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# Wooden and bamboo materials in the implementation of water for all Tanzanians by 1991

ABSTRACT

Lack of foreign money, ill concieved and undefined levels of service, adverse global economics of the 80's and embezzlement of funds and dishonesty on the part of the implementing authorities are but a few of the snags that hindered implementation of a resolution by the ruling party; then TANU, of 1971 which stipulated water for all Tanzanian by 1991 within a distance of short walk, defined as 400 m.
A government sponsored project to investigate on use of locally available materials; wood and bamboo as water conduits was started by T.N.Lipangile in 1974. Results of this research and their possible impact in the implementation of the rural water supply programme are discussed in this paper.

## INTRODUCTION

Ten years before launching the International Water and Sanitation Decade, the Tanzanian government embarked on a twenty year program of safe water for all Tanzanians by the year 1991.
At 1971 prices it was estimated that the government would be spending not less than 260 million TAS (Tanzanian shillings) annually of which 80% was expected to be acquired from foreign sources in form of materials, transport equipment and training of staff.
No sooner than the program took off, following problems that hindered smooth implementation became apparent:

a) Scarcity of foreign money
b) Adverse global economic conditions also affected those countries which would have contributed to the success of the program
c) Although rarely put onto records, funds embezzlement and dishonesty on the part of the implementing authorities, misuse and mismanagement of resources are also significant factors that contributed adversely towards the programmes progress.
d) Increased costs of projects due to general rise in cost of industrial products.
e) Desirable levelsof service were ill concieved by water experts and were not defined. As a result unnecessarily stringent conditions governed selection and development of water sources leading to enormous investments benefitting only few people. It is only at present that government is thinking to alter the existing adopted technological mix in favour of less expensive technologies. Shallow wells should serve 50% of the rural population in stead of the origanally planned 9% (ref.1). However even with shallow wells constituting 50% of the technological mix for rural water supply, government would be required to invest not less than TAS 1030 million annually (100 TAS = 4.87 Pound Sterling).This represents about 15% of the entire 1984 National Budget if the 1991 target is to be met. From the previous money supply records (ref.2) it seems unlikely though that government will, in the near future be in a position to afford such massive investment in the rural water sector. The previous annual financial inputs are shown in figure 1.

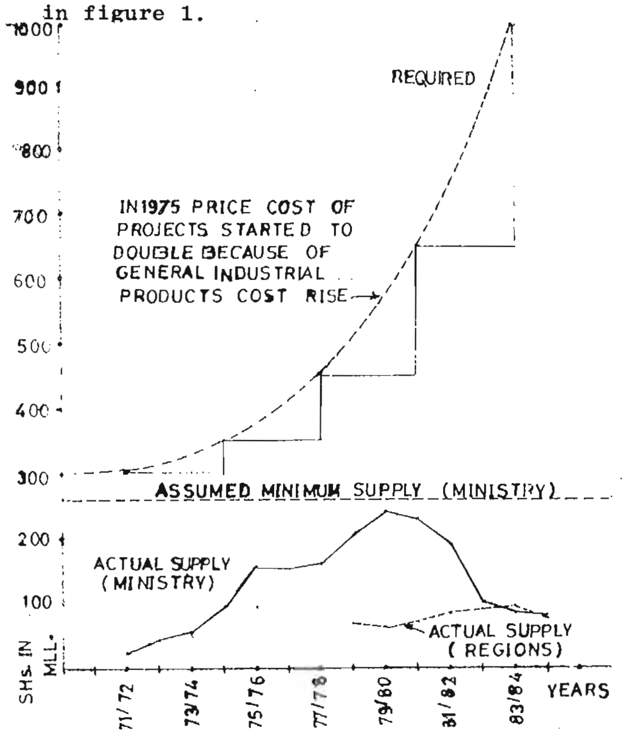


fig.1 Required, assumed and actual annual financial input for rural water supply

From the foregoing it is apparent that little success has been recorded so far in implementing the programme and the future of the programme remains gloomy. Improvement of this situation calls for:

- More elaborate definition of levels of service in short and long terms i.e. desirable combinations of availability, dependability quality and quantity of water to be supplied at different development stages.
- Simpler and cheaper technlogies in the de-

velopment of sources and distribution of supplies.
- Increased beneficiaries participation in realization, implementation, operatiòn and maintenance of supply systems.
- Enhancing education; as benefits of safe water supply are a bit obscure compared to those of health service and education, community participation in water supply has not been as pronounced as in those other two sectors.
- Less dependance on external inputs as the number of external supporters has been invariably decreasing. Water expert's attitude should reflect more of the national policy of self reliance.

BAMBOO PIPES

Bamboos, belonging to the family of the grasses, vary greatly in appearance from small thin species to species with stems as thick as 30 cm and as high as 30 m. All are however, characterized by hollow stems with solid partitions at intermediate distances. This property makes them attractive for use as water conduits (after removing of the partitions). Although there are many varieties of bamboo, those extensively used by the project include Arundinaria alpina, also known as the green African mountain bamboo, and Bambusa vulgaris (a green striped yellow bamboo). Whereas the former is an indigenous specie, the latter was introduced by the Germans from Asia. Both species are found in millions in a number of places in Tanzania.

Physical and mechanical properties

Bamboos reach their full length in the first year of growth and become only thicker after that. The culm of a mature bamboo starting from one metre to five metres above ground is more or less of uniform size and thickness. Variation of average bore size and the difference in pipe diameters between the two ends within those four metres is as shown in table 1

table 1: The average bore size and the difference in diameter

| | | | | | |
|---|---|---|---|---|---|
| average bore size | 38 | 50 | 63 | 75 | mm |
| difference in diam. | 3 | 3 | 1 | nil | mm |

From the table it is apparent that the smaller the bore size, the larger is the difference in diameter at the two ends.
Bamboo fibres are longitudial and are more or less glued together by pectins with few inter connections. This gives bamboos a low shear strength. Experiments carried out to ascertain pressures that bamboos can withstand revealed the following:
- For Bambusa vulgaris instantaneous pressures as high as 10 bars were recorded
- For Arundinaria alpina instntaneous pressures of 6 bars were recorded

It has to be mentioned however, that pressure bearing capability differs from bamboo stem to bamboo stem and that maximum values drop considerably when the stem is exposed to those pressures for longer times. Parameters affecting pressure capability are yet to be established. From field experience it has been concluded that working pressures of Arundinaria alpina and Bambusa vulgaris should not exceed respectively 1.5 and 3.0 bars. The lower working pressures compared to instantaneous pressures are thought to be due to water hammer effects and possibly less-effective tightening of the reinforcement wires onto the bamboo in a field situation. The higher pressure bearing capability of Bambusa is probably due to its shorter internode distances and thicker walls.

Hydraulic properties

Discharge-pressure measurements were conducted by the Hydraulics laboratory, University of Dar es Salaam. The variation of friction factor ($\lambda$) as determined by Darcy-Weisbach equation with Reynolds number (Re) is plotted as shown on the Moody diagram (fig 2)(ref 3).

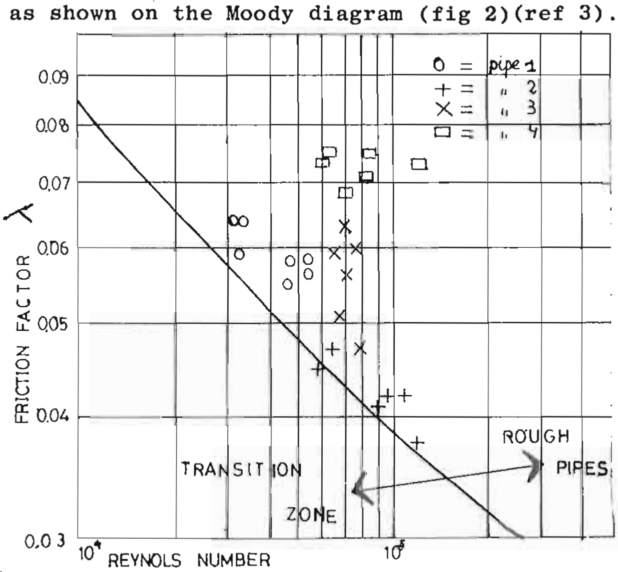


fig 2: friction factor $\lambda$ of tested pipes on Moody diagram

The diagram clearly depicts that the values plotted in the turbulent flow zone where $\lambda$ is governed by the relative surface roughness of the pipes. Consequently the use of the exponential formular for the flow through the pipes is justified. The average values of Manning's (n) and Hazen-William's (C) roughness coefficient were determined and found to vary between 0.013 - 0.016 and 75 - 90 respectively. The lower n-value and the higher C-value correspond to good node removal. For design purpose the project adopts a value of C between 70 - 75. This is because presently pipes are not centrally processed which makes control of quality unreliable.

## Economics of bamboo pipes

With the assumptions made in SIDA's evaluation mission report (ref 4), bamboo pipes of sizes 63 - 75 mm are found to be price competitive to polythene pipes both in terms of financial and economic annualized costs. In terms of present expenditure however, bamboo pipes are several times cheaper both in financial and economic costs (ref 5). The economic costs in table 2 are based on CCA - a copper, chrome, arsenic preservative - treaetment of the pipes to enhance their durability.

Table 2: Economic cost comparison between bamboo pipes and plastic pipes.

| | ECONOMIC COST TAS/MTR | | |
|---|---|---|---|
| | Arund. | Bambusa | PE 63mm |
| manufacture of bamboo | 13.80 | 16.45 | - |
| purchase of poly | - | - | 46.45 |
| transport, installat. | 20.85 | 20.85 | 42.30 |
| SUB - TOTAL | 34.65 | 37.30 | 88.75 |
| maintenance | 1.60 | 1.60 | - |
| ANNUALIZED COST | 7.35 | 7.85 | 12.85 |

Remarks:
- transport cost based on weigthed average distances to construction site
- for calculations a shadow exchange rate of 200% of the fixed rate of March 1983 is used (all calc. based on March 83 level)
- overhead expenses for bamboo are 50% of manufacturing cost and non for PE
- bamboo pipes are depriciated in 10 years, PE pipes assumed to have a residual value of 50% after 10 years

From the analysis transport costs is seen to be a major contributor to the costs of bamboo pipes. It is hoped that once the research on preservation gives positive results, transport costs can be significantly reduced by encouraging wide spread growth of bamboo all over the country.
Depending on what size of a polythene pipe a bamboo pipe is going to replace, the economic advantage of using bamboo pipes as a function of hydraulic gradient and discharge is depicted in fig 3.

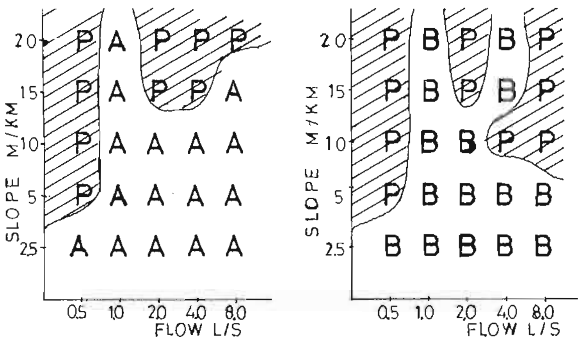


fig 3: least cost comparison of Arundinaria alpina (A) // Bambusa vulgaris (B) and PE pipe as a function of gradient and flow

It is generally observed from the figures that at low gradients, say up to 10 m/km, a system of bamboo pipes will convey increased flows with economic advantage. This is because manufacture costs of bamboo are not dependant on the size of the pipe unlike purchase of polyethene pipes.
The gradient difference shown for the two species is due to the fact that wire reinforcement on Bambusa vulgaris was then considered not effective in enhancing the pressure withstanding capability. Recently however, it was discovered that it was the mode of wire tigthening which rendered reinforcement non-effective on Bambusa vulgaris.
It is unlikely though that at any discharge a system of bamboo pipes would be of economic advantage at increased gradients. This is because at higher gradients bamboo schemes require more break pressure chambers while also more closely spaced wire reinforcement is needed.
An added potential advantage of using bamboo pipes is the possibility of community participation by encouraging people to grow their own bamboo. This will make construction and maintenance more village orientated.

## Preservation of bamboos

Being organic in nature, upon its death bamboo is bound to undergo biological decay caused by bacteria and fungi and termite attack. Thus without protection a bamboo pipe would not last long in the soil environment which normally harbours all these decaying organisms.
Present practise involves a combination of preservation procedures which include:
- External coating of the pipes by boiling them for a short time in tar
- trench treatment with aldrin
- intermittent chlorination of systems

The ideal solution would be the impregnation of the bamboo culm itself with a preservative which is both insecticide and fungicide. However experiments conducted so far, failed to quarantee the non-leaching of these chemicals into the drinking water.

# WOODSTAVE MATERIALS

## Introduction

The present woodstave technology started developing in the United States of America in the 1860's. Although Wood/Bamboo project adopted this technology, it has nevertheless carried out investigations to ascertain actual carrying capacity for the locally manufactured staves and safety of water carried through or stored in woodstave structures treated with the toxic preservative CCA. Presently the project is also involved in investigations leading to use of staves inpressurized flow conduits. Todate woodstaves have been success

fully used in the construction of tanks, irri gation channels and culverts. It is envisaged that woodstave technology will also find use in construction of silos for grain storage and sewarage pipes.
Although there are numerous types of trees available in the country, present efforts are mainly restricted to the use of soft wood (pine). This is because pine is abundantly available, cheap compared to other wood species, easily workable and can be treated to enhance its life-time.

## Engineering properties

As a building material, mechanical properties are well known. The project carried out investigations to establish hydraulic performance of wooden pipes. Results from experiments carried out at Hydraulic's laboratory, University of Dae es Salaam, indicate minimum and maximum Hazen-William's C - values of 70 and 115 respectively (ref 3). Although earlier work by Scobey (1916) gave higher C - values of 120 (ref 6), the hydraulics laboratory recommended a value of 85 for hydraulic calculations. The experiments further showed that with the normal thickness of staves used there was excessive sweating at pressures above 0.5 atm. Recent trials however showed that sweating can be reduced considerably by using thicker staves or by coating the staves with tar or bitumastic paint. Pressures as high as 5 atm were reached without experiencing sweating.
A known additional advantage of timber pipes is its non-corrosive nature; unlike concrete and metallic pipes in which corrosion is a problem especially when used in chemical industries and sewarage systems.

## Economics of investment

At present the Wood/Bamboo project buys ready made staves from the factory and assembles them on site. As it is apparent from fig. 4 ground level tanks are very cost competitive with the more conventional materials; steel and concrete.

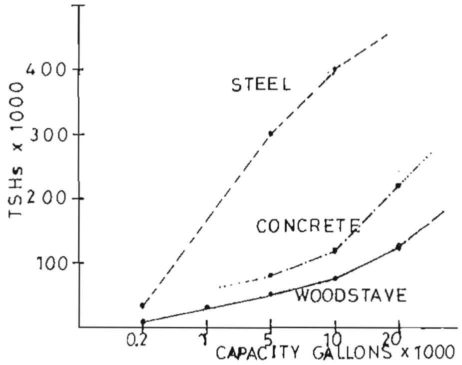


fig.4: construction cost for ground level water tanks

A recently constructed irrigation pipeline of 600 mm diameter and 365 m length costed 420,000 TAS whereasthe same would have costed 630,000 TAS and 1,125,000 TAS had it been constructed of respectively concrete or steel (ref.7).

## Preservation and durability

Impregnation of chemicals into pine timber to preserve it, has been successfully practiced. Records on CCA preservation of pine wood in direct contact with the soil, show that the timber will last for at least 20 years (ref.8).
As all preservatives are however more or less poisonous, a careful selection of the preservative should be made when the treated timber is to be used in ... water conveying structures. Fixation characteristics of the preservative and intended use of the water are important parameters to count with.
At present CCA has been used in all water tanks and open flow pipes. Investigations showed that the leaching of the chemical compounds does not pose a health hazard when storage does not exceed 10 days (ref.9).

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