IRC Symposium 2010
Pumps, Pipes and Promises

New incentives: economic projections with the water-person-years concept

Lucrezia Koestler, Marius A. Koestler, Christoph Gisler

Abstract

Despite a significant investment to increase the access to water supplies in Africa, the progress is slow. One of the reasons for this is that there is too much focus on putting in place new infrastructure, and not enough focus on operation and maintenance and the institutional arrangements necessary for ensuring sustainability. In order to incentivize donors and governments to spend more on operation and maintenance, a new indicator was developed. Water-Person-Years takes into account not only the population served by a new infrastructure today, but over the full lifetime of the infrastructure. In order to test this approach with real numbers and integrate factors such as population growth, inflation and interest rates, an economic model was created. The model has two versions; in the first the given information is the money available to be spent, and it calculates the money units per water-person-years. The second takes the population to be served as a starting point, and shows the investment needed. Both versions compare two scenarios, one where the system breaks down after a few years, and one where a fraction of the initial investment is allocated each year for operation and maintenance. The models clearly show that the money units per water-person-years are significantly lower if money is provided for operation and maintenance. This paper discusses the first version of the model in detail.

Keywords

Cost, rural water supply, model, water-person-years, operation and maintenance, WPY

INTRODUCTION

The overall aim of the water sector in developing countries has for the last few decades been to increase the access of population to safe and improved water supplies. The objective was underlined through the setting of the Millennium Development Goals (MDG) that aim to halve the population without access to water by 2015. Consequently, a large sum of money has been committed by donors and governments to expand water systems, especially to rural areas. Some achievement has been made, and many countries are on track to meet the MDGs. However, while effort is put into new water systems, the existing ones are left behind. The management systems and support mechanisms are not adequate and sufficiently funded to provide for sound management, operations and maintenance. Therefore, every year a number of rural water systems fall into disrepair, and are not fixed (Lockwood, et al 2010). In order to make this evident to policy makers, donors and NGOs, a new indicator was developed. Water-Person-Years (WPY) takes into account not only the initial cost of establishing the infrastructure, but the cost of supplying water continuously over a number of years. When a water project is evaluated in water person years, a project that stays functional over some years scores higher than a project that constructs many new systems. The concept was first introduced in 2009 (Koestler, et al 2009), but only as a theoretical idea. The simple calculations did not take into account issues such as population growth, depreciation, interest rates and inflation. In order to test the indicator, a model was created. This paper will show how the model works, and evaluate its projections for different scenarios.

Water Person Years

Thinking in water-person-years offers a new way to measure the performance and progress of the water sector. WPY gives a figure of how many people get access to water from year one and each following year throughout the lifetime of the water infrastructure (Koestler, et al 2010). In this way, the investment is seen as having an effect over a period of time in a cumulative way.

The best way to understand WPY is to look at an example: an organisation wants to supply water to communities in a given area. If the main goal was an increase in coverage, the organisation would spend the 300 money units at its disposal on three villages, the capital cost for the system in each village being 100 money units. Based on research in many countries and functionality data for rural water systems (Koestler, et al 2010), it can be assumed that a system breaks down after 3 years of operation unless funds are put aside or provided yearly for maintenance (RWSN, 2007 and WATSAN Consult). If each village has 1000 people the calculation is as follows:

3 villages x 1000 people x 3 years = 9000 WPY

If the goal instead was to maximise WPY, the situation would be different. We assume that the lifespan of this particular water supply system is 20 years. The organisation now spends 100 money units on one village, but keeps the 200 remaining units for operation and maintenance, about 10% of the capital cost per year for 20 years. The calculation looks as follows:

1 village x 1000 people x 20 years = 20,000 WPY

Thinking of it from a service delivery perspective, the system that runs for 20 years is much more valuable to the people than three systems that break down after three years in operation. If WPY was used by decision makers as an indicator instead of coverage, fewer but longer lasting systems would be put in place. This would increase the coverage in the long term, because people given access do not lose it again. It would also increase the efficiency of the investment considerably because new money is not needed every 3-4 years to do a complete rehabilitation of broken down systems (Koestler, et al 2010).

However, this model has several challenges. First, there are no systems in place to keep money for operation and maintenance over such a long time. This is mainly an institutional challenge. Second, this example does not take into account the depreciation of infrastructure, population growth, inflation and the cost of capital. This challenge can be addressed by introducing these factors into the calculation.

Testing the concept

Due to the challenges mentioned above, it was necessary to test the two different approaches against each other based on real numbers. Will the cost in monetary terms also be lower per person if we think in WPY? Will the investment have a bigger impact in the long run than the conventional approach?

The main objective of the following calculations is to provide a sound argument for why it makes financial sense to spend more money on less people over a longer period of time.

To prove this point we have created a purpose adopted cash flow projection for a rural drinking water system from the perspective of an implementing NGO. In addition to the cash flow, the population growth of the served community is also projected. The cash flow- and population projections provide a basis for calculating the WPY as well as the money units (today) per WPY over the lifespan of the water scheme.

In order for the model to be as accurate as possible, we have based our assumptions, which serve as the input factors, on numbers from real cases and on the projects we have the most experience with.

<u>Assumptions</u>

The background information for the creation of this model was taken from the experiences of Fontes Foundation, a small Norwegian NGO focusing on water, sanitation, education and environmental projects. The organisation runs several rural water projects in Uganda and Mozambique, and has several years of experience in providing rural water services to communities in developing countries. The numbers for the sample calculations are taken from the experience of the organisation because it is easier to confirm whether the results are reliable. However, since all assumptions are variables that can be put into the model, it is also possible to apply this model to other rural water schemes, like for example handpumps. The model was developed in cooperation with students from the University of St.Gallen, Switzerland (Gisler, 2010).

It is important to note that the projects which we base our model on are small piped water systems with community taps. They are operated by a water committee which, besides the technical operators and the caretakers of the taps, operates on a voluntary basis. The water is sold at the taps to the community by the caretakers and the revenue generated covers the day-to-day operations such as fuel for the pumps, chemicals, maintenance, minor repairs and allowances.

More specifically the projects on which these calculations are based are located in southwest Uganda. The water systems treat surface water since ground water is not of potable quality and clean surface sources are not available.

The Excel-model provides two different perspectives. For one, the population is given and the donation required is calculated for different scenarios with different interest rates, administration rates, population growth and maintenance ratio. The second perspective is where the donation is given and the number of people served under the given assumptions is calculated.

The first perspective is more practically oriented, as the data for a given village can be inserted and help the project coordinator to determine the capital needed under different scenarios. The second perspective, however, where the funds are the determining input factor, is more interesting from a policy perspective and for theoretical comparison. In this paper we will discuss the latter perspective only.

Assumptions		
Donation	USD 100 000	Own assumption
Water supply system (potential)	2	Own assumption
Unit cost of infrastructure p.c. (in USD)	USD 58	Own assumption
Administration (in %)	15,0%	Own assumption
Maintenance, mon. and follow-up (in %)	30,0%	Own assumption
Depreciation (in %, declining-balance)	10,0%	Own assumption
Interest rate (in %)	2,0%	Own assumption (avg.)
Inflation rate (in %)	2,0%	Own assumption
Growht rate population Uganda (in %)	2,73 %	CIA The World Factbook
Timeframe (in years)	21	

Figure 1 **Overview of numerical assumptions**

Donation: In our example we take a donation of a 100,000 USD as a starting point as this is what a typical small piped scheme serving a population of around 1,000 would cost. In this example we have excluded the cost of capital. This is because we look at scenario from the perspective of an NGO. An implementing NGO receives funds, mostly earmarked for a specific program either as a lump sum at the beginning of a project or as a larger donation the first year with smaller donations for the consecutive years. Since the capital is donated and earmarked, there is no cost of capital from the *NGO's perspective* since firstly, the capital is provided for free and secondly, the capital is earmarked meaning that it cannot be invested in alternatives. With no opportunity costs there follows no capital costs.

Water Supply System Potential: This figure illustrates to what extent the water scheme is over-dimensioned compared to the demand the first year. For instance, with a factor of 2, as in our example, the water scheme would be dimensioned for 200 people based on a population of 100 the first day. This factor could have been calculated based on the initial population and the growth rate of the population (see below). However, since more factors than only population growth rate come into play when deciding the dimensioning of a water scheme, we decided to leave this as a separate input variable. Some of the factors that can make a difference in addition to population growth are technical considerations and economic development which will increase demand over time because people have more resources to spend on buying water.

Unit Cost of Infrastructure: This figure illustrates the required infrastructure investments per capita. This figure is based on practical examples from our own field work. Needless to say, this figure can vary greatly depending on, amongst others factors, technology choice, water sources available, population size and topology of the area to serve.

Administration: This factor specifies how much of the initial donation falls back to the implementing and fund raising organisation. This value is also based on own experiences.

Maintenance, monitoring & follow-up: This ratio is only relevant for one of the two cases below. It comes into play in the case where less people are served but at the same time a certain percentage of the donation is put aside for maintenance, monitoring and follow-up. In our example, 30% of the initial donation is set aside for future expenses, and these 30% will be distributed over the full life-cycle of the project.

Under maintenance, monitoring & follow-up we have included the expenses on support to the water committee for repairs (which are too costly for the committee to cover), the administrative follow up of the project as well as support through yearly seminars, stakeholder relations, field visits and training.

Depreciation: For some, the assessed monetary value of the water system over time will be of interest, especially if cost-of-capital assessments and net present value calculations are of interest. To illustrate both the monetary value of the water scheme as well as the effects on the monetary long term value when funds are invested in maintenance, monitoring & follow-up, a declining-balance depreciation ratio has been included in the calculations.

Interest rate: This rate is used to calculate the interest rate on cash which is set aside and not spent yet. This rate is relatively low since we assume that NGOs will not make risky (and also possibly higher returning) investments with donated funds. In reality, it should be possible for a NGO to find an investment which is relatively secure and at the same time outperforms the inflation rate. However, in order to simplify the interpretation of the model in this paper, we have left inflation rate and interest rate at the same level for this example. We assume that funds which are kept on the bank by the NGO are placed in a western bank in a relatively stable, western currency.

Inflation rate: As the projections cover a span of 21 years, inflation has to be included in the calculations, especially in the projected maintenance, monitoring & follow-up costs. As stated before, we assume that the funds of the NGO will be kept in a western bank in a western currency. If the inflation in the receiver's country should outpace the inflation of the western economy, this will most likely be reflected in a more favourable exchange rate from the NGO's perspective.

Population growth rate reflects the current growth rate of the target population. This rate may increase or decrease in the future. Also, the target population will most likely not follow the national over-all trend. Therefore, additional adjustments can be made through the input variable *Water Supply System Potential* (see above).

Timeframe: This variable illustrates the number of years the system will be operative.

Furthermore, an important assumption is that a well functioning water scheme will break down after three years if no additional funds are available for supporting the community in some maintenance issues, monitoring of the system and the community as well as general follow-up.

For Case 2 we assume that a well maintained system will be able to operate a full 20 years.

The Cases

As already mentioned in the initiating chapter, we would like to illustrate that it makes financial sense to serve *initially* less people, but to serve these people over a longer period of time.

Case 1: A classical funding approach
In this first case we will look at a classical funding approach where with a given donation the maximum of people gain access to a water supply. Besides the administration of initiating the project, the donation covers the hardware costs as well as the initial training of the community.
Based on the assumption that this system will break down after three years, the model looks like the following:

Case 1: No maintenance/ monitoring								
	2010	2011	2012	2013	2027	2028	2029	2030
Donation	100 000	0	0	0	0	0	0	0
Administration	15 000	0	0	0	0	0	0	0
Remaining cash	**85 000**							
Installation/ material	85000	85000	76500	0	0	0	0	0
Depreciation	0	-8500	-7650	0	0	0	0	0
Total Material	**85000**	**76500**	**68850**	**0**	**0**	**0**	**0**	**0**
Potential coverage	1466	1466	1466	0	0	0	0	0
Population	733	753	773	794	1158	1190	1222	1256
Sum (cont.)	733	1 486	2 259	3 053	16 745	17 935	19 158	20 413
Water person years (cont.)	733	1 486	2 259	0	0	0	0	0
Total water person years	**2 259**							
Effective Coverage	100,0%	100,0%	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Working Time	3							
Water Person Years	2 259							
Total Donation	100 000							
Money units per water person year	**44,27**							

Figure 2 Case 1 with no extra funds for maintaining the system. The system fails after three years (first four and last four years, all in USD)

The figure above shows the first four years and the last four years of the period of time examined in these two cases. It can clearly be seen that since the system breaks down in year three, the Water Person Years are zero from year four and onwards. Potential coverage is calculated by taking the total donation, minus the administration costs and then dividing the remaining sum by the unit cost per capita which is 58 USD. The cumulative WPY is only the population served each year during the first three years, which is 2259. The model also shows that serving one person with water for one year in this case costs 44.27 USD.

Case 2: A long term funding approach

In a second case we set aside a substantial amount of the donation for future maintenance, monitoring and follow-up. This means that we have less funds to build infrastructure and hence a smaller number of people can be served with water. The second significant difference is that, given the funds provided for maintaining the system, we assume that the water system will last the full 20 years.

Case 2: Proposed model

	2010	2011	2012	2013	2027	2028	2029	2030
Donation	100 000	0	0	0	0	0	0	0
Administration	15 000	0	0	0	0	0	0	0
Maintenance/ monitoring	30 000	0	0	0	0	0	0	0
Remaining cash	**55 000**							
Installation/ material	55 000	55 000	51 030	47 488	25 332	24 899	24 552	24 282
Maintenance/ monitoring/ follow up	0,0	1530,0	1560,6	1591,8	2100,4	2142,4	2185,2	2228,9
Depreciation	0,0	-5 500,0	-5 103,0	-4 748,8	-2 533,2	-2 489,9	-2 455,2	-2 428,2
Total value	**55 000**	**51 030**	**47 488**	**44 331**	**24 899**	**24 552**	**24 282**	**24 082**
Maintenance/ monitoring/ foll. up (cash	30 000	29 070	28 091	27 061	6 301	4 285	2 185	0
Interest	600,0	581,4	561,8	541,2	126,0	85,7	43,7	0,0
Total Cash	**30 600**	**29 651**	**28 653**	**27 602**	**6 427**	**4 370**	**2 229**	**0**
Present value of cash at end								**0**
Potential coverage	948	948	948	948	948	948	948	948
Population	474	487	500	514	749	770	791	813
Water person years (cont.)	474	961	1 462	1 976	10 835	11 605	12 396	13 209
Total water person years	**13 209**							
Effective Coverage	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Utilization of supply system	50,0%	51,4%	52,8%	54,2%	79,0%	81,2%	83,4%	85,7%
Working Time	21							
Water Person Years	13 209							
Total Donation	100 000							
Money units per water person year	**7,57**							

Figure 3 Case 2 where 30% of the initial donation is set aside for monitoring and follow-up of the system (first four and last four years, all in USD)

This figure also shows the first four and last four years of the projection for Case 2, where 30% of the initial donation is put aside for maintaining the system. Installation/material shows the value of the initial investment each year, taking into account depreciation of 10%. These values are added to the yearly maintenance cost to see what the value is of the system each year under “total value”. Maintenance costs are distributed equally over the years representing an average figure, but could also be accumulated to carry out large rehabilitation or replacement. The expenses for monitoring and follow up are the same each year, because the same effort is put into capacity building and sensitisation. It has to be mentioned that this case does not consider the positive spin-offs that capacity building in communities can have in the long term, but since the modality of the support is not considered here it is not expressed in values. The figure shows that WPY increases each year due to population growth. It also shows that in year 2030, 85.7% of the capacity of the water system has been exhausted which means that it can still run for more years before large expansions are necessary. In summary, this investment has delivered 13,209 WPY over 21 years, and serving one person with water for one year only costs 7,57 USD. This is despite the considerable amount that is spent on maintenance, follow up and support every year.

Comparing the two cases

When looking at the two different cases it is natural to compare the most important figures: Potential population coverage at beginning, Water Person Years (WPY) and Money Units per WPY:

Comparison of both cases:	Case 1	Case 2	Change
Potential pop. coverage at beginning	1466	948	-35 %
Water Person Years	2 259	13 209	485 %
Total Donation	100 000	100 000	0 %
Money units per water person year	**44,27**	**7,57**	**-83 %**

Table 1 Comparison table Case 1 and Case 2

The potential coverage, which is the total sum available for construction divided by the per capita unit cost, is evidently higher for Case 1 than for Case 2, because no money is set aside for maintenance. 35% less people are served in Case 2 than in Case 1 at the beginning, and today Case 1 would therefore be more attractive because it increases coverage to more people faster. Other indicators, however, such as WPY and the cost of serving one person with water per year show a different side. It is evident that since the system in Case 1 breaks down after only three years, the system in Case 2 can provide drinking water over a longer period of time. Interesting to note is that (as seen in

Figure 2 and

Figure 3 under *"Water Person Years cont.)"* year 2012) after three years of operations the delivered WPY of Case 1 is 797 WPY higher than in Case 2. This means that 797 more people have had water for a full year after three years of operations than in Case 1. It takes in fact five (not visible in figure due to space restrictions) years before the same initial donation can deliver as many WPYs in Case 2 as can be delivered in Case 1 after three years time.
When comparing WPYs, the table shows that Case 2, with the same amount of funds, over the full lifespan of both cases (Case 1 lasts for three years only against Case 2's 21) can deliver 485% more WPYs, 13,209 compared to 2259. In real numbers, this implies that Case 2 would deliver water to 10,950 more people for a year than Case 1. This difference is significant.

From a policy and project planning perspective, it might be interesting to note that one water person year costs 44,27 USD in Case 1 and 7,57 USD in Case 2, which is 83% less.

CONCLUSION

With these calculations we have numerically shown that it makes financial sense and is more effective to invest development aid funds in long term projects. Although the need and necessity for maintenance is by now a well established fact in academia, there are still few examples on the ground. This paper has illustrated the effect which long term commitment of funds can have. The ratio of 1:5.8 between WPYs delivered in Case 1 and Case 2 should be quite convincing. Although this ratio is based on the assumption that the WPY approach is applied on the big projects of several villages in the same region (leading to economics of scale) favourable ratios of 1:2 to 1:3 can also be reached for smaller projects.

This example does not take into account the practical problems with saving money in developing countries over a long period of time, or what kinds of support mechanisms will make sure the communities are followed up on and the systems maintained. It assumes that the money will be spent wisely, and that communities are capable of running the system on a day-to-day basis. However, it gives an important insight into the magnitude of the difference between the conventional approach and an approach where money is spent on keeping systems running over time.

The model has a great potential, and will in future be tested with different assumptions and numbers. The second version which takes the population served as a starting point, is more interesting for implementing actors such as local government and implementing NGOs, since it does not make a direct comparison between the two scenarios but rather informs on the investment necessary to serve a certain number of people over 20 years. It has therefore not been included in this paper, which focuses on making a case for thinking in WPY. Both models however are important tools that could be used by a number of stakeholders in the rural water sector.

In conclusion, if donors and governments want to make good investments and achieve maximum efficiency of aid, this model shows that spending money on the maintenance of systems over time serves more than five times more people with water during the lifetime of the system than if the system breaks down after a short time. The model can show in figures and ratios what was formally only a theoretical concept of WPY, and increases the credibility of the approach. If development goals are set with the aim of providing water to a maximum of people, as well as providing sustainable systems, post-construction spending has to be considered and one way of doing this is to start measuring progress and impact in WPY.

REFERENCES

Gisler, C., 2010. 'A new concept to look at development aid for water supply', *SIMagination Project at the University of St. Gallen,* Switzerland.

Koestler, L., Koestler, A.G., Koestler, M.A. and Koestler V.J (2010) 'Improving sustainability using incentives for operation and maintenance: the concept of water-person-years' *Waterlines,* Vol. 29 No. 2, Practical Action Publishing, UK

Koestler, A.G., Koestler, M.A. and Koestler, L., 2009. ' Coverage as a misleading development goal; the concept or Water-Person-Years' *Water, sanitation and hygiene; Sustainable development and multisectoral approaches,* 34th WEDC International Conference, Addis Ababa, Ethiopia.

Lockwood, H., Smits, S., Schouten, T. and Moriarty, P., 2010. *Providing sustainable water services at scale,* Background paper to International Symposium on Rural Water Services, Kampala.

RWSN, 2007. *Handpump data – selected countries in Sub-Saharan Africa,* Rural Water Supply Network, Switzerland, www.rwsn.ch (accessed 05.11.2009)

WATSAN Consult (undated), http://www.handpump.org/afri_pump/index.htm (accessed 30.10.2008)

CONTACT DETAILS

Fontes AS,
Bernhard Herres vei 3, 0376 Oslo, Norway

Lucrezia Koestler	Lucrezia.koestler@fontes.no
Andreas Koestler	andreas.koestler@fontes.no
Marius Koestler	marius.koestler@fontes.no