Water Supply Projects as Entry Points for Building Information and Communication Technologies Centers in Rural Areas of Central Tanzania

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Abstract: In this paper, the economic profitability of a rural information and community center is analyzed. The objective is to demonstrate the economic viability of incorporating information and community centers as sub-projects in rural development programs. The center, a subunit of the community-based water supply system is powered by a solar power, and communication is through a wireless phone line extender. This is to facilitate long-term sustainability, through cost-recovery, as well as portfolio diversification to avoid marketing risk. The prototype is developed based on available technologies, and cost consideration. Investment analysis is conducted to compare the profitability and long-term economic benefits of the prototype at Chitemo Village, in the Dodoma Region. The results indicate that with careful planning the prototype was economically feasible and self-sustaining. While the results may be specific to Central Tanzania, it is a pity for Tanzania to continue to be an end user of solar power and wireless communication technologies, and not taking a lead in research and development. These technologies provide great opportunities to bridge the global digital divide and rural development in Tanzania.

1. Introduction

The old debate, about choosing between information and communication technologies (ICT) and other development imperatives, has shifted from one of trade-offs to one of complementarity. Experiences around the world show that, used for the right purposes; ICT can play a key role in national development strategies. Countries have pursued diverse strategies: some have focused on developing ICT to boost exports, or to build domestic capacity, or other countries are pursuing strategies which seek to use ICT as an enabler of a wider socio-economic development process (http://www.opt-init.org/framework/).

The unique Characteristics of ICT is derived from the fact that ICT is crosscutting. ICT can be applied to the full range of human activity from personal use to business and government. The "digital" and "virtual" nature of many ICT products allows declining marginal costs. Replication of content is virtually free regardless of its volume, and marginal costs for distribution and communication are near zero. As a result, ICT can radically reduce transaction costs, especially in developing countries.

A focused, micro-level application of ICT can contribute to individual development goals, including health, education, economic opportunity, empowerment and participation, and protection of the environment. ICT is being used in many communities to facilitate remote consultation, diagnosis and treatment (e.g., malaria Internet sites) that enable remote healthcare professionals to keep abreast of the rapidly evolving stock of medical knowledge. The use of ICT for education is well documented. The experience of the University of South Africa (http://www.unisa.ac.za) shows that the cost of Internet based distance education programs are 80 percent less than residential based education system. The development of scientific research networks is helping to empower indigenous researchers. Networking enables solution sharing and provides access to practical information, weather trends and farming best practices. Timely access to market information helps farmers make decisions about what crops to plant and where to sell their produce and buy inputs (http://www.opt-init.org/framework/pages/2.2.3.html).

Encouraging information sharing among people fosters community empowerment and participation. Using ICT, governments can improve the quality of the services as well as expanding the reach of services. Communities can share and exchange information of mutual interest, strengthen their

collective power, and shape their own development solutions (http://www.grameen-info.org/vcip/mission.html).

For Tanzania, two non-mutually exclusive approaches can be pursued to carry out the strategy of ICT as enabler of economic development. The first step is deploying ICT to position Tanzania to the global economy by creating high-tech environment and infrastructure that can attract national and international investors and create spillover effects in the rest of the economy. The good example is the Malaysia's Multimedia Super Corridor Project (http://www.export.ee/IT/text.html). However, this approach is capital intensive, and the success depends on availability of infrastructure and trained human capital with the required skills. Another approach is using ICT to balance sustainable economic growth with social empowerment. This approach is used in Estonia (http://www.africanconnection.org/). Increased competition in the telecommunications market has resulted in a 50-80% in the price of international long-distance calls, and price reductions of 50% for Internet connections. Rural telecottages supported by local governments help to promote economic development, education and scientific research in rural areas. Web design firms in remote area of Estonia, work for clients all over the world.

A report prepared for the African Connection Secretariat (http://www.**carlson**wireless.com/) identifies three major actions for ICT development in Rural Africa. Step 1: identify and promote rural market opportunities through market studies in the targeted regions, and create forums to present market information to telecommunication investors. Step 2: development of a dynamic rural toolkit that provides recommended basic standards, and steps for rural ICT projects initiatives. This toolkit would bring about a basic level of standards for rural ICT initiatives in order to guide agencies, research institutions, and private sector companies in networking activities. Step 3: building on the experience of Latin America, a government should work with private sector to promote and support the establishment of rural ICT funds for local projects, and ICT application in rural areas.

This paper analyzes the economic profitability one of the toolkits available in the market. The toolkit is used in rural America for communication purposes. The ICT center is built in the Chitemo Village, Dodoma Region, as a sub-project of the community-based water supply system. The toolkit is designed to facilitate long-term sustainability (through cost-recovery systems), community involvement, increased collaboration with the private sector, as well as portfolio diversification to avoid market risk. The toolkit or prototype is developed based on available technologies, and cost consideration.

To start with, the solar panel replaces the dies-el engines of the traditional deep-bore-hole water supply system. Apart from supplying power to the solar water pump, it generates electricity for the information and communication center. The telephone service is through the phone line extender manufacture by Carlson Wireless Technologies, Inc (http://www.opt-init.org/framework/pages/appendix3Case7.html), which provides both voice and data transmission up to 80 km away from the established phone line. Investment analysis is conducted to compare the economic profitability of the rural water supply system using the diesel engine and the solar-power system that include the ICT center in the village's water investment plan.

The paper is organized as follows. The following section presents an overview of the ICT situation in Tanzania. The objective is to give the highlights of what is happening in terms of infrastructure development, capacity building and policy changes. In the third section, the prototype of the rural ICT center is discussed. Required solar and communication technologies are identified and their usefulness presented. Investment analysis results are presented and discussed. The last section presents the conclusion arising from the study and policy implications.

2. Tanzania and ICT

There are some signs that Tanzania is preparing to reposition itself in the global network economy. Steps are being taken to leverage the benefits of ICT for its national priorities of growth and poverty reduction (http://www.tenet.res.in/Papers/papers.html). Key actions include: the creation of an e-secretariat, including key stakeholders to create supportive leadership for ICT development; communications infrastructure improvements; and restructuring of the financial sector to sustain a more market-driven economy. From the agriculture-based economy to a knowledge-based economy, Tanzania hopes to

antelope-jump many stages of ICT development. So far, the following steps have been taken.

2.1. ICT Policy

In 1995, Tanzania established an independent regulatory commission by separating the operations of the Tanzania Telecommunication Company from its regulatory functions. This led to the deregulation of the telecommunications market, and the government sale of 30 percent of its stake to international and local consortia companies. Infrastructure: The capital city, Dar es Salaam, has seen dramatic improvements in the local core network infrastructure. Advances include: new digital exchanges, cellular networks with nearly more than 50,000 subscribers, dozens of new ISPs, and pay phones in different locations. While there has been rapid improvement in infrastructure, network access in areas outside Dar es Salaam is still very limited and teledensity remains extremely low (http://www.unu.edu/unupress/unupbooks/uu19ie/uu19ie0i.htm).

2.2. Enterprise Development

Tanzania's development has been funded by donations rather than foreign direct investment. By deregulating its telecommunications market, Tanzania has been able to attract international operators by issuing licenses for a fee, but other industries have not yet seen much investment due to the need for both policy and procedural reforms. A number of ISPs are now offering Internet trading to farmers and other businesses to sell their products around the world. The government has embarked on an effort to improve the business environment through the revision of the regulatory and tax regimes to stimulate private sector led growth. Tanzania has successfully restructured the financial sector, resulting in an increase in the number of private financial institutions and a more market-oriented business sector.

2.3. Human Capacity Development

A 20-year prohibition on importing computers has adversely impacted development in ICT skills. Training centers that focus on the development of ICT knowledge are only now beginning to emerge. The Soft Tech Training Center, established in 1993, is committed to the development of local expertise through ICT skills enhancement. However, Tanzania has placed a short-term emphasis on the urgent need to develop ICT skills, rather research and development.

2.4. ICT Content and Applications

The government has initiated plans to launch a campaign to encourage Tanzanians to develop and propagate content that is relevant to local interests and social values. Tanzania has also implemented several ICT applications relevant to its national objectives. Examples of such initiatives include an information system to strengthen the capacity of wildlife institutions and a computerized case flow management system that has facilitated an increase in transparency and professionalism in the judiciary system.

2.5. Strategic Compact

In 1999, Tanzania started an e-think tank to bring together different Tanzanian stakeholders, including the government, for the purpose of discussing ICT benefits and formulating National ICT strategies. An e-secretariat was designated to coordinate the activities of the e-think tank. Its mission is to offer ICT leadership by utilizing policy changes and supporting related developments aimed at enabling Tanzanians to participate effectively in the modern Internet-based global economy.

Nevertheless, a challenge of establishing rural information and communication technologies centres (ICTC) is to provide telecommunication access, and power at reasonable cost. Exchanges/remote terminal units (RTUs) or cable connections are needed to connect the ICTC to the rest of the world (http://www.digitalpartners.org/baramatipresentations/**rural**.ppt). One key issue is that entry costs may be prohibitive due to limited revenue potential and small market size. The investments will be high irrespective of technologies used to provide these services separately or through convergence with other economic activities. Any approach to rural ICT needs to be based on a diversified portfolio that can generate enough return to support telephones services without necessitating the subsidy from the government. The ICT Center should be an investment that offers a variety of services to different sectors or organizations in the area to cushion market risks.

However, ICT investors are generally reluctant to invest in rural areas, due to risk associated with small and dispersed markets. Additionally, demand for information services in rural areas is

unavailable; overheads have to be kept low to serve a cost sensitive market. Moreover, technology solutions will have to be adapted to local conditions. Thus, private investors driven by profit are unlikely to invest in rural ICT centre. Public investment in infrastructures, and research and development are essential in reducing entry costs, and generating market information for private investors.

3. Investing in ICT Centers Converged on Rural Water Supply

Past failures of rural water development policy in Tanzania has encouraged the adoption of a new water sector vision, based on the demand responsive approach (DRA). This vision regards water as an economic and social good to be managed at the lowest appropriate level. The DRA recognizes the existing capacity of communities to take responsibility for identifying and solving their water supply problems. WaterAid, an NGO based in London, is investing some fund to develop community-based water projects in Dodoma Region under "WAMMA" project. The government provides technical assistance for ongoing WAMMA projects, with WaterAid and the community providing initial capital requirements, overhead costs and supervision in the design and implementation of the projects. When the water utility is operational, the villagers pay for the water from the utility. Some follow up studies conducted in the region indicate that the projects were economically profitable and sustainable (http://www.uaex.edu/akaliba/Documents.htm). With careful planning, the water supply projects can be a hub, for developing rural ICTC.

This study uses the data corrected in July 1999 to demonstrate the economic profitability of rural ICT center converged on a water supply project in Chitemo Village. The village is in the Mpwapwa District, about 20 km from Mpwapwa Township. In 1999, the village was resident to about 1,898 people (385 households). The neighboring villages are Berege (3,016 residents and 615 households) and Mima (2,929 residents and 604 households). Berege is about 3 km West of Chitemo and Mima is about 8 km East of Chitemo. The Village water supply project in Chitemo was installed by WAMMA. The source of water is a borehole operated by a single piston diesel engine. The ICT center is proposed to be in Chitemo village, but also serving Berege and Mima villages. The installed 250watt solar panel supplies electricity to the water pump, the ICT center, the nearby dispensary, and the village administration office. Another 50-watt solar panel is installed at the school to run the school computers and other communication equipment. The ICT center provides voice and electronic communication. There is also booster antenna to increase the range of wireless communication to Berege and Mima Villages.

Table 1 presents the basic components required to establish the ICT center in Chitemo Village. The toolkit uses solar energy to pump water for both livestock and domestic use, and generate electricity to power the ICT center and other necessary equipments. Solar or photovoltaic (PV) panels produce electricity from sunlight. Solar water pumps are specially designed to utilize DC electric power from photovoltaic panels. Solar water pump technology can benefit only a slightly from economy of scale, whether it is sized for 0.5 KW or 50 KW. Today's market for small solar pumps (less than 2 HP) is far greater than the market for larger ones. How much water will a 2 HP solar pump move? As an example, with a vertical lift of 5m it can pump about 800 liters per minute in full sun (http://www.solar-electric.com/water.html). In one day, it will pump about 350 cubic meters. Demand for water by both households and livestock use in rural areas is approximated to be 20-50 liters/day/person; cattle, 25-40 liters/day/LU; and small animals, 5-10 liters/day/animal.

A charge controller is an essential part of all power systems that charge batteries, whether the power source is PV, wind or hydroelectric. Its purpose is to keep batteries properly charged. The charge controller blocks reverse current and prevent battery overcharge. An inverter changes direct current (DC) electricity from the batteries into alternating current (AC) electricity to feed standard house loads. A phone Line Extender is a fixed point-to-point wireless local loop (WLL) telephone system that delivers two full-service telephone lines. The system provides both voice and dial-up modem capabilities with data transmission at distances up to 22 km or up to 80 km with an optional external antenna.

Results of a partial budget for the two technologies (i.e., diesel engine and solar based water supply system) are also presented in Table 1.

A partial budget is used to calculate expected change in profit for a proposed change in investment choices (Kay, 1981). When the ICT center is considered, there is an additional cost of about 24 million Tanzania shillings (Tshs) for building and equipping the ICT center, which generate about 25 million Tshs annually from the services provided by the ICT center and saving from the diesel-engine-based project.

Table 1. Partial Budget for ICT center at Chitemo Village, Dodoma Region, Tanzania

a. Addition costs		**Cost/unit**	**Number units**	**Tshs***
1. Telephone connection	Phone Line extender	4,000,000	1	4,000,000
	Parabolic External Antenna	250,000	1	250,000
	Cables	103,200	1	103,200
	Different Cards	1,930,000	1	1,930,000
	Serial programming adopter	193,000	1	193,000
	Sub total			**6,476,200**
2. Power Supply	Solar Panels (250 and 50 W)	3,500,000	1	3,500,000
	Battery, inverter & charger	350,000	2	350,000
	Cable and other accessories	50,000	1	50,000
	Installation and other charges	175,000	1	175,000
	Sub total			**4,525,000**
3. Water pumping system	2HP Solar water pump	1,500,000	1	1,500,000
	Accessories (20%)	300,000	1	300,000
	Sub total			**1,800,000**
4. ICT center and structures	Building and other structures	3,500,000	1	3,500,000
	Computers: 2 for school & 3 for the ICTC	750,000	5	3,750,000
	TVs: 1 for school & 1 for the ICTC	200,000	2	400,000
	Photocopy and fax machines	250,000	2	500,000
	Accessories for the equipments (20%)	190,000	1	815,000
	Sub total			**8,965,000**
5. Other charges	Salaries for the ICT technician	840,000	1	840,000
	Training and consultancy	500,000	1	500,000
	Maintenance of the system (1%)	1,110,076	1	1,110,076
	Sub total			**2,450,076**
B. Total additional costs				**24,216,276**
C. Additional Revenue	Telephone and fax services	48,000	160	7,699,200
	E-mail services	48,000	160	7,699,200
	TV services	48,000	80	3,849,600
	Other services	120,000	1	120,000
	Sub total			**19,368,000**
D. Reduced Cost	Diesel engine	3,500,000	1	3,500,000
	Parts and Services	1,085,245	1	1,085,245
	Diesel and oils	1,050,860	1	1,050,860
	Sub total			**5,636,105**
E. Total additional Revenue and reduced Cots (D+E)				**25,004,105**
F. Net Change (E-B)				**787,829**

*Exchange rate: $1=1000Tshs

The additional revenue is calculated based on the following assumptions. A hundred and sixty households (10%) in Berege, Chitemo, and Mima villages can afford to pay 1000 Tshs a week for telephone and fax, and e-mails services, and 80 households (5%) can spend Tsh 1000 a week for television services. The ICT center is also running a cold drink shop that generates a net profit of Tshs 120,000 a year (personal experience). Based on Table 1, there is a 739,829 Tshs net-change in profit by switching from the old to the new system with the ICT center.

Investment analysis or capital budgeting was used to determine the long-term profitability of the investment (Tables 2). Initial investment costs for the traditional technology were adapted from WAMMA estimates. About 7,500,000 Tshs is needed as an initial investment for traditional technology. For the traditional technology, revenue, operation, and management costs were obtained from Chitemo Village financial record books. Operation and management costs include expenditure on diesel fuel and oil to run the engines (Tshs 548,275/year), replacement of spare parts and servicing the engines and the borehole (Tshs 566,215/year). Labor costs are for salaries to water managers, security guards, honoraria (Tshs 353,243/year), and other costs (Tshs 167,189/year). The project was able to generate 2,461,196 Tshs annually. For the water project with ICT center, operation and management costs are for parts (Tshs 1.11 million/ annually), labor (Tshs 1.2 million annually), and other costs related to the management of the project (Tshs 667,189/ annually). The third scenario is for an independent ICT center not converged to the water supply system.

The estimated annualized revenue and costs for the villages were used to generate 21 years of cash flows and to estimate three economic profitability measures (i.e modified internal rates of returns (MIRR), net present value (NPV), and average annual profit (AP)). Demand for water is estimated to grow by 2.5% annually (population growth rate), and demand for ICT services is estimated to grow by 5% annually. By definition, MIRR is the discount rate that makes the present value of the cash flows equal to the present value of the cash outlays required by the investment. The MIRR considers both the cost of the investment and the interest received on reinvestment of cash (Barry et al. 1995). It is anticipated that all the funds to finance the investment were borrowed and the loan repaid by the cash proceeds from the investment as they were earned, additionally, some of the proceeds are reinvested to yield an interest rate equal the cost of capital (i.e., 10%).

The difference between AP and NPV is that the AP is an average per year profit while the NPV is the present value of profit (Barry et al, 1995). The calculated MIRR for the three scenarios were 22.7%, 23.4%, and 20.1% for the traditional, new water system with the ICT center, and the ICT center alone. The MIRRs were calculated based on the reinvestment rate of 10% to cushion for inflation. Given the average nominal (market) interest rate of 30% and inflation rate of 8%, the real interest rate is 20.4%. The real interest rate is calculated as follows: $r^*=(1+r)/(I+f)-1$, where r^* is the real interest rate, r is the nominal interest rate, and f is inflation rate. Whereas all projects were economically profitable, only the traditional technology and the water project with an ICT center can borrow from the bank at 30% interest rate and be able to pay back the loan in 21 years, while investing 10% of the revenue to cushion for inflation.

The calculation of the NPV helps to identify the level of cost of capital at which the project becomes economically unattractive (i.e., NPV becomes negative) and helps in setting an interest rate ceiling for capital borrowing. In Table 2 it can be seen all projects were still economically profitable at the interest rate of 30%. Despite high initial investment requirements, the water project with the ICT center outperforms the traditional water system and the independent ICT. Additionally, note that the water system with the ICT center provides some services to schools, dispensaries and administration buildings. These benefits were not quantified by the analysis. The environmental benefits from the system need not to be overemphasized.

4. Conclusion and Implication for Policy

Financial institutions and ICT investors are generally reluctant to invest in rural areas, due to risk associated with small and dispersed markets. Additionally, demand for information services would have to be generated through aggressive marketing, overheads will have to be kept low to serve a cost sensitive market. Moreover, techno-

logy solutions will have to be adapted to local terrain and conditions. Large organisations are unlikely to be able to operate in these situations. However, currently, a lot is so much happening in the technology front and it is becoming easier to provide telecommunication services to rural areas. This study demonstrates that it is economically profitable to build information and communication technologies centres in rural areas of Central Tanzania, as business subunit of a water supply program. This is achieved by using a wireless telephone line extender that connects telephone services from the existing lines. This technology is appropriate because it is relatively cheap, and it is easy to regulate. When combined with other important services such as water supply projects, ICTC may attract more people and minimize marketing risk.

Tanzania can reap the benefit of solar power and wireless communication technologies bypromoting public investment in infrastructures for rural communication.

Table 2. Investment and Economic Analysis Results *

		Traditional	T-ICT	ICT only
Total Investment		7,500,000	22,539,510	22,539,510
Operation and management costs	Diesel and oils	548,275	0	0
	Spare parts	566,215	1,629,116	1,062,901
	Labor costs	353,243	1,193,243	840,000
	Other costs	167,189	667,189	500,000
Total annual operation and management costs		1,634,922	3,489,548	2,402,901
Annual Sales		2,461,196	21,781,196	19,320,000
Economic Analysis Results	Modified IRR	22.74%	23.41%	20.22%
	Net Present Value (30%)	1,982,529	38,232,454	29,232,275
	Average annual profit (30%)	406,080	7,831,117	5,987,619

* T-ICT=Traditional water technology with ICT

The local governments at the district level need to establish ICT units. In collaboration with the e-secretariat, units should develop and test the standardised toolkit to be adopted at the district level. Involvement of local governments is important in ensuring availability of the required money through borrowing, providing ICT services to the rural poor, and serving the public interest. For example, a district may invest into the infrastructures and lease the management of the infrastructures to local entrepreneurs at a fee. Since the technologies can be spliced into subunits, competitions among units will ensure investment in emerging technologies that are more efficient and future growth of the services.

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