A. Case studies

B. Methodology

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B.1 Benefits and Costs
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B.3 Market mapping
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Below is a more detailed description of the process the team used to analyze the costs, benefits and poverty impacts of multiple-use approaches compared to single-use approaches

Type and Extent of Uses Supported at Each Service Level

Identified common water use activities—home gardens, livestock, small-scale enterprises and domestic use of irrigation systems: To assess incremental benefits (both financial and non-financial), the research team identified the most common additional livelihood activities (home gardens, livestock, small-scale enterprises and domestic uses of irrigation systems). Identification of common livelihood activities was based on a review of the literature (see next slide for selected list of studies reviewed to identify uses and poverty impacts).

Assessed water requirements for each activity. Water service requirements to support each livelihood activity were estimated based on literature review and consultation with practitioners. For example, home gardens require 3-8 lpcd per m^2 and livestock drinking includes a wider range of water quantities (cattle 25 lpcd, goats and sheep 5 lpcd, chickens 0.3 lpcd). Other service level criteria, such as quality (required to support drinking and domestic uses), distance and reliability were assessed (see slide at the end of this section for analysis of distance, quantity of water hauled and time)

Estimated extent of activity that could be supported at each service level for domestic+ and irrigation+. For each service level, the potential extent of each livelihood activity was estimated. For example, number of cattle, square and meters of garden. Uses and water requirements were validated through consultations with experts in the field.

	Geographical Area	Home Gardens	Livestock	Small Scale Enterprises
Domestic plus	**Sub-Saharan Africa**	**South Africa (9)** (Perez de Mendiguren, 2003; Hope, Dixon and von Malitz, 2003; McKenzie, 2003; Perez de Mendiguren and Mabelane, 2001; Soussan et al, 2002; Maluleke et al 2005; Maunder and Meaker, 2006; Gilimani, 2005; Averbeke and Khosa, 2007); **Zimbabwe (3)** (Proudfoot, 2003; Plan International; FAO, 2005); **Senegal (2)** (Brun et al, 1989; Marek et al 1990); **Cameroon** (Bradford et al, 2003); **Sudan** (Plan International); **Zambia** (Plan International); **Mauritania** (Bingham, 2007)	**South Africa (3)** (Perez de Mendiguren, 2003; Perez de Mendiguren and Mabelane, 2001; Gilimani, 2005); **Uganda** (Kabirizi, 2004); **Mauritania** (Bingham, 2007); **Sudan** (Plan International); **Zambia** (Plan International)	**South Africa (3)** (McKenzie, 2003; (Perez de Mendiguren and Mabelane, 2001; Perez de Mendiguren, 2003) **Malawi** (Mulwafu, 2003)
	South Asia	**Nepal (2)** (Pant, 2005; NEWAH, 2005) **India** (Bradford at al., 2003) **Bangladesh (2)** (Helen Keller Foundation, 2001; Marsh 1998)	**India (4)** (Bradford, et al 2003; Upadhyay, 2004; James, 2003; Verhagen, 2004); **Nepal** (NEWAH, 2005)	**India (3)** (James, 2003; Verhagen, 2004; James et al, 1992)
	Other	**Vietnam (2)** (SEI; URS, 2004)**; Nicaragua** (Alberts and van der Zee, 2003); **Global** (Nugent, 2000; IFRI, 2001); **Asia-Pacific** (Helen Keller International, 2001)	**Global** (Gura and LPP, 2003)	**Colombia** (Smits, et. al., 2003);
Irrigation plus	**Sub-Saharan Africa**	**Kenya** (Plan International);l **Sub-Saharan Africa** (Inocencio, 2002)	**Uganda (2)** (Dolan, 2002; van Hoeve and van Koppen, 2005); **Kenya** (Plan International); **Ethiopia (2)** (van Hoeve, 2004; van Hoeve & van Koppen, 2005);	
	South Asia	**Sri Lanka (2)** (Meinzen-Dick & Bakker, 2001; Molle and Renwick, 2005); **Bangladesh** (AVRDC, 2000)	**Sri Lanka (2)** (Meinzen-Dick and Bakker, 2001; Bakker and Matsuno, 2001) **Pakistan (4)** (Jehangir, Madasser, Ali, 2000; Ensink et al 2002; Jensen et al 2001; van der Hoek, 2002b); **Nepal** (Thomas-Slayter and Bhatt, 1994)	**Sri Lanka (2)** (Meinzen-Dick and Bakker, 2001; Bakker and Matsuno 2001)
	Other		**Morocco** (Boelee & Laamrani, 2003)	**Morocco** (Boelee and Laamrani, 2003)
MUS by design	**Sub-Saharan Africa**	**Zimbabwe (2)** (Waughray, et al, 1998; Matthew, 2003)		**Zimbabwe** (Matthew, 2003)
	South Asia		**India** (Palanisami and Meinzen-Dick, 2001); **Nepal** (Winrock 2007d)	**India** (Palanisami and Meinzen-Dick, 2001)

Benefits and Costs: Domestic plus--Relationship between distance, quantity and time hauling water

Quantity liters	# trips	Minutes to source round trip							
		0	5	10	15	20	30	60	90
		….. minutes ….							
10	**1**	0	5	10	15	20	30	60	90
20	**1**	0	5	10	15	20	30	60	90
40	**2**	0	10	20	30	40	60	120	180
60	**3**	0	15	30	45	60	90	180	270
80	**4**	0	20	40	60	80	120	240	
100	**5**	0	25	50	75	100	150		
150	**7.5**	0	38	75	113	150	225		
200	**10**	0	50	100	150	200			
250	**12.5**	0	63	125	188	250			
300	**15**	0	75	150	225				
400	**20**	0	100	200					
500	**25**	0	125	250					

Assumes 20 l/trip

The willingness of the poor to haul water for productive uses depends on a number of factors including physical capability, available labor, method of transport (e.g., wheelbarrow vs. bucket), income potential, and alternative sources of livelihoods.

Note: Some research suggests that men are willing to participate in hauling water and investing in water transportation and storage when productive activities are involved. Further research is needed to address this issue.

Financial Benefits

At each service level, the team calculated the potential income generated from home gardens, livestock, and small-scale enterprises using the following process:

Reviewed literature to identify estimated returns by activity area: Extensive review of literature for existing estimates of net returns for home, livestock and small-scale enterprises based those actually observed in the field supplemented by limited primary data collection (**see data and estimates below**).

Standardized estimates to allow comparison by:

Converting to common production units. All returns were converted into a standardized production unit, such as returns per head of livestock or square meter of garden.

Annualized. All returns were annualized where necessary.

Currency conversion to 2004 purchasing power parity international dollars (PPP $I). Because the data was collected from several countries over many different years, country specific GDP deflators were used to inflate/deflate to 2004 local currencies and then convert to US$ Purchasing Power Parity (PPP) (World Development Indicators, 1994-2006).

Estimating average returns per unit activity: For each of productive use, we conducted statistical analyses of standardized estimates to generate standard summary statistics such a mean, median and standard deviations (see summary statistics in annex C for each use).

Calculating potential income by service level: To estimate the potential income generated from livelihood activities at each service level, we multiplied the mean income generated by the extent of the activity supported at each service level. For example, based on the literature review, the average annualized return for home gardens was found to be $1.08/m^2. To reflect seasonality of home garden production and differences in intensity of production (some households produce year round, others only for one season), one-third of the average annualized return ($0.36/m^2) was used to derive an income range. Thus, the income potential from a 100m^2 home garden was estimated to be from $36-108/year (see estimates in Annex C below).

Calculating potential income by service level cont.

Validating estimates: Income estimates by activity and service level were cross-checked with available estimates from the literature, where possible, and were validated by experts in the field.

Converting household-level income estimates to per-capita estimates: For each service level, the range of annual household income estimates per activity were converted to per capita estimates, assuming an average household size of 5, to make comparable to cost data, which is expressed in per capita terms.

Incremental income benefits by service level: Incremental income benefits were estimated taking the difference between income generated at each service level.

Costs

Based on available data, ranges of estimated costs were determined for identified technologies and service levels. Costs include hardware, software, and recurrent annual costs (see data at end of section for further details on what is included in each cost component as well as data used for the analysis).

Identified technologies: Based on review of available global data, several key technologies were selected for the cost analysis based on the following criteria: (1) prevalence of use in large segments of the rural population in South Asia and sub-Saharan Africa; (2) potential to support multiple-use services; (3) availability of data (on prevalence and cost). Main technologies evaluated for domestic+ and irrigation+ (estimated number of people currently receiving such services in South Asia and sub-Saharan Africa are listed in parentheses):

For domestic+

- Networked piped systems (500 million)
- Communal boreholes with hand pumps (500 million)
- Hand-dug wells (>150 million)
- Infrastructure add-ons to support activities such as livestock troughs, lifting devices and community gardens

Irrigation+

- Large-scale irrigation systems (450 million); infrastructure add-ons to support domestic and productive activities such as livestock troughs, cattle crossings, bathing facilities, canal steps, communal and household storage, home water treatment

Identifying technologies cont.

Although there is significant potential for rainwater harvesting to support multiple use approaches, we have not included rainwater harvesting in our analysis for two reasons. First, rooftop household level rainwater harvesting generally does not reliably meet water needs year round or provide sufficient water to support many productive activities. Second, surface collection of rainwater for productive uses must be used in combination with improved sources to provide domestic needs. More research is need on the potential for rainwater harvesting to support multiple uses.

Hardware costs

Reviewed literature and conducted limited primary research to identify range of hardware costs: Conducted an extensive literature review coupled with limited primary research and expert consultations to identify per capita hardware costs for selected technologies in rural South Asia and sub-Saharan Africa for both new services and incremental upgrades based on starting and ending water service levels (see selected data used for cost analysis at the end of the section).

Standardized estimates to allow comparison. Standardized estimated of hardware costs for each estimate to make them comparable:

Common units—per capita measures. All costs were converted, if needed, into a per capita basis.

Currency conversion to 2004 purchasing power parity international dollars (PPP $I). Because data was collected from several countries over many different years, country specific GDP deflators were used to inflate/deflate to 2004 local currencies and then converted into Purchasing Power Parity $US I (World Development Indicators, 1994-2006).

Estimated incremental hardware costs by technology and service levels for irrigation+ and domestic+. For each technology, estimated the average costs of new services and upgrades to existing services to support multiple uses.

Software costs
Software costs for domestic systems are typically on the order of 10% of hardware costs. For multiple use approaches, software costs are likely to be significantly higher because of the need for new management capacity, extension, and related inputs for productive uses and hygiene education, as well as cross-sectoral coordination and new management models to support implementing at scale. Based on the ongoing multiple uses research, the International Water and Sanitation Centre estimates that total software cost (technical assistance and program support costs) for multiple use approaches could be on the order of 30-50% of hardware costs. This estimate is corroborated by evidence from Winrock and IDE's implementation of over 60 multiple-use by design systems in Nepal where total software were on the order of 40-50%. For the purposes of the financial analysis, we assume 40%.

Recurrent annual costs: Recurrent annual costs include operation and maintenance, source water protection and capital maintenance fund and were estimated based primarily on Hutton and Haller (2004),

- Annual operations and maintenance costs were estimated at 5% of total hardware costs for all systems, except for household piped connections, which were estimated at 30%.
- Source water protection was estimated at 5% of hardware costs for boreholes and protected wells and 10% for piped schemes.
- Capital maintenance fund costs were estimated based on the estimated useful life of the capital investment. For example, 25% of capital costs per year for a useful life of 5 years, 15% for 10 years, and 10% for 20 years. In addition, for irrigation plus investments involving home water treatment and hygiene education programs, annual recurrent costs of $2 per capita were included for point-of-use home treatment costs.

Repayment periods were calculated based on the period of time it would take to cover hardware and software costs based on estimated average annual income benefits less annual recurrent costs.

Cost-Benefit ratios

Cost-benefit ratios for new services and incremental upgrades were calculated assuming a discount rate of 10% where:

- Costs were defined as the per capita full capital investment costs in year 1, including hardware and software costs
- Average useful lifetimes for infrastructure we estimated following Hutton and Haller (2004) and Brikke and Bredero (2003)
- Benefits were defined as the net present value of the stream of annual per capita mean income benefits less annual per capita recurrent costs (operation and maintenance , source water protection and capital maintenance fund) over the useful lifetime of the infrastructure.

Sensitivity Analysis: To evaluate how variations in net returns might influence the results, benefit-cost analysis was conducted under four net income scenarios, where net income equals annual per capita mean income less recurrent costs:

- Conservative (25% of estimated annual net income potential achieved)
- Moderately conservative (50% of estimated net income potential achieved)--base case
- Moderately optimistic (75% of net income potential achieved)
- Optimistic (100% of income potential achieved).

Non-financial benefits and poverty impacts

To capture non-financial benefits and impacts on poverty, the study analyzed a series of global poverty surveys and approximately 40 credible research studies (see preceding table for selected list of studies and bibliography). Drawing on the sustainable livelihoods framework, assessments were made of the non-financial incremental benefits and poverty impacts of multiple use water services verses single-use services in terms of four key factors known to impact poverty: food security, health and nutrition, vulnerability/livelihoods diversification and social equity and empowerment (Ravnborg, et al. 2007). Each of these factors can contribute to other improvements in financial, human, physical and social capital, simultaneously alleviating multiple dimensions of poverty," (Ravnborg, et al. 2007). The potential poverty impacts of home gardens, livestock, small-scale enterprises and domestic uses of irrigation water for each factor were qualitatively ranked (low, medium, high).

To accurately reflect the incomplete nature of the available evidence, the research team utilized a ranking system key findings based on the quality, quantity and consistency of available supporting data:

- **Well-supported**: significant number of high quality that consistently provide corroborating evidence
- **Partially-supported**: number of high quality studies, or numerous studies with only partial data, that provide consistent, but partial corroborating evidence.
- **Inconsistent evidence**: inconsistent findings from studies
- **Anecdotal evidence**: observed but not well-studied or documented

For each key finding, illustrative examples were provided. See Annex A for a detailed discussion of selected case studies for multiple-use by design, domestic+, and irrigation+ and Annex C for further examples by use and type of poverty impact.

Market entry points—domestic and irrigation systems

The research team identified and evaluated two market entry points for reaching the rural poor in sub-Saharan Africa and South Asia:

Domestic+. The study evaluated the potential for providing multiple-use water services through domestic water service models, either by providing new services for a portion of the **440 million people** without services or by upgrading existing systems for a portion of the **1 billion people** with services.

Irrigation Services. The research evaluated the potential for upgrading existing irrigation systems to support multiple uses through incremental improvements for a portion of the **450 million people** living in irrigated areas of South Asia and sub-Saharan Africa.

Overview of basic process used for identifying high potential markets

The research team used the following process to identify to identify high potential markets for multiple use services (further details are below):

Step 1: Assess potential markets based on existing service levels using available global data sets, including remote sensing, to identify attributes of water services (quantity, quality and distance) for populations by country based on market entry point (irrigation or domestic) and current service levels.

Step 2: Disaggregate potential markets by technology/water source for water service levels using available global data sets.

Step 3: Identify markets with highest potential using results from cost and benefit analysis.

Step 4: Assess socioeconomic characteristics of households in these markets to determine if they could benefit from multiple-use services, i.e. are characterized by poverty and malnutrition but with the necessary assets (land and livestock) to make productive use of water.

Data. Two global data sets were used to estimate populations who might benefit from multiple use approaches-- 2004 Joint Monitoring Program for Water Supply and Sanitation (JMP) and 2003 World Health Organization (WHO) World Health Surveys (an overview of the data sources are provided on the next slide).

Estimating populations by service level. The JMP data (located at http://www.wssinfo.org/en/watquery.html) provides data for rural populations in all countries of South Asia and sub-Saharan Africa on households with and without "improved" water services. Improved water services are defined as follows:

Quantity: >20 lpcd
Quality: "improved" source
Distance: < 1 km (30 minutes round-trip) from the household.

Households with services were further disaggregated into those with and without household connections. No information is available on the type of water system used.

Intermediate Output: JMP data was used to estimate rural populations at the following service levels for each country:

Highest MUS—household connections from improved sources
Combined Intermediate MUS, Basic MUS and Basic Domestic—households with improved domestic water services (excluding household connections)
No Services—households whose water services are either of from an unimproved source, too distant (>1km) and/or <20 lpcd from an improved nearby source.

A primary limitation of the JMP data for the purposes of this study is that it does not provide sufficiently detailed information on domestic service levels (such as distance) to disaggregate the households into the three "intermediate multiple uses, basic multiple uses, and basic domestic" groups. In addition, the JMP global data set does not contain easily available and comparable data on types of technologies used to provide water services.

B.3 Market Mapping: Domestic+—overview of data used for analysis

Data Sources	Services levels	Entry-points: Type of system	Comments	Usefulness in mapping exercise
JMP*	**Quantity**: households >20 lpcd & < 20 lpcd **Quality**: improved & unimproved sources* **Access**: <1km (30 minutes) **Reliability**: ?	No information on how services are provided (e.g., wells, surface water, etc.), except hh connections	Full geographic coverage for sub-Saharan Africa and South Asia, including rural and urban populations	•Identification of populations with existing domestic services and those without by country: •Identification of possible domestic + market (domestic to intermediate) •Identification of high-level mus potential (household connections)
DHS**	**Quantity**: no information **Quality**: no **Access**: % hh <15 minutes to source & median time to source **Reliability**: no	Sources of drinking water: piped, wells, surface, rainwater, tanker but doesn't distinguish between improved and unimproved	Good geographic coverage for most of sub-Saharan African and South Asia, including regional and provincial data for all countries, including urban and rural. Some data is dated (<2000).	•Identification of sources of water and time to source (% < 15 minutes & median time to source •Provides basis to estimate of populations with access (e.g. physical proximity to source) to support MUS
WHO	**Quantity**: households >20 lpcd & <20 lpcd **Quality**: improved and unimproved sources **Access**: hh/yard connections plus distance in time RT for others (<5 min, 5-30 min, 30-60 min, > 60 min **Reliability**: no	Sources of water by type of source (piped to hh/ yard tap, well, spring, rainwater, etc.) disaggregated by improved and unimproved sources	Most geographic coverage—13 countries in sub-Saharan Africa and all of South Asia.	•Possible to map data into defined domestic plus service levels, allowing estimates of populations for no access, basic domestic/basic mus, intermediate mus and high mus. Because of data limitations, basic domestic & basic mus are estimated together. •In addition, the data permit disaggregating populations considered" by JMP data—limited basic domestic (those having access to nearby improved sources but less than 20 lpcd) and productive (those having access to nearby unimproved water sources with >20lpcd that could be used for productive activities.

*Joint Monitoring Programme between WHO and UNICEF, 2004; **Demographic and Health Surveys, 2007

Further disaggregating service levels using WHO data.

The World Health Survey data (see http://surveydata.who.int/webview/index.jsp), which provides much more detailed information on the nature of water services and technologies, was used to further refine estimates of rural populations by service level for South Asia and sub-Saharan Africa and technology source. World Health Survey data was available for all countries in South Asia and the following 15 countries in sub-Saharan Africa: Burkina Faso, Chad, Congo, Cote d'Ivoire, Ethiopia, Ghana, Kenya, Malawi, Mali, Mauritania, Namibia, Senegal, South Africa, Swaziland, and Zimbabwe.
For surveyed countries, most contain representative surveys of several thousand rural households.

Using searchable database options, the survey data was disaggregated into the following 4 categories by type of water source/technology, allowing estimates of the percentage of rural population with the following service levels:

Highest Level MUS – household connections, >20 lpcd from an improved source, piped sources
Intermediate MUS – > 20 lpcd from an improved source that is < 5 minutes (150 m round-trip) from household
Basic MUS/Basic Domestic – > 20 lpcd from an improved source that is 5-30 minutes roundtrip (150-1km) from household
No Services – same as JMP definition

Because data on distance to source is aggregated to 5-30 minutes roundtrip (instead of 5-15 and 15-30 minutes), separate population shares for the basic multiple-use and basic domestic service levels cannot be estimated.

***Intermediate Output:* Percentage of rural households by service level and technology for South Asia and 15 countries in sub-Saharan Africa.**

Linking WHO and JMP datasets to estimate populations for each service level and technology.
Estimates of rural populations by service level and technology are estimated by multiplying the WHO percentages developed above with 2004 rural population data from JMP data for each of the surveyed countries.

Validating WHO estimates. Country level estimates were validated by comparing population estimates based on WHO Health Survey information with JMP estimates, as follows:

JMP Highest MUS = WHO Highest MUS
JMP Improved = WHO Intermediate MUS + WHO Basic MUS
JMP Unimproved = WHO No services

For all but a few countries, the WHO estimates were within 5% of JMP estimates, corroborating the validity of the WHO estimates.

Disaggregating service levels for JMP data based on WHO analysis.
JMP data for each country was disaggregated into the four multiple use service level categories by applying the distribution calculated for the corresponding WHO data. For instance, to find the JMP Intermediate MUS category, we multiplied JMP Improved by the fraction for WHO Intermediate category:

JMP Intermediate = JMP Improved x [WHO Intermediate MUS/ (WHO Intermediate MUS+ WHO Basic MUS)]

In this way, for the 15 countries with WHO data, we were able to estimate populations for JMP Intermediate MUS and JMP Basic MUS based on the JMP general categories and WHO distribution.

For the 28 sub-Saharan countries that have JMP data but do not have WHO data, we applied an averaged distribution derived from the 15 WHO countries. First, the WHO countries were divided based on the Highest MUS category. This category was trimodal – most countries (9 out of 15) had Highest MUS for only 5% or less of the rural population, with the remaining in the 10 to 20% range (4 of 15), and the greater than 30% range (2 of 15).

For each of these three ranges of Highest MUS, we calculated the average fractional distribution of the other three service level categories. We then applied this WHO distribution to the JMP data to find the JMP Intermediate MUS and JMP Basic MUS breakdown, based on each country's Highest MUS value.

Of the 28 continental sub-Saharan Africa countries and Madagascar, 24 countries had Highest MUS values in the 0 to 5% range. For Gabon and Lesotho, which have a Highest MUS level of about 8%, we used the distribution found by the overall average (over all 15 WHO countries), which corresponds to a Highest MUS level of 9.7%. Only Sudan fell in the 10 to 20% Highest MUS range at 13%. For Botswana, which had a Highest MUS of 28%, we used the distribution for the "Greater than 30%" range, which had an average Highest MUS proportion of 32.5%.

Assumptions. For each of these data sets, we use the JMP 2004 Rural Population as the population basis. The WHO and JMP data sets, however, are not necessarily from 2004. For a limited number of countries, some of the data dates back to the 1990's. Even though the year may not correspond, we assume the relative proportion stayed the same.
In estimating the MUS populations based on the JMP data, we use the relative fractions determined by the WHO data. Thus we assume that, within the JMP Improved category, the relative proportion of Intermediate MUS and Basic MUS is the same as for the WHO data.

B.3 Market Mapping: Domestic+—Disaggregating domestic market based on service level

Burkina Faso Example: The table shows the how rural populations were disaggregated into various service levels

	< 5 minutes		5 - 30 minutes		> 30 minutes
>20 liter water available:	**yes**	**no**	**yes**	**no**	
Main source of drinking water	**Rural population**				
Piped water through house connection or yard	0	0	0	0	2,879
Public standpipe	227,422	25,909	1,019,081	198,634	466,359
Protected tube well or bore hole	210,150	11,515	1,105,444	339,694	575,752
Protected dug well or protected spring	259,088	14,394	469,238	57,575	120,908
Unprotected dug well or spring	924,082	25,909	1,163,019	135,302	575,752
Rainwater (into tank or cistern)	0	0	5,758	0	2,879
Water taken directly from pond-water or stream	2,879	0	0	0	2,879
Tanker-truck, vendor	14,394	0	109,393	20,151	31,666
Total	**1,638,015**	**77,727**	**3,871,933**	**751,357**	**1,779,074**

Color	Service Level
(dark blue)	**Highest MUS**
(cyan)	**Intermediate MUS**
(yellow)	**Domestic/Basic MUS**
(pink)	**No Services**

The methodology used to estimate rural populations living in irrigated areas in Sub-Saharan Africa and South Asia rely on products derived from remote sensing (a graphical illustration of the process is shown on the next slide).

Data. Three datasets were used along with GIS techniques to estimate the rural irrigated area and population per country in both regions.

- Global Map of Irrigated Area 1999 (GMIA) version 2.0 created by the International Water Management Institute (IWMI) (Thenkabail et al, 2006a). This dataset identifies 28 classes of major crop types and cropping pattern at 10 km resolution. The dataset is created using various remote sensing data (AVHRR – 10-km monthly data from 1997-1999, SPOT vegetation 1-km data for 1998, GTOPO 1-km DEM data) and validate with ground truth data.
- Global Rural-Urban Mask. This dataset is produced by the Columbia University Center for International Earth Science Information Network (CIESIN) in collaboration with the International Food Policy Research Institute (IFPRI), The World Bank, and Centro Internacional de Agricultural Tropical (CIAT), (2004). The spatial resolution is 1 km. The datasets represents the urban areas with a population of 1,000 people or more and rural areas with population less than 1,000 people.
- Gridded Population of the World, version 3. This dataset is also produced by the Columbia University Center for International Earth Science Information Network (CIESIN) in collaboration with the International Food Policy Research Institute (IFPRI), Centro Internacional de Agricultura Tropical, and The World Bank (2004). The population count grid contains the estimated number of people living in area of 1 km2.

GIS Methodology. The GIS methodology for estimating rural irrigated area and population in these areas in Sub-Saharan Africa and South Asia include the following steps:

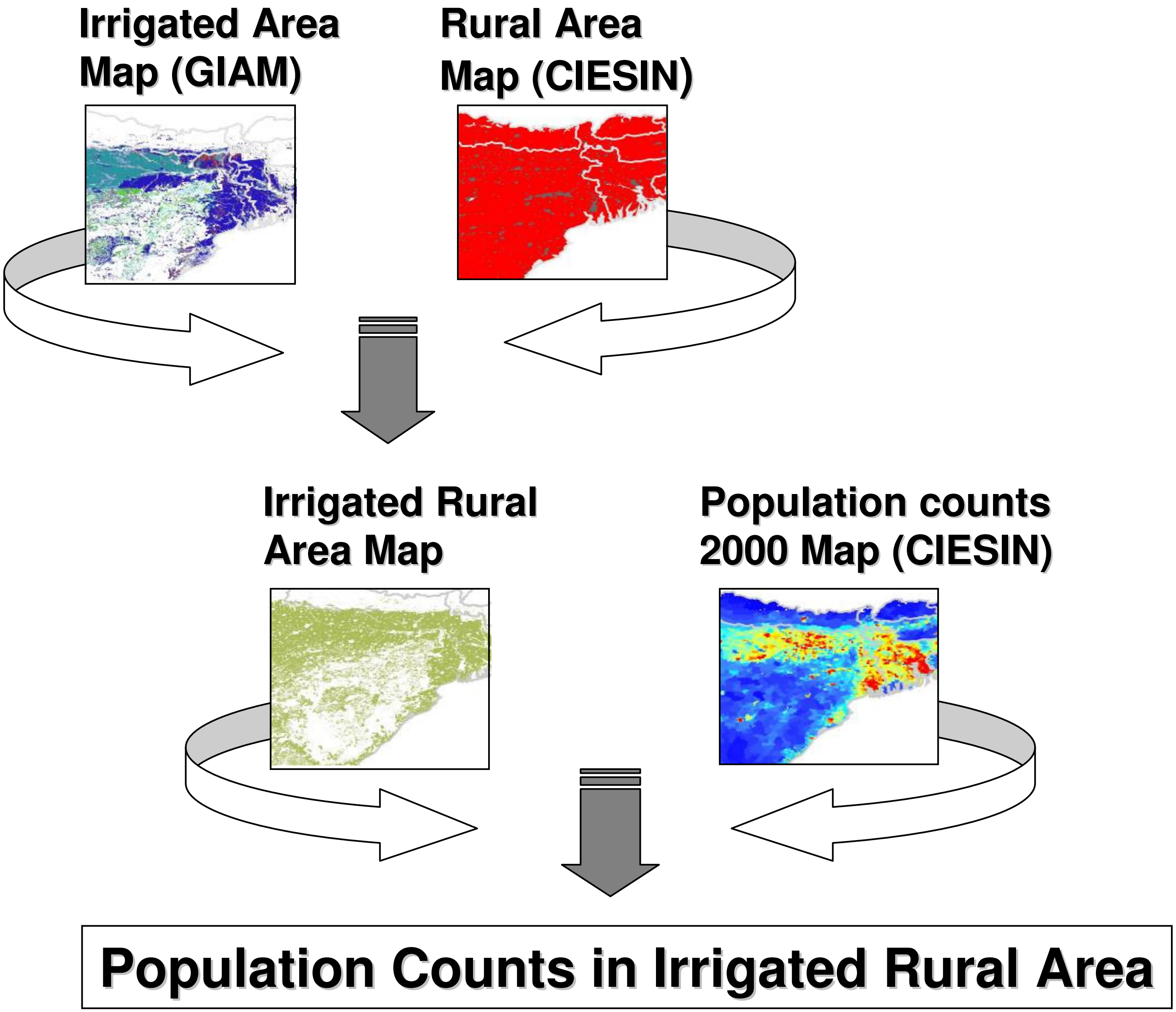
Identifying rural irrigated areas in Sub-Saharan Africa and South Asia

- The extent of rural area in both regions was extracted from the Global Rural-Urban mask dataset and combined with the 28 classes of the GIAM dataset for both regions to create a base rural irrigated area map. The base rural irrigated areas were corrected with an Irrigated Area Fraction (IAF) to estimate the total rural available area for three types of irrigation (surface, ground and conjunctive) per country.

Estimating the population in total rural irrigated areas in Sub-Saharan Africa and South Asia.

- The base rural irrigated area map was combined with the population count grid map to extract the population in the rural area with surface, ground and conjunctive irrigation types. The total population estimates were adjusted according the total rural area available for irrigation.

B.3 Market Mapping: Irrigation+—overview of methodology



B.4 Data: Financial Benefits of Home Gardens

Country	Context	As reported (PPI)	PPI$ m² garden/yr	$m³ water			Reference
				3l per m²/d	5 lpm²/d	8 lpm²/d	
Zimbabwe	Community garden: 60m² per member; splash garden from public standpipe (check)	Avg gross income per member for 6 month season is $32.80	1.09	1.00	0.60	0.37	Waughray, Lovell, Mazhangara (1998)[1]
		Gross income per member (high) for 6 month season is $96.73	3.22	2.94	1.77	1.10	
		Gross income per member (low) for 6 month season $9.79	0.33	0.30	0.18	0.11	
South Africa	Home gardens: 60-600 m², average 300 m²; network w/ yard & house tap –vs.-unreliable public tap	Gross income/yr: network system: $324.59	1.08	0.99	0.59	0.37	Perez de Mendiguren et al. (2003)
		Gross income/yr: unreliable tap: $179.45	0.60	0.55	0.33	0.20	
Cambodia	Community garden: (median ranged from 750-1000 m²)	Average for 3 project areas	0.25	0.23	0.14	0.09	HKI-Cambodia, Round Report, 1,1, (2000)
	3 village: median size: 885 m²	Average gross income (after home cons) $13.76 per 3 months	0.06	0.06	0.03	0.02	
	8 villages median size =984 m²	Average gross income (after home cons) $27.51 per 3 months	0.11	0.10	0.06	0.04	
	3 villages median size =750 m²	Average gross income (after home cons) $110.06 per 3 months	0.59	0.54	0.32	0.20	

[1] 7 schemes participated; multiplier effect--income generated from home gardens used in other income generating activities such as small livestock, free trees, pottery, knitting, selling clothes. Gross margins from these activities ranged from $10-$262/yr

B.4 Data: Financial Benefits of Home Gardens (cont.)

Country	Context	As reported (PPI)	PPI$ m^2 garden/yr	$m^3 water			Reference
				3l per m^2/d	5 lpm2/d	8 lpm2/d	
Cambodia[1]	Community garden: avg size 800-1000 m^2	Traditional: Average income after home cons. $6/4 mo	0.02	0.02	0.01	0.01	HKI-Cambodia, Round Report 4,2,1, (2001)
		Mixed: Average income aft. Home cons. $27/4 month	0.09	0.08	0.05	0.03	
		Year round: Average income aft. Home cons. $57/4month	0.19	0.17	0.10	0.07	
Nepal	Home gardens:	62 m^2/ per hh (median)—avg income $51/3 months	3.30	3.03	1.82	1.13	HKI-Nutrition Bulletin 2,1, (2004)
		90 m^2/ per hh: $47/3 month	2.10	1.92	1.15	0.72	
	Community gardens:		0.5	0.48	0.29	0.18	
			0.9	0.79	0.48	0.30	
Bangladesh	Home garden: average size 40 m^2	Overall: Average hh income: $16 per 2 months	2.41	2.20	1.32	0.83	HKI, Monitoring of activities in villages and hh gardens (2001) **(note: survey of 45,164 households)**
		Winter: Average hh income: $14.26 per 2 months	2.14	1.96	1.17	0.73	
		Summer: Average hh income: $17.87 per 2 months	2.68	2.45	1.47	0.92	

[1] Sampled 136 community gardens of 230; 30 minutes per day average time spent gardening; can generate $2-5/month plus consumption; increased income $10/month; annual household income is $82/year in Cambodia. 80% hh spent additional income on food, 80% on fish or fish paste & 5 % on pork

B.4 Data: Financial Benefits of Home Gardens (cont.)

Country	Context	As reported (PPI)	PPI$ m^2 garden/yr	$m³ water			Reference
				3l per m^2/d	5 lpm^2/d	8 lpm^2/d	
Zimbabwe	Home garden/Small scale irrigation: 100 m^2 (only 1 season of vegetables); rope pump plus drip	$75 for one season vegetables	0.88		0.80	0.50	Polak, et al. 2003
Nepal	Home garden/small scale irrigation: gravity system plus drip kit, 500 m^2	$250 for one season of vegetables	0.58	0.53	0.32	0.20	Polak, et al. 2003
India	Small scale irrigation: gravity system plus drip kit, 400 m^2 over 2 seasons	$800 for two seasons	0.73	0.67	0.40	0.25	Polak, et al. 2003

B.4 Data: Financial Benefits of Large Livestock

Country	Context	PPI$	Drinking Water Use		Reference
			lpcd	$/m3	
LARGE LIVESTOCK					
Kenya	Mixture of cattle and goats Laikipia –site 1	61.00	17.3	3.54	Mizutani, Muthiani, Kristjanson, Recke (2005)
	Laikipia –site 2	61.00	17.3	3.54	
	Laikipia –site 3	-8.00	10.9	-0.74	
	Amboseli	21.00	26.2	0.80	
	Average	**34.00**	**18.1**	**1.88**	
	Cattle/sheep and goats. Avg holding = 4.5 TLU/capita*	45.00	30.0	1.50	Radney (2007)
South Africa	Cattle	40.00	30.0	1.33	Dovie, Shackleton, Witkowski, (2006)
India	Adult male cattle	15.88	30.0	0.53	Priya Deshingkar, et. Al (2007)
	Adult Female cattle	13.24	30.0	0.44	
	Adult Female cattle cross bred	15.88	30.0	0.53	
	Cattle young stock	6.62	20.0	0.33	
	Buffalo	15.88	40.0	0.40	
	Buffalo young stock	6.62	20.0	0.33	
	Buffalo dairy (no water source)	89.00	20.0	4.45	Upadhyay (2004)
	Buffalo diary (secure water source)	317.00	71.0	4.46	
	Cow dairy (secure source)	109.00	54.0	2.02	
	Cow dairy (no source)	5.00	14.0	0.36	

TLU = total livestock unit, the standardized measure of livestock. All livestock can be converted into a standardized TLU.

Country	Context	PPI$	Water Use		Reference
			lpcd	$/m3	
LARGE LIVESTOCK					
Ethiopia	Don-irrigation			1.22	Ayalneh, et al (2005)
	Don-no irrigation			2.14	
	Bata-irrigation			0.98	
	Batt- no irrigation			1.67	
	C-irrigation			1.96	
	C- no irrigation			4.14	
	M-irrigation			3.34	
	M- no irrigation			2.14	

Country	Context	As reported (PPI)	PPI$	Water Use		Reference
				lpcd	$/m3	
India	Andhra Pradesh and Madhya Pradesh	Adult male cattle	15.88	30		Priya Deshingkar, John Farrington, Pramod Sharma, Laxman Rao Jayachandra Reddy, Ade Freeman and Dantuluri Sreeramaraju (2007)
		Adult Female cattle	13.24	30		
		Adult Female cattle cross bred	15.88	30		
		Cattle young stock	6.62	20		
		Buffalo	15.88			
		Buffalo young stock	6.62			
		Goat	1.32	4.5		
		Sheep	1.32	4.5		
		Poultry—100 adult poultry	0.07	.3		
	Compared two areas: one with secure water and another without					Upadhyay (2004)
	Source	Buffalo—dairy	317	71		
		Cow—dairy	109	54		
	No-source	Buffalo—dairy	89	20		
		Cow—dairy	5	14		

B.4 Data: Financial Benefits of Small Livestock – Goats and Chickens

Country	Context	PPI$	Water Use		Reference
			lpcd	**$/m3**	
GOATS					
South Africa	Goats	3.40	4.50	0.76	Dovie, Shackleton, Witkowski (2006)
India	Goats	1.32	4.50	0.29	Priya Deshingkar, et. al (2007)
India	Sheep	1.32	4.50	0.29	Priya Deshingkar, et. al (2007)

Country	Context	PPI$	Water Use		Reference
			lpcd	**$/m3**	
CHICKENS					
Bangladesh	Chicken (scavenger based systems –13 chickens): $10.90/mo	10.00	0.30	33.33	Alam (1997)
Tanzania	Family poultry flock comprised of five adults	7.60	0.30	25.33	Chitukuro and Foster (1997)
Senegal and Gambia	Out of an average flock size of 21 birds **$130/yr---$6/bird**	6.00	0.30	20.00	Balde (2006)

B.4 Data: Financial Benefits of Small Livestock (cont.)

Country	Type of livestock operation	As reported (PPI)	PPI$	Water Use		Reference
				lpcd	$/m3	
Kenya	Mixture of cattle and goats Laikipia –site 1		$61	17.25		Mizutani, Muthiani, Kristjanson, Recke, (2005)
	Laikipia –site 2		$61	17.25		
	Laikipia –site 3		-$8	10.88		
	Amboseli		$21	26.18		
	Average		**$34**			
South Africa	Cattle		$40	30		Dovie, Shackleton, Witkowski (2006) $688 cattle/yr; avg holding =19 cattle; $17.33/goats/yr; avg holding =5.6 goats
	Goats		$3.4	4.5		
Bangladesh	Chicken (scavenger based systems –13 chickens): $10.90/mo	$131/yr	$10	.3		Alam (1997)
Tanzania	Family poultry flock comprising five adult chickens enabled women to earn US$ 38.00 annually, which is about 10% of the annual income. **(5 chickens = $38/yr or $7.6/chicken)**	$38/yr	$7.6	.3		Chitukuro and Foster (1997)
Senegal and Gambia	Out of an average flock size of 21 birds **$130/yr--- $6/bird**		$6	.3		Balde (2006)

B.4 Data: Financial Benefits of Small Livestock (cont.)

Country	Context	As reported (PPI)	PPI$	Water Use		Reference
				lpcd	$/m3	
Kenya	Cattle/sheep and goats Avg holding = 4.5 TLU/capita	Mean gross income per TLU=$73 (std $62), costs of prodn = $28 (std =$30), net returns=$45 (std $63) 12% hh negative returns. Increasing TLU by 10% increases income by 7.5%	$45	30		Radney (2007)
Ethiopia	Don-irrigation				1.22	Ayalneh, et al (2005)
	Don-no irrigation				2.14	
	Bata-irrigation				0.98	
	Batt- no irrigation				1.67	
	C-irrigation				1.96	
	C- no irrigation				4.14	
	M-irrigation				3.34	
	M- no irrigation				2.14	

B.4 Data: Costs for domestic+ analysis

Description of cost components [1]	Overview of what's included
Capital investments in fixed assets	Water supply specific: Water resources facilities, boreholes, piped systems, irrigation infrastructure. Other: Offices, IT systems, maintenance vehicles, depots and warehouses; land for protecting water quality; extension of the distribution (non networked)
Operating & maintenance expenditures (OPEX)	Labor; power costs, fuel, chemicals, cost of materials for operation and maintenance; Water source protection and conservation, point source water treatment, non network water distribution.
Capital maintenance fund (CapManEX)	Rehabilitation and replacement of infrastructure and catchment protection
Software costs	
Direct support costs	Community capacity building, overheads of intermediate support agencies, outreach and extension for productive uses, hygiene awareness and education campaigns, etc.
Indirect support costs	Institutional capacity building and skills training at local government and national government levels; Cross-sectoral coordination. Development and maintaining IWRM, water and wastewater management and development plans Regulation, development and maintaining monitoring and assessment information systems Ongoing development, refining and implementation of policy

[1]Sources: Cardone, R. and C. Fonseca. December 2003. "Financing and Cost Recovery" IRC Thematic Overview Paper. http://www.irc nl/page/7582; Franceys, R., C. Perry and C. Fonseca. June 2006. "Guidelines for User Fees and Cost Recovery for Water, Sanitation and Irrigation Projects." IRC/Cranfield report for the African Development Bank. Unpublished

B.4 Data: Costs for domestic+ analysis

Summary of costs per capita/per year for non-networked rural water (US$I PPP 2004)

Summary of data ranges	Capital investment		OPEX		Direct support costs		CAPManEX		Indirect support costs	
	min	max	min	max	min	max	min	max	min	max
Technology typology										
Global data on "rural water"	0.2	25	2.41							
Self supply well lining	1				2		1.7			
Self supply well lining and hand pump	2				3					
Spring catchment and protection	4	222			24		0.1	21		
Hand dug well with hand pump	9	82	2				0.4	12		
Shallow tube well	10		1		1		1			
Sub-surface dam with hand dug well	17						0.1			
Borehole with hand pump	18	199	1	2			20			
Rainwater harvesting	36	229	3	4						
Gravity flow	45		9		6		3			
Sand dam with standpipe	56						0.1			
Rock catchment	244						1.6			
Total ranges (excluding lower ranges of UN MP data as they are for the whole population)	**1**	**229**	**1**	**4**	**1**	**24**	**0.1**	**20**	**0.3**	
Point water treatment	0.1		0.3	0.4						
Institutional support for the whole population in one Region					1.2				0.3	

Costs per capita/per year for non-networked rural water (US$I PPP 2004)

Details of technology, country, program	Population served	Currency	Date costs collected	Capital investment	OPEX	CAPManEX	Direct support costs
Africa				Costs per capita/per year PPP (US$I)			
Hutton & Haller - borehole		USD	2000	25	2		
Hutton & Haller - disinfection point use		USD	2000	0.1	0.4		
Hutton & Haller - dug well		USD	2000	23	2		
Hutton & Haller - rainwater		USD	2000	53	4		
Smits - rural areas		USD	2004	25			
SNNPR Ethiopia - Community hand dug well (10m)	75	ETB	2005	35			
SNNPR Ethiopia - Lined standard dug well (15m)	270	ETB	2005	82.1		12	
SNNPR Ethiopia - Medium scheme spring development	3978	ETB	2005	222		21	
SNNPR Ethiopia - Motorized deep borehole	3313	ETB	2005	199		20	
SNNPR Ethiopia - Shallow borehole	589	ETB	2005	108		16	
SNNPR Ethiopia - Spring development	338	ETB	2005	99		14	
UN Millennium Project (2004) Ghana		USD	2000	0.4	0.4		
UN Millennium Project (2004) Tanzania		USD	2000	0.4	0.4		
UN Millennium Project (2004) Uganda		USD	2000	0.4	0.2		
WHO/UNICEF - borehole		USD	2000	25			
WHO/UNICEF - dug well		USD	2000	23			
WHO/UNICEF - rainwater collection		USD	2000	51			

Costs per capita/per year for non-networked rural water (US$I PPP 2004) cont.

Details of technology, country, program	Population served	Currency	Date costs collected	Capital investment	OPEX	CAPManEX	Direct support costs
Africa cont.				Costs per capita/per year PPP (US$I)			
WSP Kenya - Rock Catchment (1.5m3/day)	200	Kshs	2005	244		1.6	
WSP Kenya - Roof Rainwater Catchment (30l/day)	10	Kshs	2005	229		1.7	
WSP Kenya - Sand-dam w/ standpipe (3m3 /day)	500	Kshs	2005	56		0.1	
WSP Kenya - Spring Catchment/protection (20m3/day)	500	Kshs	2005	4		0.0	
WSP Kenya - Sub-surface Dam w/ HDW (3m3 /day)	500	Kshs	2005	17		0.0	
WSP Zambia - improving self supply - well lining	100	USD	2004	1			2
WSP Zambia - improving self supply - well lining plus hand pump	100	USD	2004	2			3
WSSCC Vision 21 - basic levels of service		USD	1999	16	2		
Asia							
Hutton & Haller - borehole		USD	2000	18	1		
Hutton & Haller - disinfection point use		USD	2000	0.1	0.3		
Hutton & Haller - dug well		USD	2000	24	2		
Hutton & Haller - rainwater		USD	2000	36	3		
UN Millennium Project (2004b) Bangladesh		USD	2000	0.3	0.5		
UN Millennium Project (2004b) Cambodia		USD	2000	0.2	0.1		
WaterAid Nepal - Deep tube well		USD	2004	45	8	3	6

Costs per capita/per year for non-networked rural water (US$I PPP 2004) cont.

Details of technology, country, program	Population served	Currency	Date costs collected	Capital investment	OPEX	CAPManEX	Direct support costs
Asia cont.				Costs per capita/per year PPP (US$I)			
WaterAid Nepal - Gravity flow		USD	2004	45	9	3	6
WaterAid Nepal - Shallow tube well		USD	2004	10	1	1	1
WHO/UNICEF - borehole		USD	2000	18			
WHO/UNICEF - dug well		USD	2000	24			
WHO/UNICEF - rainwater collection		USD	2000	36			
Global							
GWP - water supply		USD	2000	16	2.41		

B.4 Data: Costs for domestic+ analysis

Summary of costs per capita/per year for networked water supply (US$I PPP 2004)

Technology typology	Capital investment		OPEX		Direct support costs		CAPManEX		Indirect support costs	
	min	max	min	max	min	max	min	max	min	max
Urban water	0.3	100	0.1	8						
Large scheme spring development	17						6			
Standpipe	33	69	2.57	8.04						
Household connection - small town	40		2.4		5.15		2.78			
Improvement and expansion town water supply	66		0.3							
Household connection	99	214	4.27	32.16	6.4					
Piped system borehole with chlorination	116		11				4.35			
Household connection - large town	312									
New town water supply	429									
Total ranges (excluding lower ranges of UN MP data as they are for the whole population)	**17**	**429**	**0.3**	**32**	**5.15**	**6.4**	**2.78**	**6**		

B.4 Data: Costs for domestic+ analysis

Costs per capita/per year for networked water (US$I PPP 2004)

Details of technology, country, program	Pop. served	Currency	Date costs collected	Capital investment	OPEX	CAPManEX	Direct support costs
Africa				Costs per capita/per year PPP (US$I)			
Hutton & Haller - house connection		USD	2000	109	4.73		6.40
Hutton & Haller – standpipe		USD	2000	33	2.57		
Smets - urban areas		USD	2004	100			
SNNPR Ethiopia - Improve and expansion town	11000	ETB	2005	66			
SNNPR Ethiopia - Large scheme spring development	28756	ETB	2005	17		6	
SNNPR Ethiopia - New town water supply scheme	15000	ETB	2005	429			
UN MP (2004) Ghana		USD	2000	1.2	1.2		
UN MP (2004) Tanzania		USD	2000	0.5	1.0		
UN MP (2004) Uganda		USD	2000	0.3	0.3		
WHO/UNICEF - household connection		USD	2000	109			
WHO/UNICEF - standpipe		USD	2000	33			
WSP Kenya - Piped System BH Source Chlorination	100,000	Kshs	2005	115.90	11.01	4.35	
WSSCC Vision 21		USD	1999	55	8		

B.4 Data: Costs for domestic+ analysis

Costs per capita/per year for networked water (US$I PPP 2004) cont.

Details of technology, country, program	Pop. served	Currency	Date costs collected	Capital investment	OPEX	CAPManEX	Direct support costs
				Costs per capita/per year PPP (US$I)			
Asia							
Hutton & Haller - house connection		USD	2000	99	4.27		6.40
Hutton & Haller - standpipe		USD	2000	69	5.31		
UN MP (2004b) Bangladesh urban water		USD	2000	0.5	0.1		
UN MP (2004b) Cambodia urban water		USD	2000	0.4	0.2		
WaterAid Nepal - large town household connection		USD	2004	312			
WaterAid Nepal - small town household connection		USD	2004	40	2.4	2.78	5.15
WHO/UNICEF - household connection		USD	2000	99			
WHO/UNICEF - standpipe		USD	2000	69			
Global							
GWP - household connection		USD	2000	214	32.16		
GWP - standpipe		USD	2000	54	8.04		
Kariuki - small independent network		USD	2005?	101			
Kariuki - small independent network		USD	2005?	304			

Costs for irrigation+ infrastructure add-ons (US$)

Added Structure	Capacity/Dimensions	Approx. Capital Cost (USD)	Source
Home storage (excludes stand and fittings)	Cement jar 0.1-1.2m^3	10-100	SWI
	Covered plastic tank 1-2 m^3	140-250	IWMI
	Covered aluminum tank 1-2m^3	410-820	IWMI
	Covered fiber glass tank 1-2 m^3	280-510	IWMI
	Covered cement ground tank 2 m^3	140	IWMI
	Plastic tank on steel tower 2 m^3	450	IWMI
	Covered cement overhead tank 2 m^3-3m^3	470/100-300	IWMI/SWI
Stand and fittings	Overhead water storage	650	N/A
Community storage small (exclude stand and fittings)	Cement 8-10m^3	810	IWMI
	Covered plastic tank 10m^3	1180	IWMI
	Covered aluminum tank m^3	4050	IWMI
	Covered fiber glass tank 10m^3	2030	IWMI
	Circular masonry 10m^3	1180	IWMI
Community storage medium	Circular masonry 50m^3	6000	IWMI
	Covered cement ground tank 50m^3	2250	IWMI
	Covered cement overhead tank 50m^3	7090	IWMI
Community storage large	195 m^3 excavated	1080	HCS
	Underground open trapezoidal masonry 500 m^3	23,400	IWMI
	Underground open trapezoidal masonry 1000 m^3	47,700	IWMI

Costs for irrigation+ infrastructure add-ons (US$) cont.

Added Structure	Capacity/Dimensions	Approx. Capital Cost (USD)	Source
Pump (electricity or generator needed)	Electric, 32 mm diameter	35	IWMI
	1.5 HP submersible, 2 l/s	910	IWMI
	2.4 HP submersible, 4 l/s	1230	IWMI
	Electric pump 2 inch diameter, 1620 l/s	35-60	HCS
Generator	4.0-5.5 kV for electric pumps	960-1,550	IWMI
Pipe connection	Steel, 2 inch diameter, 6m long	40	IWMI
	Plastic, 2 inch diameter, 1m long	25	IWMI
	Plastic, 20 mm diameter, 4 m long	3	IWMI
Connection tap	Plastic 20 mm tap	2	IWMI
Cattle trough	For 4-10 animals	450/820	IWMI/HCS
Laundry basin	For 3 people	150/525	IWMI/HCS
Washing room	Enclosure with cement floor, corrugated iron and wood pole walls and roof, soak pit (bucket excluded)	450	HCS
Bathing and laundry steps in canal	Concrete steps in main canal	4060	IWMI
	Concrete steps in secondary canal	610	IWMI

B.4 Data: Costs for Irrigation+ infrastructure add-ons

Costs for irrigation+ infrastructure add-ons (US$) cont.

Structure Description	Short Description	Approx. Capital Cost (USD) Based on 2 liters of clean drinking water/capita/day	Recurrent cost/capita/ Year (USD)	Source
Centers for Disease Control and Prevention (CDC) Safe Water System – component 1	Chlorine treatment	1.5-8	1-5	CDC
CDC Safe Water System – component 2	Safe storage; 50 liter; can filter	2-5	1	CDC
Cement/bamboo sand filter	300 l/day	35	<1	Arbaminch University
Ceramic filter		N/A	25-100	
Clay pot with sand filter	18 liters	5	<1	IWMI
Coagulation/filtration/chlorination	Sachets	5-10	7-11	CDC
Disinfection filter	Treats 475 l	<1	15	SWI
Electric disinfection	Treats 45 l/h	200	10-30	SWI
Solar Water Disinfection (SODIS)	Plastic bottles on black surface exposed to sunlight	<1	1	CDC
Solar stills	0.5-12 liter/day	55-450	100	SWI
Solar oven	7-11 l/day	10-50	<1	SWI
Water disinfection tablets	Emergency treatment	<1	5-10	SWI