♦ Appraising the Returns for a Cistren: One Case Study in the Brazilian Semi-Arid Tropics

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The semi-arid tropics in Northeast Brazil occupy na area of 1,149,000 km2 and contain 24 million inhabitants. Most of the people are dependent on subsistence farming characterized by small land holding, limited financial resources, and productivity which is both unstable and low.

From the viewpoint of natural recources, those semi-arid zones have shollow soils low in fertility, infiltration capacity, moisture holding capacity and organic matter content. In addition, they also are subject to intensive rainfall interspersed with droughts, high evapotranspiration rate and a great desertification hazard. For the majority of such areas, erratic rainfall is the only source of water, and no attempt has been made to conserve soil and water at the farm level, with the situation becoming worse every day. In recent years, government spending on relief programs has been increased substantially.

Similar to other developing countries, drinking water supply in the rural area is among the main problems os the region. In this area, the small farmers utilize whatever water they find to supply the family's needs. Usually they share the same water source with the animals and expand a great amount of time and calories to carry the water for miles. This aggravates even more their sanitary situation which is already unsatisfactory.

A cistern is one of the practical and sanitary ways to harvest drinking water. Within the Brazilian semi-arid tropics, several models of cistern construction has been examined by the Center of Agricultural Research for the Semi-Arid Tropics (CPATSA) (Silva et al 1984). Substantial cost reduction was observed in the construction. Despite efforts to introduce cistern at the farnm level, its current use still is limited. Among other factor, this limitation is because a cistern can not produce income directly. Thus, the researcher and extensionist have difficulties in evaluating the benefits of a cistern. Therefore, it is the objective of this paper to illustrate a cost/ benefit approach for making economical evaluation of the application of a cistern at the farm level.

1. THE PROPOSED APPROACH

The method of analysis used in this case study addresses two possible ways of putting a cash value to the benefits of a cistern by making inference about the labor savings for the whole family. The first one is considered as the primary benefit and its evaluation is based on the corresponding cost of the annual amount of labor that must be spent if the cistern is not constructed. The second one is considered as the secondary benefits and its evaluation is based on the corresponding cost of the family labor reduction due to the indirect effect from deseases caused by inadequate drinking water if the cistern is not constructed.

The basic assumption in this study is that the farm family will increase work time for hired work or to produce more on their own farm. In another words the shodow price of labor is not zero.

On the other hand, cost data are available for some specific size of cistern (Silva et al 1985). With those data a regression analysis was carried out which permit to estimate the cost in U.S.$ of any size of cistern. Figure 1 gives some details of the cost curve.

2. PRIMARY BENEFITS

Family labor is one of the dominant factors of production in the small farm. In the Brazilian semi-arid tropic, the small farmers exloit a group of integrated activities mainly as na attempt to overcome the adversity of the environment. The activities which form their farming system usually include crop production and livestock raising, but also include production of charcol from natural vegetation, food processing, handicraft and hiringout of labor and animal power.Some of the activities are very competitive for labor and depend on the rainfall regime. Thus, labor is na important input and its efficienty distribution among family member is imperative.

Labor involvement in carrying drinking water for farms without water storage is variable within the year. During the rainy season the water requirements are less, the water sources are not too far away from home, and this activity is given to the child or womam. Also, the demand for labor on agricultural operations is high. So, as a consequence the price of labor is more stable. On the other hand, the situation in the dry season is different. The water requirements are almost twice as much, the distance to the water source are farther and this activity now ewquires a adult male labor with the help of animal power. Because the demands for agricultural operations are low in this season, the wage rate is low. Table 1 gives the cyclic effect on wage rate for the dry season.

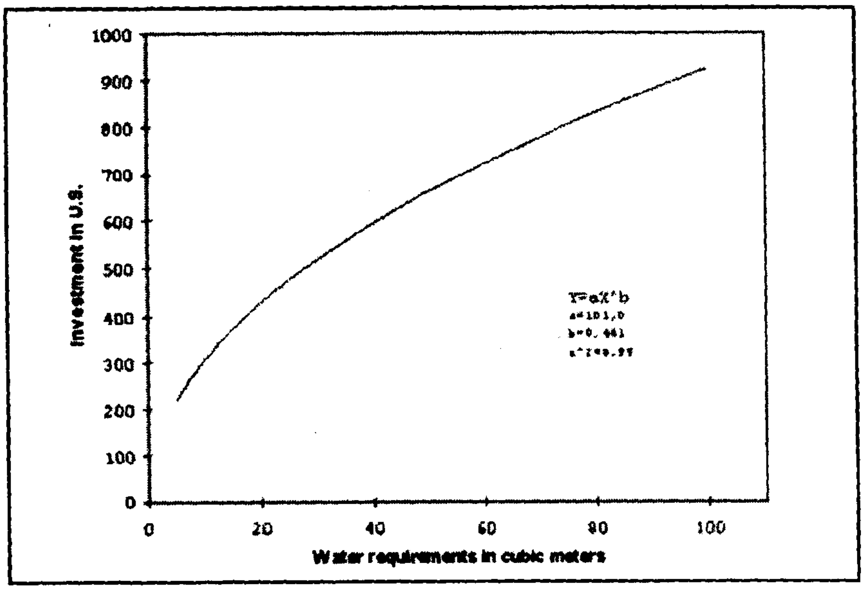

Figure 1: Needed investment for cistern construction as a function of total water requirements

Table 1. Corresponding factor for wage rate in the dry season.

Month after rainy season	Factor (%)
1	90
2	80
3	70
4	60
5	50
6	50
7	60
8	80
Average for the whole dry season	**60**

With all these considerations in mind, the labor requirements were estimated for both seasons considering different family sizes and distance from home. By experience, on the average it takes 2 hours of labor to get four 15 liters capacity containers at a 2 km distance (bothways) carried by na animal. Eight hours of work was considered as a man day unit. These figures ware used to generate the labor requirements presented in Table 2. For the rainy season just a 0,5 km travel distance was assumed.

Table 2. Labor requirements in carrying driking water.

Family size	Water Requirements* (liters/season)		Distance from home (km, both way)					
			0,5	0,5	1,0	2,0	3,0	4,0
	Rainy	Dry	Rainy				Dry season	
			Labor Requirements (man/day) per season					
4	12.500.	24.000.	4.4	8.4	16.8	33.6	50.4	67.2
6	18.750.	36.000.	6.4	12.6	25.2	50.4	75.6	100.8
8	25.000.	48.000.	8.7	16.8	33.6	67.2	100.8	134.4
10	31.250.	60.000.	10.9	21.0	42.0	84.0	128.0	168.0

*For details see Silva et al 1984.

Table 3 shows the inferred annual cost of labor saving in carrying drinking water broken down according to the distance from home and family size. These costs are considered to be the primary benefits.In the calculation both season were considered. For the rainy season a $ 2.00 per man day, figure was used. For the dry season, due to the cyclic effect on the wage rate a $ 1.20 figure was used.

Table 3. Primary benefits: annual cost of labor saving in carrying drinking water

Family size	Distance from home (km)				
	0.5	1.0	2.0	3.0	4.0
	Cost / Year (US$)				
4	18.88	28.96	49.12	69.28	89.44
6	28.32	43.44	73.68	103.92	134.16
8	37.56	57.72	98.04	138.36	178.68
10	47.00	72.20	122.60	173.00	223.40

3. SECONDARY BENEFITS

It has been estimated that 80% of all sickness in the world is in some way the results of drinking contaminated water and lack of washing. Diarrhoea itself kills 25 millions people in the third world countries annually (Agarwal et all 1985). But, there are other side-effects.

Because during an attack of diarrhoea intestinal absorption is reduced, peasant agricultural workers may lack sufficient energy to work. This effect has not been precisely quantified. As cited by (Agarwal et all 1985), in Nigeria up to 25% of the working population miss work at least 10 weeks every year. It is also pointed out that, compared with developed nations, the productive work force in developing countries is reduced by one third due to similar factor. It has been estimated by the same source that, in general terms, 75% of the rural population in those countries are completely unable to work for over 5 weeks every year.

In the Brazilian semi-arid tropics, no data are available concerning this fact. Thus, it is assumed that for the long term mean a 5 weeks period of work reduction per year is a reasonable figures. The corresponding cost of labor for this period was considered as the secondary benefits if a cistern is constructed. To compensate for the labor force dsitribution within the family and the working productivity capacity by each inbdividual, a work productivity index was generated for the whole family. This index is presented in Table 4. In this table it is showed na equal distribution of components. In other words, 33% of the family is formed by man, 33% by woman and 33% by child. The working capacity of each group is related to the man's capacity. The index is found by multiplying both values per each group.

Table 4. Working productivity index for the whole family.

Individuo	**Working** Capacity	**Family weight** Distribution	**Work productivity** Index
Man	1.0	.33	.33
Womam	0.8	.33	.25
Child	0.6	.33	.20
	For the whole family		.78

Table 5 shows the secondary benefits. Those annual cost were calculated by multiplying the work productivity index for the whole family by the family size and 35 days which corresponds to 5 weeks. The difference in wage rate for both season was considered.

Table 5. Secondary benefits: equivalent annual cost for the reduction in work productivity.

Family	**Annual Costs (US$)**		
size	Rainy season	Dry season	Average
4	218.40	131.04	174.72
6	327.60	196.56	262.08
8	436.80	262.80	349.44
10	546.00	327.60	436.80

Before proceeding to the calculation of the total net benefit it is necessary to estimate the annual cost of the investiment for a cistern . The annual-loan payment for any total-loan size can be evaluated if interest rate and loan lenght are known. Five interestn rates were assumed for the calculation. The suggested useful life for a cistern is considered between 15 and 20 year depending of the maintenance. So, a 15 years planning horizont was shoosen. Table 6 presents the annual-loan payments for the total investment according to the family size and interest rate. Since all the costs are given in dollar vallues, no attempt was made to correct for the inflation rate. The investment cost was estimated by using equation in Figure 1.

Table 6. Annual costs of the total investment for a cistern.

Family size	Total Investment ($)	Interest Rate (%) 2.0	4.0	6.0	8.0	10.0
			Annual - Loan Payments $			
4	465.80	36.25	41.89	47.96	54.42	61.24
6	566.10	44.06	50.91	58.29	66.14	74.43
8	650.10	50.59	58.47	66.94	75.95	85.47
10	723.80	56.33	65.10	74.52	84.56	95.16

Table 7 presents the total net benefit. These net benefits were calculated based on an real interest rate of 6% since it is the expected rate for this region of Brazil. The values are given according to the familysize and the total distance from home, and each figure was calculated using the following equation:

Net benefit = primary + secondary benefits - annual loan payment

Table 7. Net benefits for a cistern at 6% interest rate.

Family size	**Distance from home (km)** 0.5	1.0	2.0	3.0	4.0
			Annual Net Benefits $		
4	145.65	155.72	175.88	196.04	216.20
6	232.11	247.23	277.47	307.71	337.95
8	320.06	340.22	380.54	420.86	461.18
10	409.28	434.48	484.88	535.28	585.68

4. FINANCING RURAL DRINKING WATER SYSTEMS

In spite of a cistern being economicaly benefitial, it is recognized that because of the very low marginal productivity of capital obtained by the traditional farming process in arid lands, the small farmer do not havé economical supoport to fund its adoption. Thus, financial assistence is needed.

In the majority of the developing countries, rural water supplies are subsidized by governments (Agarwal et all 1985). However, considering the public deficit and the scale os the problem at the moment in Brazil, where more than one million of small farms has not safety drinking water, government subsidy is a prohibitive option.

Cross-subsidy is suggested as a way to facilitate financing rural system (Agarwal et all 1985). Acoording to this cross-subsidy, the price of water in urban areas should have a progressive luxuary tax, after the minimum water consumption for basic needs. This can be considered as na externality. In this process, funds can be created by the government to finance water system in rural areas. For doing this, a more detailed study is needed concerning two points: the average real income of the urban population and the proportion of that income which can be spent on water.

5. CONCLUSIONS

The indirect return produced by a cistern at the farm level can be represented by cash values when a cost-benefit approach is used. From this case study it can be seen that just in a few cases the net benefit is positive when only the primary benefit is considered. However, a significant gain is obtained when the secondary benefits are included. This impact can be extremely helpful in justifying investments in rural water supply. Experience suggests that those are not the only benefits. Improved water supplies can contribute to reduce rural-to-urban migration and also the costs of medical treatment related to desease caused by unsafety water. However, those benefits were not considered here.

No mention has been made concern risk. It is argured that projects appraisal must embody risk in the accounting process. In this case, it is suggested that a sensitivity analysis be carried out in order to gain more confidence in the results. Thus, several re-appraisal is suggested considering different sets of assumptions regarding the life of the project, interest rate, wage rate and reduction in productivity due to sickness.

6.REFERENCES

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