Arunachalam 2002; Athreya 2004; Bollou and 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, the rich and the poor and between generations. Thus while there may well be a link between ICT and poverty reduction, the mechanisms through which the connection takes place are not fully understood. In fact, whatever dimension of welfare change is being considered, the direction of its causal link to ICT is contentious. Problems of reverse causality and spurious correlation that apply to the relationship between any investment in infrastructure and increasing output are equally of relevance to the analysis of the ICT/poverty nexus.

"Poverty, ICT's in Urban and Rural East Africa" (PICTURE-Africa) is 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. PICTURE uses a panel survey methodology with data collection taking place in 2007 and scheduled again for 2010. This paper discusses the results from the first wave of data collection in order to identify the dimensions of poverty associated with differential access and usage of ICT. The causal link between changes in ICT usage and poverty status can be examined once the second wave of data has been collected.

2 ICTs, growth and poverty reduction

Even prior to the current era of wide-spread mobile telephony and internet usage, a causal relationship between telecommunications infrastructure and economic output was identified for the period 1970-1999 using data from the 21 OECD countries (Röller and Waverman 2001). More recent data suggests that this relationship may also hold for mobile telephony (Coyle 2005). For the period 1997-2003, data from 177 countries, 45 of which are Sub-Saharan, shows that an increase of 1 percent in access to mobile networks is correlated with 0.5 percent increase in real GDP per capita (Djiofack-Zebaze

and Keck 2009). At the macro level, data from 113 countries over a 20 year period showed that a 1 percent increase in telecommunications penetration rate leads to a 0.03 percent increase in GDP (Torero and von Braun, 2006). However, the penetration of telecommunications had a non-linear effect on economic output for a group middle income of countries where there was a lower level of penetration. The implication proposed is that a critical mass of telecommunications access is necessary before a discernible impact on economic growth can be observed. Indjikian and Siegel (2005) confirm the positive correlation between ICT and economic growth in the developed world but argue that for this to occur in the developing countries, policy makers have to implement policies that facilitate a faster rate of access and more resources into the ICT sector. This is supported by Djiofack and Keck (2009) who note that regulation is a key factor affecting the performance of the telecommunications sector.

ICTs have also been argued to have broader developmental impact. Kenny (2002), Flor (2001) and Marker et al (2002) argue that ICTs are powerful tools for empowerment and income generation in developing countries as well as for increasing access to education and other social services. As an example, mobile phone usage among fishers in Kerala has been shown to benefit both producers and consumers through improved information and better functioning markets while mobile telephones have been found to assist businesses in the informal economy by helping them to attract additional business (Van Dijk and Hacker 2003; Jensen 2007). Other studies go further to point out that the role of ICTs is not limited to promoting growth but also includes non-income dimensions of development such as empowerment and security (Gerster and Zimmermann 2003).

Not all analysts are as sanguine about assuming a positive impact of ICT on poverty reduction. In their overview Torero and von Braun (2006) found that some studies have expressed scepticism of the beneficial views of the benefits of ICTs. The authors of these studies argue that access to ICTs depends on income, education and resources and that the so-called "digital divide" is part of the of a much broader development divide. They argue that socio-economic development contributes to a greater use of ICTs rather than the reverse. As examples, Arunachalam (2002) argues that ICTs are a necessary but insufficient condition for development and recommends that the focus should 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. Still others argue that using ICTs as an engine of growth is complex (Bollou and Ngwenyama 2008); that development is not merely a matter of technology but needs a sound political economy along with the political will to prioritize development problems (Nulens and van Audenhove 1999; Athreya 2004); and that while ICTs are critical for getting and sending information, the role of information in development itself is contentious (Talyarkhan, Grimshaw et al. 2005). Reviews of ICT projects designed to bring about economic development and poverty reduction concur and argue since few of these projects have carried out a systematic impact assessment, the results are not conclusive about the relationship of ICTs to poverty reduction (Batchelor and Sugden 2003; Slater and Tacchi 2004).

As Torero and von Braun (2006) conclude, ICTs offer an opportunity 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 context in which these technologies are

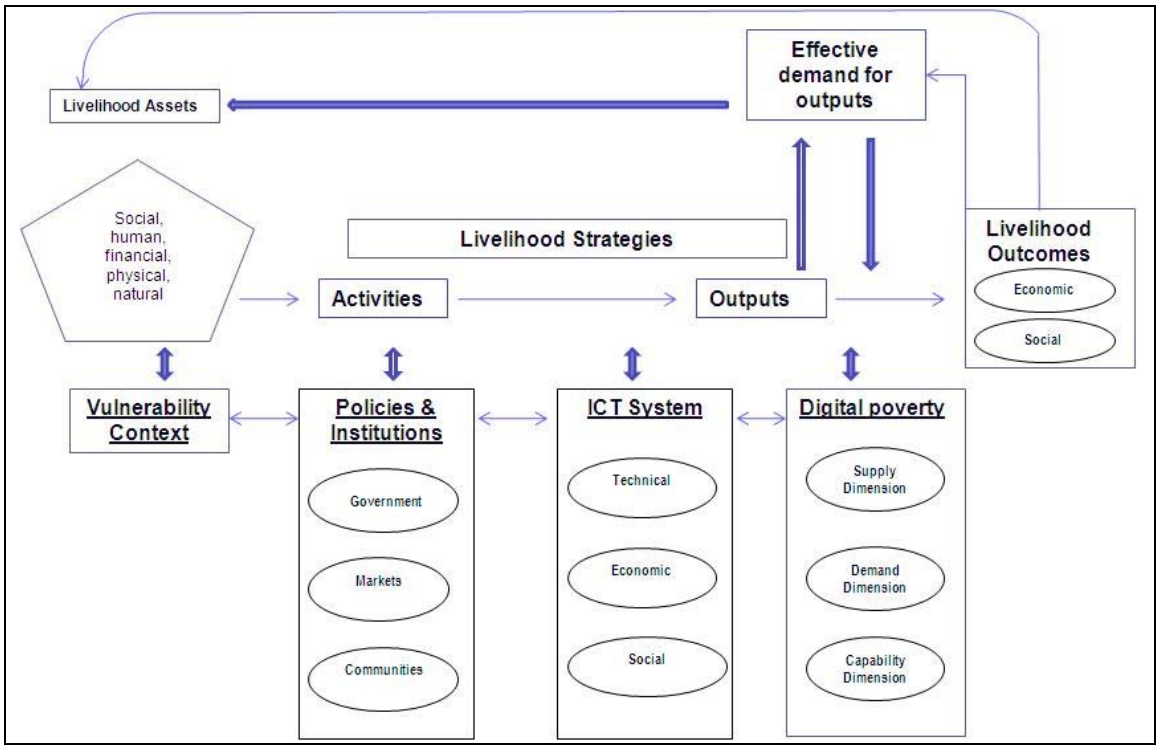
deployed, the preparedness of the users and the opportunities that exist for their application. Access to information through ICTs is thus a question not only of connectivity but also of capability to use the new tools and relevant content provided in accessible and useful forms

3 Conceptual framework and methodology

A useful point of departure for an analysis of the ICT/poverty nexus is the Sustainable Livelihoods (SL) Framework which brings together a multi-dimensional 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 can be extended to take account of markets, institutions and technology (Chambers and Conway 1992; Moser 1998; Carney 1999; Hussien 2002; Dorward, Poole et al. 2003). Further, the SL Framework is grounded in the capabilities analysis of Sen, and can be used to identify dimensions of deprivation beyond that of financial poverty. Finally, the SL Framework has been shown to have relevance to studies concerned with the impact of ICT (Chapman and Slaymaker 2002; Marker, McNamara et al. 2002).

The interaction between the SL Framework and ICT is summarised in Figure 1.

Figure 1: ICT, poverty and livelihoods



Source: Adapted from Carney (1999) and Dorward Poole et al (2003)

In the upper part of the diagram the conventional SL framework is shown whereby assets are used by households in livelihood strategies to produce livelihood outcomes. However, following Dorwood Poole et al (2003), several innovations are introduced including the separation of livelihood strategies into activities and outputs. This allows their interaction

with ICT to be revealed in the lower part of the diagram where conditioning influences are shown. The first of these is the vulnerability context (household and community exposure to risk and the shocks that result) and the second is the policy and institutional context (markets, government structures and community networks). The ICT system is included as an additional conditioning influence and encompasses several sub-systems that influence livelihoods. The technical sub-system comprises end-user technologies, networks and access infrastructure, and the applications for use. The economic sub-system comprises economic institutions (including markets, enterprises and consumers), cost structures and regulatory frameworks. Finally, the social sub-system comprises social actors (communities, enterprises, households and individuals), political processes, social interactions and networks, and the content of what is being delivered. Their interaction can result in 'digital poverty', which is defined as "…the lack of goods and services based on ICTs" (Barrantes, 2005:30). Digital poverty thus incorporates a demand dimension (the ICT service cannot be afforded), a capability dimension (the skills to use the service are not available) 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 and will feed back to the persistence of digital poverty.

In operationalising this conceptual framework the multi-dimensional nature of poverty is acknowledged and five dimensions of poverty are identified, the most widely used of which is financial poverty. Here deprivation is conceptualised as the inability to attain an absolute minimum standard of living reflected by a quantifiable and absolute indicator applied to a constant threshold, usually a minimum income line that separates the poor from the non-poor (Ravallion 1995). Financial poverty can further be broken into two components, the flows of income and the stocks of assets. The latter form of deprivation is sometimes referred to as asset or structural poverty and can result in persistence of poverty over time (Reardon and Vosti 1995; Carter and May 2001; Carter and Barrett 2006). Flows can be proxied using monthly per capita expenditure and the consumption of home production, while the indicator for economic stocks will be the number of different assets owned by each household.[2] The latter indicator ranges between 0 (no assets) and 10 (the maximum possible).

Flows are measured using a poverty score derived from monthly household per capita expenditure normalised to a poverty line.[3] In order to adjust for cost of living differences in the four countries, all incomes and expenditures have been converted into Purchasing Power Parity US dollars (PPP$) using the Penn World Tables. Further, due to the methodological differences in the national poverty lines that are used in each country, the international threshold of PPP$2.00 per capita per day has been used to ensure that the data are comparable when combined. However this does mean that the results reported in this synthesis report will differ from the country reports in which national lines were used together with national protocols regarding adult equivalence scales, the items including in

[2]/ As these indicators are only weakly correlated (Pearson's correlation coefficient = 0.344) both will be used. The assets included are refrigerator, electric or gas stove, TV, VCR, lounge suite, motor vehicle, oxen, cattle, donkeys/horses/camels/goats and sheep.

[3]/ In common with many studies which make use of income and expenditure data, there is substantial variation in the data and thus the log transformed poverty score is used.

the poverty measure and of course the poverty threshold itself. This score ranges from 0.07 (each month the household spends 7 percent of what it members require in order to subsist) to the maximum, 32 (each month the household spends 32 times what it members require in order to subsist).[4]

Physical poverty reflects inadequate access to essential services and is largely derived from a basic needs approach to development. Deprivation in this dimension is proxied using indicators concerning house structure and the services that the structure provides.[5] Following Fiadzo Houston et al (2001), de Vos (2005) and others, principal components and factor analysis has not be used to develop this services index, and instead an approach is adopted that theorizes a structural relationship between the components of each of the uni-dimensional measures of housing quality. The variables to be used are selected by assessing their inter-correlations, item-rest correlations and then calculating Cronbach's α. The higher the α, the higher correlation between the observed value and the true value, and 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 generally considered to be respectable and in this case $\alpha = 0.856$ (Arias and De Vos 1996). The subjective assessment of housing quality, an indicator of crowding and the collection of household waste are excluded from the composite index, however since the interaction of the first of these with the services index improves the overall fit of model, housing quality is included as a further aspect of this dimension of poverty. This score ranges from 0 (the dwelling is constructed of impermanent materials and no services are provided) to 5 (the dwelling is constructed of permanent materials and all services are provided).

Within the context of ICT, capability poverty focuses on deprivation in terms of skills and knowledge (Alampay 2006). Reflecting shortfalls in human capital, at the household level this dimension of poverty is proxied using the mean education of resident adults in the household, and the educational attainment of each person is used for analysis undertaken for individuals. This score ranges from 0 (no member of the household has formal education) to 18 (adults in the household have an average of 18 years of formal education). The ability to read a newspaper or letter is included as a separate dimension of capability for analysis at the individual level.

Vulnerability refers to the shocks and the coping strategies that households adapt and has been recognised as an important dimension of poverty (Chambers 1995; Davies 1996). This dimension of poverty is included since poor households are especially at risk of negative events that result in a loss of income or assets. This dimension is proxied by the reciprocal of 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 2 years).

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[4]/ One outlier is excluded in which expenditure exceeds need by over 100 times. Inspection of the data suggests that this is not a result of field-worker error.

[5]/ The indicators are: bricks or blocks are used for walls; floors are cement or cement plus a covering; there is access to electricity; access to a protected water source; and access to a flush or improved (VIP) toilet.

Finally, a recent literature emphasises the impact of social exclusion on the persistence of poverty in developing countries (Bhalla and Lapeyre 1997; Saith 2001). While exclusion is sometimes taken to refers to a broad "...process of becoming detached from the organization and communities of which the society is composed and from the rights and obligations that they embody" (Room 1995), for the purposes of this study the focus is on participation in social institutions and governance processes. The groups to which a randomly selected adult household member belongs, and their participation in local meetings, are used as the proxies for exclusion.[6] Summing these variables yields a less satisfactory but adequate Cronbach's α of 0.633 and this score ranges from 0 (no participation) to 8 (maximum participation).

In addition to these dimensions, the distribution and extent of digital poverty is the main focus of PICTURE. As already discussed, digital poverty (sometime 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 these. Instead digital poverty can be seen as a continuum, perhaps with a critical threshold akin to a poverty line. While Barrentes (2005) is an influential analyst of digital poverty, other writers have made similar suggestions. In Estonia, Pruulmann-Vengerfeldt (2008) talks of 'digital stratification' and argues that structural and individual differentiation occurs when accessing ICT. Thus in order to be able to use the new technologies, various skills are needed: instrumental skills to deal with the operational manipulation of technology, structural skills in order to understand the structures in which information is conveyed (format, language), and strategic skills which includes the ability and readiness to actively search for information on which to make decisions. Equally, there are different outcomes and returns that follow from ICT usage, and that appropriate or relevant content is required in order to have real access. Both approaches are used and digital poverty has been proxied in terms of the access that household and individuals enjoy to different forms of ICT, as well as the activities that they undertake when using these ICTs.

The data used are derived from a questionnaire survey of approximately 400 households in each country who were interviewed in 2007/8 and are again being interviewed in 2010. Sampling consisted of the purposive selection of census Enumerator Areas (EA's) as the primary sampling unit, within which randomly selected households formed the secondary sampling unit. In principle, the purposive selection was to be based on the identification of the 20 poorest EA's in each country using data collected by the national statistical offices. In most cases, this procedure was followed, although circumstances dictated some adaptation. In particular, substitution of similar EAs took place in Kenya due to the political unrest experienced in this country during 2007 and early 2008. At the level of the household then, the sample can thus reasonably be described as being representative of the poorest regions in the four countries with the exception of Kenya in which there is

[6]/ Group membership is sometimes used as a proxy of social capital. However in the context of rural and urban East Africa, group membership seems a more appropriate proxy for exclusion than the employment-based measures often used in developed countries. Membership in religious groups is negatively correlated to all other forms of participation as well as to ICT access and is excluded. While religious groups may well serve an important function in connecting individuals, it seems that the absence of membership does not denote social exclusion and that membership is highly correlated with financial poverty. Internet groups are also excluded as these are correlated with ICT access, the dependent variable, while savings groups are excluded since these are highly correlated with financial poverty.

a known bias arising from the exclusion of settlements affected by violence. A third layer of sampling took place within the households. Once again, in principle one adult was to be randomly selected from the household roster to be interviewed about their ICT skills and usage. In practice, selection was frequently non-random and only those present at the time of the interview were included for selection. Analysis at this level cannot with certainty be said to be representative of adults in poor EAs nor of adults in the sample.

4 Background to the four countries

There are important differences between the four countries in terms of their socio-economic and ICT development as is shown in Table 1.

Table 1: Socio-economic 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
HIV prevalence (% 16-49 years)	7.1	2.8	5.4	6.7
Human Development Index (HDI)	0.541	0.460	0.530	0.514
Life expectancy at birth (years)	53.6	49.7	55.0	51.9
Adult literacy rate (% ages 15 & above)	73.6	64.9%	72.3%	73.6%
GDP per capita (PPP US$)	$1,542	$866	$1,208	$1,059
Human Poverty Index-1 (HPI-1[7]	29.5	32.9	30.0	28.8
% people without improved water source	43.0	35.0	45.0	36.0
Access to electricity (%)	14.0%	3.5%	11.0%	15.0%
Unemployment rate (%)	n.a	0.6%	3.2%	5.1%
Poverty levels (<$1 per capita/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[8]	53.7	48.5	59.2	53.6
Fixed lines (/1000)	7	2	4	5
Mobiles (/1000)	302	65	206	136
Hhds with computer (/1000)	55	3	23	51
Hhds with internet (/1000)	22	1	6	1
Internet users (/1000)	123	21	10	36
ICT Development Index (IDI)[9]	1.62	1.17	1.13	1.21
IDI Rank (of 154 countries)	116	143	145	140
IDI change (’02-’07)	33.9%	18.2%	17.7%	31.5%

Source: (Undp 2009); (MFI 2009); UNAIDS, (2009) (ITU 2009)

[7]/ HPI-1 is a composite measure of deprivation based on the proportion of people who are not expected to survive to age 40, the adult illiteracy rate; and the unweighted average of people not using an improved water source and the proportion of children under 5 years who are underweight for their age.
[8]/ The Ibrahim Index measures the delivery of public goods and services to citizens by government and non-state actors. The index uses 84 criteria in four components: safety and rule of law; participation and human rights; sustainable economic opportunity; and human development.
[9]/ The IDI is calculated by the International Telecommunications Union (ITU) and is a composite index of ICT infrastructure and access, ICT use and intensity of use and ICT skills and capacity to use ICT. The index has 11 components. This IDI of the surveyed countries can be compared the top ranking countries, Sweden at 7.5 and the Republic of Korea at 7.26, as well as the USA at 6.44 and South Africa at 2.7.

Using the HDI, Kenya and Uganda are categorized by 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 UNPP's composite measures of poverty, the HPI-1. A number of other differences are apparent, with the most obvious being Rwanda which fares badly in terms of most measures of well-being, including GDP per capita, adult literacy, poverty rates and access to electricity. Differences in the ICT indicators are also noteworthy, with Kenya far better endowed with ICT infrastructure than the other countries, and showing the fastest growth in its IDI, a composite measure of ICT status. Tanzania emerges as being the most deprived country in terms of ICT despite the prevalence of mobile telephony in this country and its favourable governance index. The data conceal a likely ICT bias towards urban areas, and in Rwanda, Bizimana (2010) observes that 75 percent of the internet cafes are located in the country's capital city.

5 Demographic and socio-economic profile

The achieved sample comprised 1606 households containing 8071 members giving a mean and median household size of 5.12 and 5.0 respectively. In all the countries the population in the sampled households was youthful with a preponderance of women. This is in line with the national census results, with about half the sampled population below 20 years of age (respectively 53.1; 47.9, 49.3 and 46.9 percent for Tanzania, Kenya, Rwanda and Uganda) and a masculinity ratio of 0.96. Households were evenly spread between urban and rural areas, with 54 percent located in the latter. However there are differences between the countries, with almost 70 percent of the samples in Kenya and Uganda found in rural areas while a marginally greater share of the samples in Rwanda and Tanzania are from urban locations.

Means, medians and standard deviations of total monthly household expenditure, total per capita expenditure, total expenditure on food and on non-food items, and finally the average food share (percentage of total expenditure that is allocated to the purchase of food) are shown in Table 2 for the four countries.

Table 2: Total and per capita monthly expenditure (PPP$)

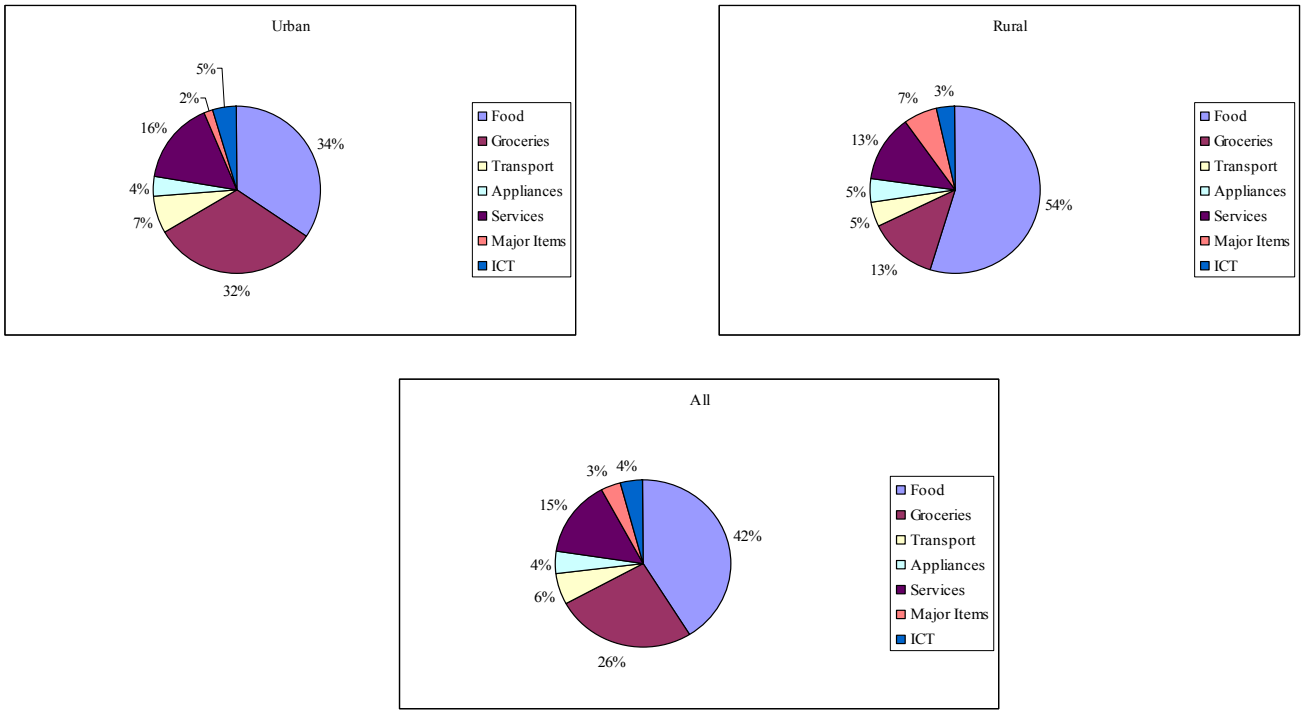
Country	Indicator	Mean	Median	Std Deviation
Tanzania	Total expenditure	474.08	328.11	540.78
	Per capita expenditure	79.67	58.70	73.54
	Food share (%)	59.6	60.1	16.4
Kenya	Total expenditure	780.87	481.10	1,119.11
	Per capita expenditure	206.02	128.15	453.78
	Food share (%)	53.1	54.8	21.1
Rwanda	Total expenditure	788.94	451.99	930.65
	Per capita expenditure	187.83	93.23	275.66
	Food share (%)	62.3	63.8	18.4
Uganda	Total expenditure	1,041.76	409.33	9,418.16
	Per capita expenditure	150.51	92.01	177.56
	Food share (%)	67.5	69.9	19.3

n= 1599

Mean total expenditure is highest in Uganda, but this is due to the presence of a few extreme cases as is evident from the very high standard deviation and the relatively low median expenditure. This is also off-set by larger household sizes in Uganda which reduces mean per capital expenditure to below that of Kenya. As a result, per capita mean and median expenditures are highest in Kenya and the relatively low share of food as a percentage of total expenditure shows this to be the country with the highest deposable income of the four case-studies, and the most likely candidate for discretionary expenditures, including those on ICT. The opposite may be so for Tanzania which has the lowest expenditures, although while the share of expenditure on food is below that of Uganda and Rwanda, this is not significantly so.

A more detailed breakdown of this expenditure can be seen in Figure 2.

Figure 2: Monthly expenditure on major items urban and rural (%)



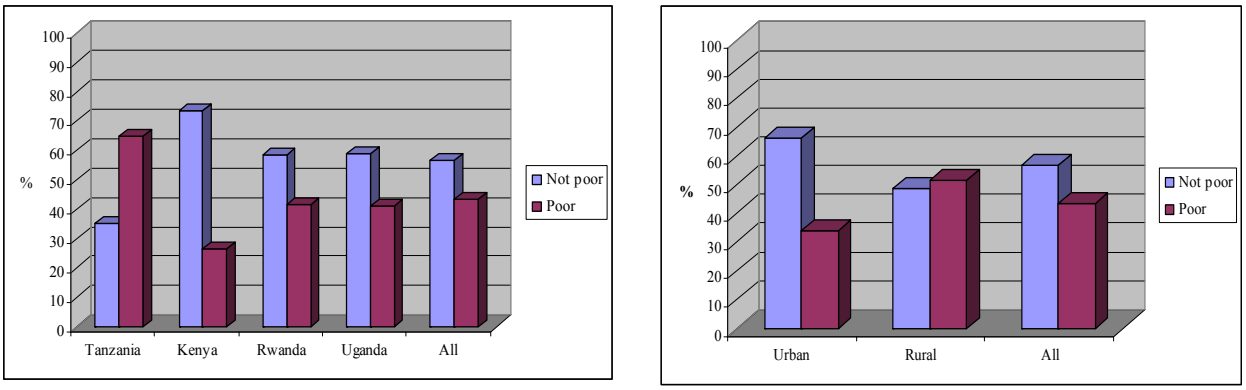
n= 1599

As would be expected, expenditure on food makes up the largest share of expenditure in followed by groceries and services. The relative importance of ICT expenditure is of interest since this exceeds the share allocated to appliances and major items such as cars and housing. Moreover, despite the larger amounts spent on ICT in Kenya, households in all countries allocate an approximately similar proportion of their total expenditure towards ICT at around 4 percent of total expenditure. There are however differences in expenditure between urban and rural areas. Groceries emerge as the single most important expenditure item for urban areas, while food remains most important for rural areas. Households in urban areas also spend a large share of the incomes on transport and appliances, as well as on ICT. The expenditure patterns of households also differ according to the sex of the household head. Male headed household allocating a much

smaller share to food than female headed households (38 percent compared to 53 percent) and a much larger share to other non-food groceries (29 percent compared to 13 percent). Other allocations are similar including that for ICT.

These expenditure data can be used to describe financial deprivation using a threshold to categorise the sample into 'poor' and 'not poor' groups. Figure 3 shows the percentage of the sample in each country and by geo-spatial type that was categorised in this manner using the international poverty line of PPP$2 per day per person.

Figure 3: Incidence of household poverty by country and geo-spatial type[10]



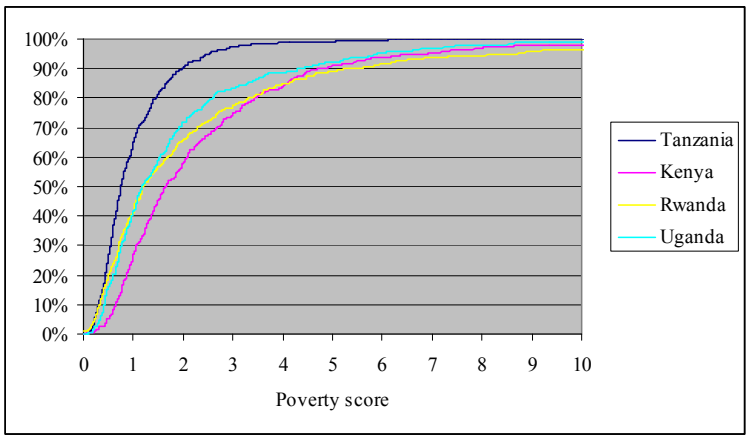
n=1606

The incidence of poverty of the PICTURE sample is higher than the national rates for Tanzania and Uganda, where these are 33 and 31 percent respectively, but slightly lower for Kenya and Rwanda where the rates are 46 and 57 percent respectively (UBS 2006; KNBS and MPND 2007). This former result is to be expected in view of the purposive sampling adopted by PICTURE although the Kenyan result is perhaps due to the substitution that took place during the fieldwork as well as the manner in which the national poverty line has been calculated. There are statistically significant differences between the countries, with the incidence of poverty highest in Tanzania at 65 percent of this sample. As anticipated, the incidence of poverty is greatest in the rural areas of the four countries, with 51 percent of households living in rural areas found below the poverty line compared to 34 percent of urban households. However there is considerable variation between countries, with the incidence of rural poverty peaking in Tanzania at 87 percent of the households sampled in rural areas, compared to 60 percent of such households in Rwanda and 45 and 34 percent of households in rural Uganda and Kenya respectively. Although there is no statistical difference in the incidence of poverty between male and female-headed households, the distribution of the poverty score does differ with female headed households having a mean poverty score of 1.6 (ie. per capita

[10]/ All expenditure items have been included in this calculation, including 'lumpy' expenditures such as health, holidays and funeral costs. Methodological differences mean that the results given in this synthesis report differ from those given in the four national reports. These include the inclusion of all expenditure items in this report, the use of expenditure rather than income as the measure of money-metric poverty, the use of per capita scales rather than country specific adult equivalence scales, and the use of a common international poverty line rather than the urban and rural poverty lines used by the different national statistical offices.

expenditure levels are on average 1.6 times the poverty line) compared to male headed households who had a score of 2.2.[11] This problem of the sensitivity of the poverty profile to the choice of threshold can be partly resolved by using cumulative distribution functions (CDF) of the poverty score. There are shown in Figure 4.

Figure 4: CDF of household financial poverty score



n=1606

The figure confirms that whatever poverty line is used, the sample in Tanzania is the poorest of the three study areas, lying above the CDF of the other countries at all incomes, and with a mean poverty score of 1.02 and a pce just less than PPP$80 per month. The sample in Kenya is the wealthiest, with a mean poverty score of 2.6 and mean pce of PPP$206 per month. Rwanda is the second poorest until the poverty line is reached where after this sample is poorer than the Uganda sample. The mean pce of each is PPP$188 and $151 respectively. In part, the result for Rwanda might be explained by the relatively high inequality shown in Table 1.

Finally, Table 3 provides the widely used Foster, Greer and Thorbecke class of poverty measures. These are P^0, the incidence of poverty already reported, P^1 which is the depth of poverty represented by the mean distance of the sample from the poverty line and P^2, a measure of the severity of poverty that emphases the distance from the poverty line of the poorest.

Table 3: Pα measurement of household financial poverty

	Tanzania	Kenya	Rwanda	Uganda	All
P^0	0.65	0.27	0.39	0.41	0.43
P^1	0.28	0.08	0.18	0.16	0.18
P^2	0.16	0.04	0.11	0.09	0.10

n=1606

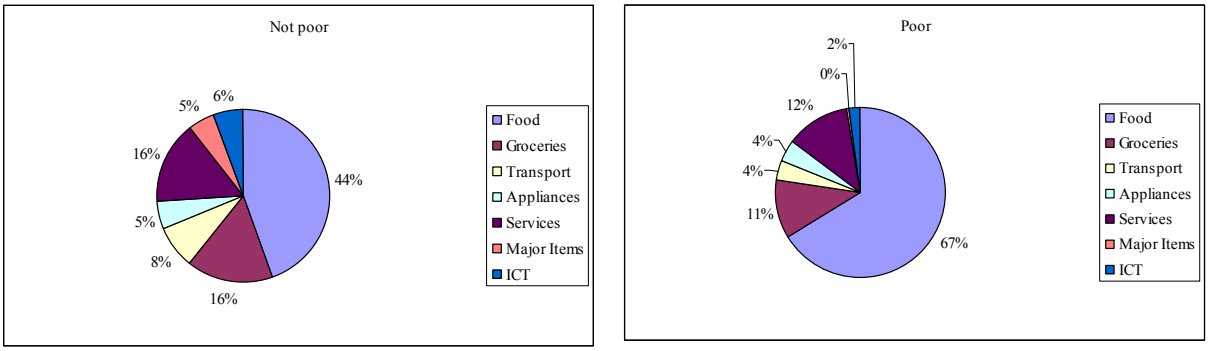
These measures confirm that the incidence, depth and severity of poverty is greatest in Tanzania, followed by Rwanda in terms of the depth and severity of poverty. Kenya is in

[11]/ Levene's Test for Equality of Variance and the T-Test for Equality of Means confirmed that the means and distribution of households in the different countries were statistically different in terms of their poverty score.

the most advantageous position, with the average depth of poverty equal to only 8 percent of the poverty line, while the severity of poverty is far less than is the case in the other countries.

Finally the breakdown of expenditure can be examined to compare the patterns of poor and non-poor households. This is shown in Figure 5.

Figure 5: Monthly expenditure on major items poor and non-poor (%)



n= 1599

Although food is still the most important expenditure item, the differences between the poor and non-poor are striking, with the share of the non-poor on this item being two thirds of that of the poor. Non-poor households spend more on services, transport, major items and on ICT, where they allocate 6 percent of their expenditure compared to the 2 percent allocated by poor households.

While these money-metric descriptions of poverty are of interest, PICTURE is explicitly concerned with analysing poverty as a multi-dimensional construct. The starting point is to examine the intersect of money-metric poverty and the other forms of poverty discussed in Section 4. 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 in PPP$ is included in Table 4 for comparison.

Table 4: Descriptive statistics of the dimensions of household poverty

Indicator	Not poor	Poor	All
Services	2.79	1.41	2.19
Vulnerability	1.32	1.21	1.27
Human capital	7.80	5.70	6.89
Inclusion	0.62	0.79	0.72
Income	3.08	0.59	2.00
Assets	3.17	1.95	2.64
PCE (PPP$)	240.49	45.72	155.99

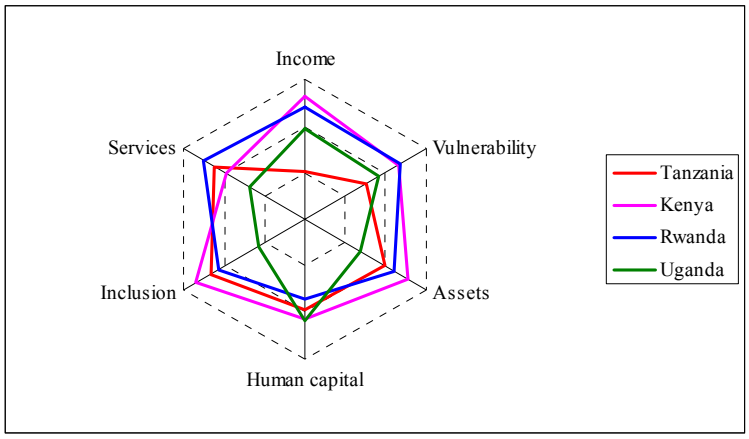
n=1569

Money-metric poverty intersects with all of the other indicators of poverty, with the financially poor 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, less educated adult household members and a lower level of service

provision. The difference in means is statistically significant between poor and non-poor for all dimensions other than vulnerability and the indicators are weakly correlated confirming that they represent different dimensions of deprivation and that they should be separately included in the multivariate analysis of the ICT/poverty nexus that follows.[12] However their intersect suggest that households can be categorised into those that are financial poor and non-poor as a proxy for deprivation that is more broadly conceptualised.

A star chart is a useful graphical device with which to show the differences in the multi-dimensional poverty status of the four countries surveyed. This is shown in Figure 6 in which the scores of each poverty dimension have been standardised to allow their comparison.[13]. The financial dimension is measured along two of the axes, the stock of assets and the flow of income.

Figure 6: Multidimensional poverty of households by country



n=1569

Tanzania emerges as the poorest country in terms of income and vulnerability, with Uganda the poorest in terms of access to services, financial assets and inclusion, and Rwanda the poorest in terms of human capital. Kenya has the highest status in most dimensions with the exception of service provision, and is similar in terms of vulnerability. Overall, Kenya and Rwanda appear to be less afflicted by almost all dimensions of poverty, with Uganda the poorest country overall. Summing the scores to produce a composite index confirms this, with Tanzania at 0.93, Kenya at 1.16, Rwanda at 1.12 and Uganda at 0.83.[14]

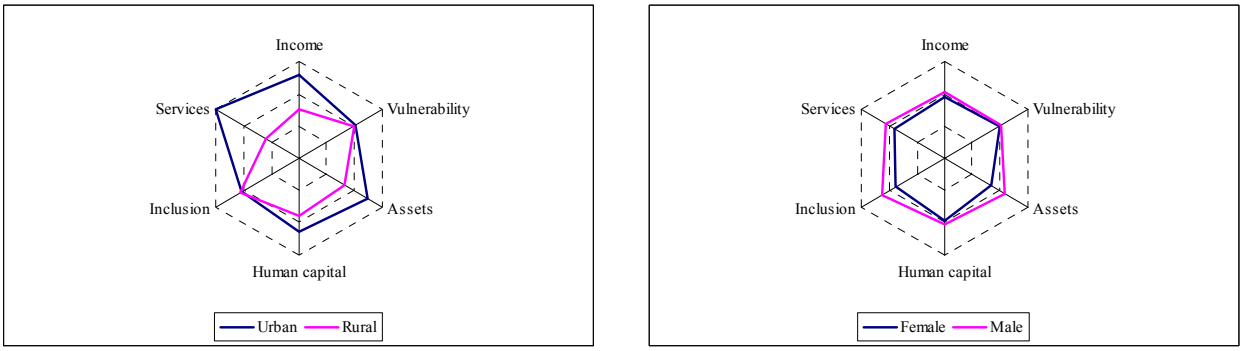
[12]/ Levene's Test for Equality of Variance and the T-Test for Equality of Means confirmed that the means and distribution of poor and non-poor households were statistically different for all indicators other than vulnerability in which does not pass Levene's test. Assets and services are moderately correlated (Pearson's correlation = 0.640) largely due to the inclusion of stoves, fridges and TV which rely upon access to electricity.

[13]/ Broadly following the methodology adopted for the HDI, the average score for each dimension in each country has been calculated as a ratio of the average score for that dimension for all countries. Thus a score of 1 can be interpreted to mean that the country average is equal to the average for all four countries. The scale for the axes in Figure 6 ranges from 0 to 1.5.

[14]/ Testing for the sensitivity of the methods used to scale the variables and to calculate a composite score shows that this result does not change under different assumptions. However it must be recalled that

The differences between urban and rural areas are also more starkly revealed by these indicators of multi-dimensional poverty. This is depicted in Figure 7 which also shows data for male and female headed households.

Figure 7: Multi-dimensional poverty by geo-location & sex of head



n=1569

Although rural areas are similar to urban areas in terms of the indicators of inclusion and vulnerability, households in these areas fare far worse in terms all other indicators, particularly income and services. Geo-location is thus likely to be important for both access to and use of ICT. The sex of household head is less important, although female headed households are less likely to be included or to have assets than male headed households.

6 Digital poverty

Attention can now be turned to the access and use of ICT and Table 5 shows the ownership of all forms of ICT for the four countries.[15]

Table 5: ICT ownership of households (%)

ICT	Tanzania	Kenya	Rwanda	Uganda	All
Radio	66.7	79.3	72.8	61.1	70.0
TV	23.7	39.3	23.5	9.8	24.1
VCR/DVD	12.0	19.8	16.9	4.5	13.3
Land line	1.8	0.5	3.2	1.0	1.6
Computer	1.8	1.8	9.1	1.3	3.5
Internet connection	0.3	0.8	2.2	0.0	0.8
Email address	5.1	16.8	29.2	18.6	17.3
Mobile phone	54.2	67.9	55.8	64.9	60.7
Any ICT	70.2	81.0	73.5	61.3	71.5

n=1606

As might be expected given the higher incomes and indicators of development, assess to

PICTURE is not a representative sample of the four countries, and that the 20 poorest EA's in each country as identified by the national statistics agency are being compared.

[15]/ Chi square tests confirm that the differences reported in this and the following tables and figures are statistically significant.

most ICT's was highest in Kenya with some striking exceptions. In the case of internet connections, computers, land lines and an email address, households in Rwanda were better endowed than Kenya, suggesting better penetration of newer forms of ICT in this country. Households in Uganda had the lowest access to ICT, with 39 percent having no form of ICT at all. Radios are the most commonly owned ICT in all four countries, ranging from almost 80 percent in Rwanda to 61 percent in Uganda and are thus an important mode of communication in the region. This is followed by mobile phone ownership by household members, which are almost as widely available as radios, ranging from 68 percent of households in Kenya to 54 percent in Tanzania. It might be anticipated the that the most frequent combination of ICTs through which information is transmitted would be radio/mobile transfers. The very low percentages of households with a land line or internet connection is indicative of a major constraint to the delivery of privately owned internet access through conventional technologies common to most countries in Africa. Households owned an average of 1.1 ICTs, with 29 percent owning no form of ICT at all.

Access to some ICTs is strongly related to financial poverty status measured in terms of per capita expenditure. 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 44 percent of poor households have at least one phone or card available in the household compared to 73 percent of non-poor households, while 59 percent owned radios compared to the non-poor in which 80 percent of households owned a radio. No poor households owned a computer, land line or had internet access in their homes.

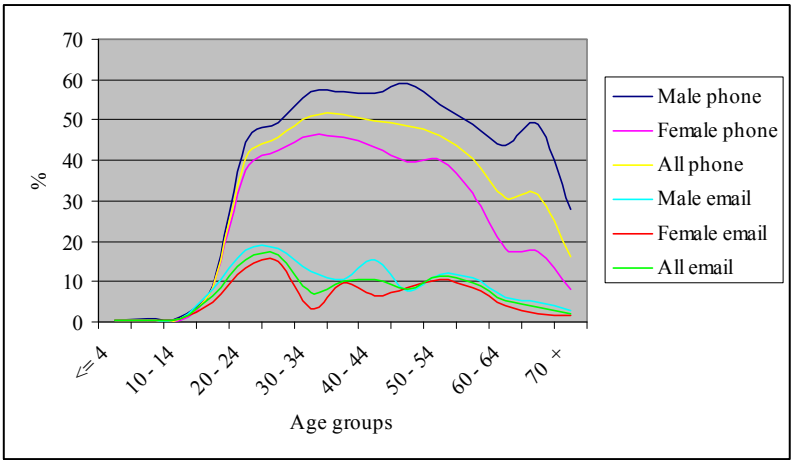
Not surprisingly, households in urban areas are better endowed with ICT assets than rural areas, even in terms of the ubiquitous radio where 75 percent of urban households own a radio compare to 65 percent of rural households. The gap between urban and rural in terms mobile phones is noteworthy, with phone ownership in the former being as wide spread as radio ownership, but only 49 percent of rural households having access to a mobile phone. Finally, access to an email address in urban areas is worth mentioning at 25 percent of households. Overall though, the results are indicative of a 'digital divide' between urban and rural areas that would require an innovative combination of conventional (e.g. radio) and new (e.g. mobile) technologies to bridge.

Access to ICT assets does differ according to the sex of the head of households in some respects. Male headed households are generally more likely to have ICT assets than female headed households, with 75 percent of the latter having some form of ICT asset compared to 64 percent of the former. In particular, male headed households are more likely to own TV's and radios (27 percent compared to 18 percent, and 74 percent compared to 62 percent respectively). Interestingly, ownership by the *household* of email addresses and mobile phones does not significantly differ, no doubt largely because these are *individually* owned items and are thus not affected by the sex of the household head.

This points to the importance of conducting similar analysis the individual level for these ICT assets. More than one third of adults older than 15 years of age for whom information was reported had a mobile/SIM (38 percent) while just 10.5 percent had an

email address.[16] Ownership of these forms of ICT access is highly correlated with 98 percent of those with an email account also having a mobile/SIM. The influence of gender on ICT ownership is now more apparent. Overall, 43 percent of men own a mobile phone compared to 33 percent of women, and 12 percent of men have an email account compared to 8 percent of women.[17] Access is also differently affected by age as is show in Figure 8

Figure 8: Age/sex distribution and individual ICT access



n=4657

The percentage in each age group that have access to a mobile phone quickly increases after 15 years of age to peak at just below 60 percent by 30 years of age. Interestingly, this peak persists until 55 years of age, and only then drops showing widespread access to mobile phones through-out the individual life cycle. The incidence of email access is far lower and peaks in the 25-29 year age group with around 10 percent of all other age groups having an email address. However there are marked differences in the ownership of both forms of ICT at all age groups, particularly in respect of mobile phones where a smaller percentage of women have ownership at all age groups, and the fall off if ownership starting at a younger age group for women. As a result while just 18 percent of women in the cohort 60-64 years of age have a mobile phone/SIM, 44 percent of men in the same group have a phone.

Education is another important factor affecting access to ICT, and both email and mobile access increases dramatically as education increases, with mobile ownership reaching almost 90 percent of those with tertiary education, and email access reaching 71 percent of this group. Although tertiary education appears to be a critical threshold for graduation into email access, it is noteworthy that those who have completed secondary school education are five times more likely to have an email account that those with primary school only, and twice as likely to have a mobile phone. It is also important to recognise the importance of primary school education in improving the likelihood of gaining access to a mobile phone. In this instance, those who have completed primary school are three

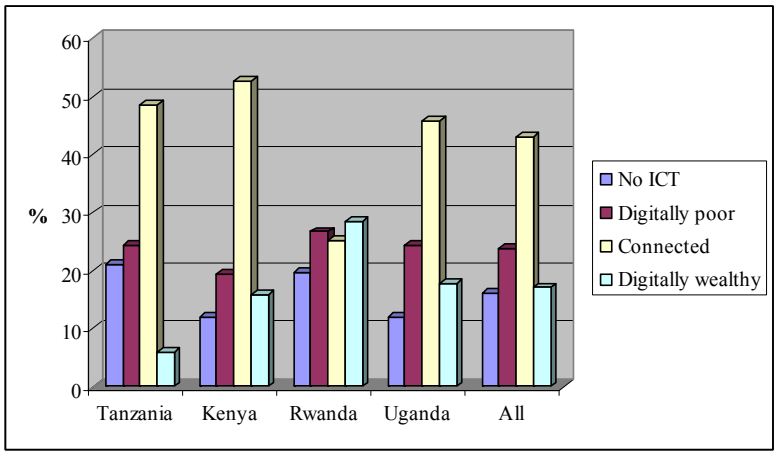
[16]/ These data are drawn from the household roster and thus are representative of adults in poor EA's in the four countries.
[17]/ Chi square tests confirm that these differences are statistically significant.

times more likely to have a mobile than those who have no education at all. All these differences are statistically significant, suggesting that improving access to education is of critical importance to improving ICT access.

The analysis presented thus far points towards the presence of considerable and differentiated digital poverty in the sampled households. For Barrentes, the extreme digitally poor are households who do not have access to any form of ICT, that is they do not have the means to receive voice communication (radio/TV), send voice communication (land line/mobile), send electronic communication (SMS/email) or interactively engage with information (broad band internet access). The digitally poor are able to receive voice information, the connected are those able to receive and send voice communication and the digitally wealthy are those able to send electronic communication and interact with electronic information. A similar approach is followed at the household level, grouping radios, TV 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 email addresses that allow electronic interactions. Since more sophisticated mobiles can also be used for electronic communication and interaction, this aspect of digital poverty can be further explored using the data gathered from the ICT respondents.

The first step is to explore the combinations of ICT access observed in the PICTURE data which confirms that this continuum of improving digital status does operate, although not perfectly. Almost all (95 percent) of the digitally wealthy households also have mobile phone or a land line, while 82 percent have a radio or TV. Just less than 80 percent of those who are connected also have access to a radio or TV. This produces the profile of digital poverty shown in Figure 9 .

Figure 9: Digital poverty of households



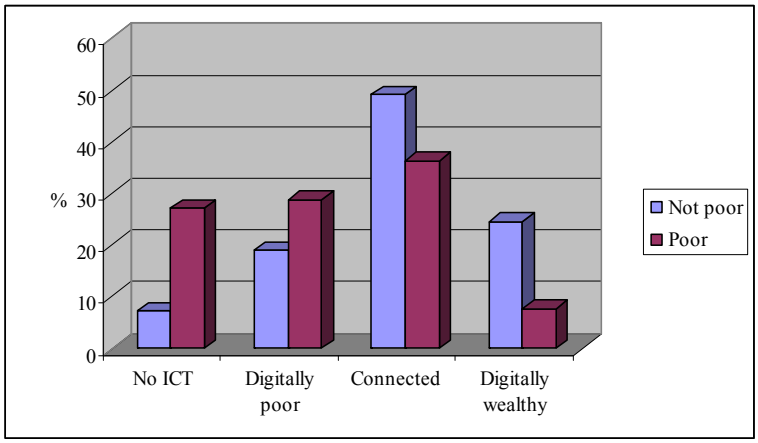
n=1604

Just over 40 percent 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 further 43 percent are connected and are able to send voice communications, while 17 percent are digitally wealthy and are able to interact with the information source. 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

this country connectedness is rapidly converted into interactive communication and that digital inequality may be related to financial inequality. Digital poverty also varies according to geo-location and 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. Female headed households are slightly more likely to have no access to ICT and not to be connected, but as before these differences are not statistically different.

Financial poverty overlaps substantially with digital poverty as is shown in Figure 10. Only 7 percent of the financially non-poor lack any access to ICT and 74 percent are connected or are digitally wealthy. In contrast, 56 percent of the poor either have no access to ICT at all or are digitally poor.[18] Although it cannot be argued that financial poverty is a cause or a consequence of digital poverty, a strong association exists between these different forms of deprivation.

Figure 10: Digital and financial poverty of households

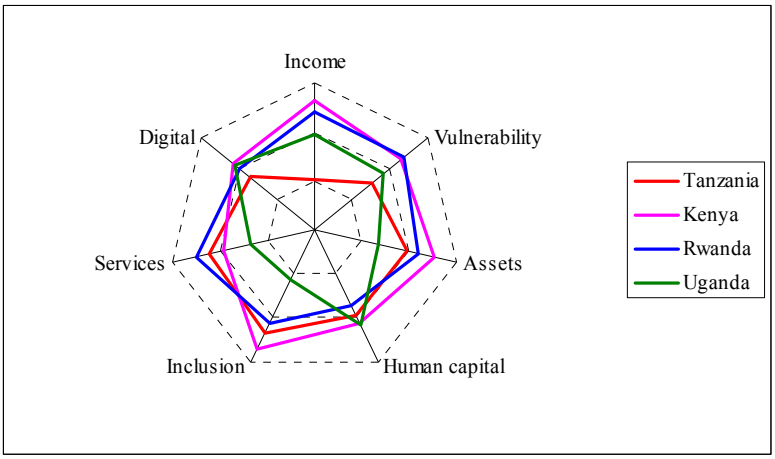


n=1606

The star charts presented earlier can now be redrawn to incorporate digital poverty as a further dimension of poverty as is done in Figure 11. Deprivation in Tanzania includes digital poverty, unlike Uganda, where lows scores in income, assets, vulnerability and services are offset by its relative strength in human capital and access to ICT. Kenya is relatively wealthy in all dimensions with the exception of access to services.

[18]/ These differences are statistically significant.

Figure 11: Multidimensional poverty of households including digital poverty



n=1569

6.1 Predictors of access to ICT

Along with control variables such as country, geo-spatial location and sex of household head, these dimensions that have been discussed can now be used as independent or predictor variables in a binary logistic regression in order to estimate the likelihood of ICT access defined here as being connected or being digitally wealthy (having a mobile phone, computer or email address). The results are shown in Table 6.[19]

Table 6: Predictors of household ICT access

Predictors	B	S.E.	Wald	Sig.	Odds ratio
Income	0.913	0.222	16.986	0.000	2.492
Services	0.246	0.055	19.968	0.000	1.278
Human capital	0.291	0.022	176.189	0.000	1.338
Assets	0.599	0.207	8.358	0.004	1.820
Inclusion	0.130	0.101	1.656	0.198	1.139
Vulnerability	-0.170	0.064	7.160	0.007	0.843
Rural	-0.568	0.160	12.621	0.000	0.567
country			8.782	0.032	
country(1)	-0.444	0.206	4.647	0.031	0.642
country(2)	0.094	0.200	0.220	0.639	1.098
country(3)	-0.394	0.207	3.604	0.058	0.674
Constant	-1.440	0.258	31.194	0.000	0.237

n=1565

The odds of gaining access to ICT are more than doubled by a unit increase in the

[19]/ 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. All variables pass a null hypothesis test that they do not significantly increase the ability to predict ICT access when entered.. Further the Cox & Snell R^2 statistic was a satisfactory 0.339. The Wald Chi-square tests the unique contribution of each predictor holding all other predictors constant. All predictors meet the conventional 0.05 level of statistical significance with the exception of the country dummy variables which is expected. The contribution of human capital is noteworthy. Interacting the predictors does not improve the model.

poverty score. Thus a move from a per capita expenditure that is equal to the poverty line, to one that is double the poverty line, increases the odds of having ICT by 2.5. A similar result is found for education, in which an additional year of school education increases the odds of having ICT access by 1.3. The odds of having ICT in rural areas are half of those in urban settlements, while additional shocks also reduce the odds of ICT access. Variables excluded from the final model include the sex of the household head which was not a significant predictor of ICT access. Excluding the country fixed effects does not change the sign or significance of any of the predictors but does increase the contribution to the model that is made by differences in income. This reflects the differences in the financial poverty incidence of the four countries.[20]

This model generates the following probability mapping of household ICT access by financial poverty status and education.[21]

Figure 12: Probability of household ICT access

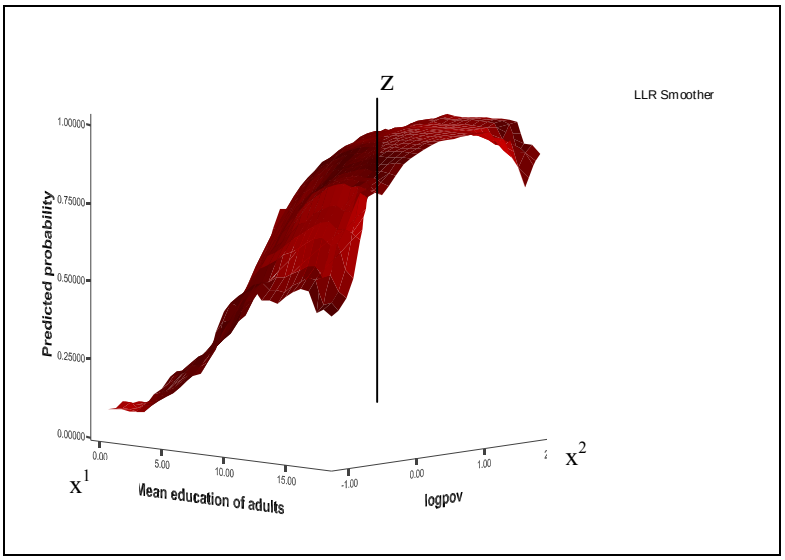


Figure 12 depicts the increase in the probability if ICT access on the vertical axis, mapped against increases in the mean education of adult household members on the x^1 axis and the log of the poverty score on the x^2 axis. The vertical line, z, represents the poverty line, with points to the left of this representing households that are poor. Confirming the results of the logistic regression, the probability of ICT access increases both as formal education levels rise, and as incomes increase. The three dimensional slope shows how the interaction of income and education dramatically increases the odds of ICT access to reach over 0.8 at around 1 times the poverty and eight years of formal education, that is 80 percent of households who are at the poverty line and who have adults with an average of eight years of education will have access to a mobile phone, SIM card, email account or a computer.

[20]/ The Wald chi square for the income predictor more than doubles to 35.380 while the odds ratio increases to 3.2.

[21]/ These independent variables have been chosen based on their contribution to the model. The results have been smoothed using a normal kernel with a bandwidth multiplier of 1.0. The method of smoothing is local linear regression.

Excluding the impact of education, the probability of ICT access is initially flat at pce's that are below half the poverty line but rises steeply thereafter to peak at four times the poverty line. The implication is that constraints on cell phone and internet access are quite quickly reduced once essential needs have been met and when households emerge from chronic poverty. Constraints on access are more likely to be in terms of location, and thus coverage, and the educational status of household members, than due to income. Finally the dip in the probability of ICT access at the extreme is probably due to the few data points at very high incomes and can be disregarded.

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 and income can be included in addition to the household measures of poverty that were used. The results of the binary logistic regression are shown in Table 7.[22]

Table 7: Predictors of individual ICT access

Predictors	B	S.E.	Wald	Sig.	Odds ratio
Age	0.018	0.003	36.851	0.000	1.018
Sex	-0.376	0.089	17.937	0.000	1.457
Individual income	0.004	0.000	131.655	0.000	1.004
Household Income	1.193	0.167	51.332	0.000	3.297
Services	0.160	0.037	18.948	0.000	1.173
Ind. human capital	0.166	0.013	175.007	0.000	1.180
Assets	0.281	0.074	14.472	0.000	1.324
Inclusion	0.103	0.055	3.593	0.058	1.109
Vulnerability	-0.120	0.044	7.327	0.007	0.887
Sex of head	-0.228	0.102	5.055	0.025	0.796
Rural	-0.304	0.115	6.989	0.008	0.738
country			2.957	0.228	
country(1)	-0.084	0.119	0.500	0.480	0.920
country(2)	0.146	0.122	1.431	0.232	1.157
Constant	-3.387	0.219	239.657	0.000	0.034

n= 3807

The household level indicators of incomes, assets and inclusion, and of vulnerability and access to services mostly have a similar effect on individual access to ICT as is the case for the household as a whole. However inclusion becomes almost significant, no doubt due to the larger sample. The formal school education of the individual makes the single largest contribution to the model, followed by the individual's income. Interestingly,

[22]/ All variables pass a null hypothesis test that they do not significantly increase the ability to predict ICT access when entered.. Further the Cox & Snell R^2 statistic was a satisfactory 0.336. The Wald Chi-square tests the unique contribution of each predictor holding all other predictors constant. All predictors meet the conventional 0.05 level of statistical significance with the exception of the country dummy variables which is expected. As before, the contribution of human capital (individual educational attainment) is noteworthy as is individual income. While it was anticipated that individual earnings and household poverty status would be highly correlated, this was not the case. Since removing the log of household poverty status does not change the sign or significance of any variable, nor the strength of the model, but does pass the null hypothesis test when included, this variable has been left in the model.

gender now emerges as an important predictor of ICT access with both the sex of the individual and the sex of the head of household being negative and significant. The latter is largely explained by the 42 percent of those who had access to ICT also being the head of the household.[23] The implication is that controlling for the different dimensions of household poverty, individual income and individual education, men are 1.5 times more likely to have access to ICT than women.

7 Conclusion

This preliminary analysis suggests a way in which multi-dimensional poverty can be depicted using scales for each of the five dimensions of poverty of interest to PICTURE, and then comparing the situation of households with and without access to ICT. When looking at the full sample, households without ICT are poorer in all dimensions than those with ICT, particularly in respect of education, services and economic assets. When only households below an income poverty line are considered, these gaps disappear, leaving only education as the major difference between those with ICT and those without. A multivariate analysis confirms the importance of formal education, but not surprisingly suggests that there is also an interaction between education and income, and that this enhances ICT access. A three-dimensional plot of the data shows that while additional units of education and income increases the probability of ICT access, the slope is far steeper when these are combined. The determinants of individual access to ICT are largely similar, although there is a clearer gendered distribution of ICT access, with women 1.5 times less likely than men to have a mobile phone or email address, controlling for income and education.

Further investigating the ICT/poverty nexus using PICTURE will require a more detailed exploration as to how education improves ICT access other than through its impact on the income generating ability of household members, and moving beyond access to explore the determinants of usage.

[23]/ Removing the sex of the head of household from the model does not significantly change any results.

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