Proceedings from the First International Conference on Appropriate Technology

Bulawayo, Zimbabwe
July 15-17, 2004

Hosted by the National University of Science and Technology (NUST)

Theme

A Knowledge Management Approach to the Development of Appropriate Technology, with a focus on Sustainable land-based projects

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A Knowledge Management Approach to the Development of Appropriate Technology, with a focus on Sustainable land-based projects

This theme of our first international conference is designed to:

1) Facilitate research on the management, assessment, archiving and tracking of appropriate technology concepts and projects through the use of state of the art knowledge management theories and practices
2) Focus on projects related to increasing the productivity of land-based projects in a sustainable fashion, while being inclusive of all areas related to appropriate technology.

Background

Underdeveloped countries throughout the world have a majority of their population involved in land-based economy, primarily farming, but also ranching and mining. Despite this economic emphasis, most of these countries are importers of agricultural products. This is a problem of low productivity. Due to insufficient technology, little of the natural resources excavated from mining are processed locally. A multi-discipline investigation of the most appropriate technology to use to increase land-based productivity is in order. To be effective this process of technology implementation must be sustainable, and culturally and environmentally sensitive.

An international call for papers was first issued in October 2003. Work, submitted by 42 authors, was reviewed by an international planning committee. All papers were subject to a double blind peer review process by at least three reviewers each. The following 20 papers reflect the international standard of this conference.

Papers are organized in five broad categories that reflect the different sessions of the conference: Industry and production; Construction and Architecture; Transportation and Solar technology; Water, Agriculture and Environment; and Knowledge Management and Appropriate Computing.

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GUIDELINES FOR SMALL-SCALE INDUSTRIAL FERMENTATION OF *MARULA (SCLEROCARYA BIRREA* SUBSPECIES *CAFFRA*) FRUIT JUICE TO PRODUCE *MUKUMBI*, A TRADITIONAL ZIMBABWEAN WINE

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Abstract
Mukumbi is a traditional alcoholic beverage prepared from fruits of the marula tree (Sclerocarya birrea subspecies caffra). The beverage is part of the regional cultural heritage. It is well known and accepted by consumers, and consequently provides an appropriate basis for agro-industrial development. The outline presented serves as a guideline to the basic process improvements that can increase the appeal of mukumbi. They can be carried out by simple means under hygienic and scientifically monitored conditions suitable for a small-scale industrial set up. The fermentation technology developed is a transformation of the traditional procedures into a technology incorporating objective methods of process control and standardizing quality of the end product without loosing its desirable attributes. Though specific to marula juice fermentation, the technology can be applied to the processing of many related fruits based fermented traditional beverages, such as masawu (Ziziphus mauritiana), mazhanje (Uapaca kirkianana), hacha (Parinari curatellifolia), and matohwe (Azanza garckeana) fruit fermentations. It is hoped that since the fermentation process has been optimised the tree and its fruit will be turned into a viable agroforestry product that is expected to bring income to rural communities and to encourage environmental conservation.

Keywords: fermentation, food processing, *marula*, small-scale industry, wine

INTRODUCTION

Mukumbi is a traditional Zimbabwean wine prepared in many rural homes in the semi-arid regions of Zimbabwe. The wine is prepared from a fruit called *mapfura* in Shona and *amaganu* in Ndebele. The majority of the people in Sub-Sahara Africa call the tree *marula* (*Sclerocarya birrea* subspecies *caffra*). The *marula* fruit is one of the most commonly utilized wild fruits of Southern Africa. Archeological evidence indicates that the *marula* fruit was known and consumed by men in Africa since 9,000- 10,000 years BC [1]. The plant is widely spread in Africa especially in semi arid regions [2]. *Marula* has characteristics which offer remarkable opportunities to the development of agriculturally based industries in Africa, which include drought resistance, exceptionally high yield of fruit per tree, the possibility to utilize both the fruit and nut contained within the seed, ease of harvesting tall trees, exotic flavor and nutritive value of the fruit. *Marula* fruit can be consumed as a fresh fruit. The fruit has been processed into products such as *mukumbi*, jelly or jam. Limited amounts of juice are utilized industrially for flavor enhancement in the production of liquor in the Republic of South Africa. The green physiologically mature *marula* fruits fall to the ground and ripen (turn yellow in color). They are then harvested and processed to *mukumbi* [3]. In Zimbabwe fermentation time varies from household to household, but is usually 72 h, the resulting *mukumbi* produced is of inconsistent

quality. In certain regions of Zimbabwe the whole process is carried under a tree increasing possibilities of contamination and the health risk to consumers.
1

In many developed countries, extensive studies done on some of the traditional fermented beverages have led to their commercialisation. Such products as wine, beer, pickles and sauerkraut have earned high status and values on the market. Their refined quality has guaranteed them continual and increasing consumption, unfortunately this is yet to happen especially in Zimbabwe. The majority of research on African fermented foods has been done in West Africa [3 - 5]. Due to the extensive studies done, some of these products have been commercialised e.g. *gari*, *dawa dawa* and *ogi* [7]. Zimbabwe's wines from fermented indigenous fruits have not been commercially accepted, because little or no research and development has been done in standardising the process and quality parameters. The harvesting, storage and processing of *marula* fruits is still basically a labour intensive time-consuming, less productive and reasonably complex family art passed from generation to generation.

The development of a starter culture for *mukumbi* is key to its expansion. Application of a starter culture with scaling-up of the indigenous technology at village level will reduce the health risk of consumers and the post harvest economic loss to producers. Optimisation of *mukumbi* preparation has not received much attention despite the fact that it has the potential to change the socio-economic status of rural communities through creation of food processing industries and employment in marginal rural areas, boosting the income of the rural folk, providing a non seasonal supply of a healthy and nutritious beverage, reduction of rural to urban drift, and ultimately sustainable development. Below is a summarized technology for small-scale industrial production of *mukumbi*. Preparation of *mukumbi* was done under laboratory conditions [8].

MUKUMBI PRODUCTION TECHNOLOGY

The key prerequisites for achieving efficient and profitable use of *marula* fruits to *mukumbi* are adequate grading and cleaning of fruits, economically sound processing and improvement of nutritive value, hygienic storage and handling, improvement of safety and appropriate packaging, prolongation of shelf life and maximum consumer appeal. Below are recommended steps for production of *mukumbi*.

Fruit harvesting and treatment

Presently harvesting can be done by picking fallen fruits from the ground. There is need for more work to improve harvesting techniques of *marula* fruits. Ripe and unbruised *marula* fruits are the ones most suitable for *mukumbi* production. All selected fruits should be of the highest quality and at the firm ripe level of maturity, otherwise whole batches may be spoiled by the presence of a small quantity of unsound fruit. Incoming fruits should be graded and washed in clean chlorinated water before processing to clean the fruit and to reduce fruit surface microbial load. Chlorinated water can be made by adding small quantities of household bleach to tape water (1 teaspoon per 4.5 l) [9]. Fruits should be thoroughly rinsed in clean water after this treatment. Large quantities of water are used in the production of *mukumbi*. It is strongly recommended that local expect advice is sought as to the suitability of water available in any location for *mukumbi* production. Mechanical washers for handling larger quantities of fruits

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can be made locally using rotating drums containing brushes. They are suitable for *marula* fruits because their skins do not damage easily.

***Marula* juice extraction and utensil treatment**

The preliminary preparations of fruits include pricking the fruits to extract the juice and mucilaginous flesh. This should take place under the most hygienic conditions possible. Workers should wear clean uniforms, wash their hands well before commencing work, and if possible wear protective gloves and use easily cleaned surfaces such as metal, plastic or wooden surfaces. Utensils should be sterilised by washing in a solution of potassium metabisulphite, and rinsing twice or thrice in clean water. Utensils should be kept clean at all stages. As *marula* juice is rather acidic, it is recommended that stainless steel, food grade plastics or wood utensils be used. Fruits from preliminary stages should be kept in covered containers while awaiting further processing. Figure 1 shows the process for small-scale industrial production of *mukumbi*.

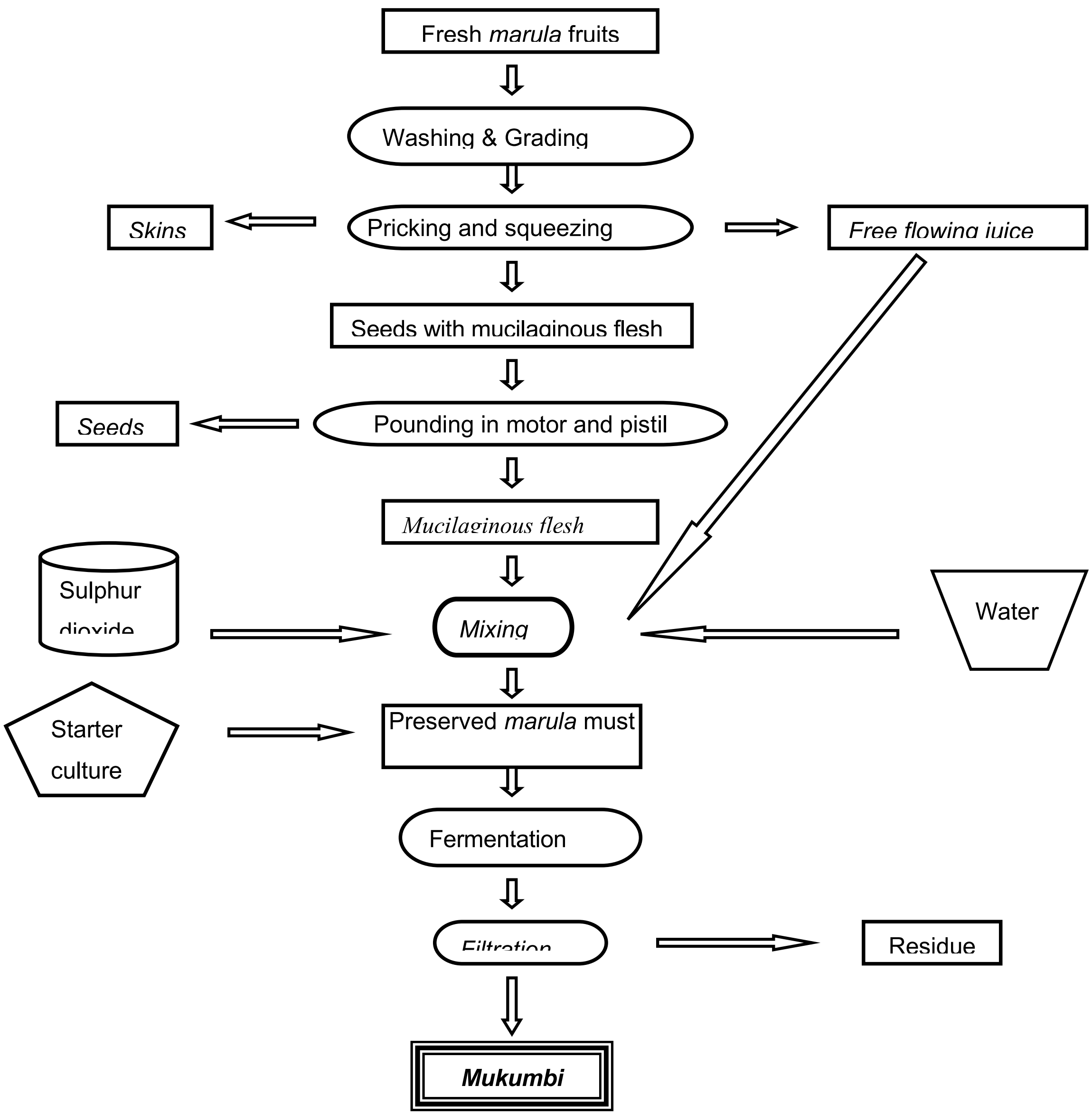

Figure 1: Small scale Industrial production of *mukumbi*

Fermentation

The fermentation vessel should be made of stainless still or food grade plastic. Stainless steel, which is easier to clean and maintain, allows the temperature of the fermenting juice to be precisely controlled. It should be sterilised by washing with a solution of potassium metabisulphite or boiling water and thoroughly rinsed with clean water before introduction of juice. Figure 2 shows the recommended design of a fermentation vessel.

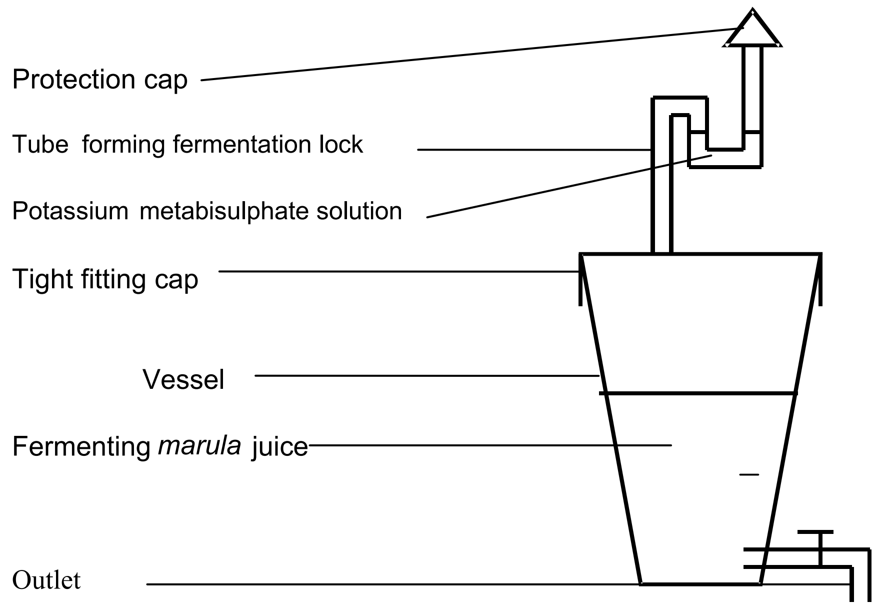

Figure 2: Fermentation vessel outline

The juice, preserved with sulphur dioxide, is then introduced into the fermentation vessel where fermentation occurs. The pH of juice should be measured before introduction of a pure yeast starter culture. If pH value is above 3.5, then it should be lowered by addition of citric acid or lemon juice. Pure yeast starter culture of *Saccharomyces cerevisiae* (10 % v/v), is then introduced. The yeast starter culture allows the fermentation process to be better controlled to produce *mukumbi* of the desired quality. The vessel should be tightly closed (air-tight) to avoid problems of dust and fruit flies coming in, possible oxidation of fermenting juice, and contamination with bacteria and fungi. It should be ensured that the fermentation lock is filled with a solution of potassium metabisulphite. Fermentation should be allowed to proceed at 25 – 30 ^{o}C for 60 h. If inoculation has been done well, within 12 h the fermentation should become vigorous with frothing and foaming. The end of fermentation can be judged when it is seen that there are no more bubbles rising to the surface through the fermentation lock. End of fermentation can also be judged by pressing an ear against the fermenting vessel and listening to the sounds of evolving bubbles. At the end of fermentation the hissing sound would have subsided. The *mukumbi* producer should open the vessel valve and smell the contents to decide whether the right nose has been developed. If these tests prove that primary fermentation is probably over, a little is sipped through a wheat straw or tubing to check the taste.

Filtering

At the end of primary fermentation, the fermenting juice should be filtered by opening the vessel outlet, and allowing the fermenting juice to flow through a sterilised sieve (435 µm).

The fermented juice is filtered to separate the fermented juice now called *mukumbi* from the residue and to help stabilise it. This process is sometimes referred to as fining or clarifying. Research needs to be conducted on the subject of pasteurisation of *mukumbi*. *Mukumbi* is then best transferred to a maturing vessel. It can, however be siphoned into bottles or drunk immediately. The final pH value should be 3.4 and the final titratable acidity value should be 0.95 % citric acid. This will make *mukumbi* fall within values recommended for sweet dessert wines [10].

Maturing

After fining, *mukumbi* is allowed to clear and mature further. This maturing or ageing occurs best in large stainless steel, wood or plastic containers. The length of time *mukumbi* is matured affects its colour, aroma and flavour and it can be few days (or hopefully several years!).

Bottling and labelling

The final step in *mukumbi* preparation is bottling. Bottles are a more permanent and convenient method for storing *mukumbi* than are maturing vessels. *Mukumbi* continue to improve, or age in the bottle. This ageing in the bottle is thought to be caused by the various elements present in *mukumbi* (such as acids, pigments, and tannins) interacting and combining with one another to create *mukumbi* specific character. The main aim of bottling is to keep *mukumbi* in quality condition until it is sold and consumed, and to encourage consumers to purchase *mukumbi*. Correct bottling is essential to achieve both these objectives.

Quality control

Quality control need not be costly and its importance cannot be over stressed. The *mukumbi* producer should introduce some form of quality control, regardless of size of operation, to ensure consistent quality and reduce losses and rejects. The producer must demonstrate responsibility to the consumer. In addition to the summary table of the main quality control points given below, there should be checks and balances on all factors relating to production such as workers hygiene, clean uniforms, plant cleanliness and utensils. Most of these checks take time but require little or no equipment or materials. These check points ensure that the quality of *mukumbi* is as high as possible and all employees should be aware of the importance of quality and should be encouraged to report any defects.

Table 1: Quality Control table

Stages in process	Quality check
1. Workers hygiene	Clean uniforms, wash hands before handling fruits and utensils.
2. Selection of fruits	Ripeness – Firm ripe stage of maturity, no moulding or bruising, correct size and colour, no insect damage.
3. Utensils	Clean and sterilised utensils, made of stainless still, food grade plastic or wood
4. Fermentation vessel	Clean and sterilised vessel made ofstainless still or food grade plastic
5. Preliminary preparation	All unwanted parts (stones, skins, dirt, insects, etc) removed
6. Monitor ingredients	Correct volumes of water added, correct volume of inoculum No contamination.
7. Bottling	New bottles, no cracks or other damage, correct size and shape.
8. Filling	Correct weight. Clean lip of container for good sealing, Vacuum formed under lid.
9. Final product	Good appearance, no contamination, correct label and fill weight.

Major spoilage defect
Development of a sharp acetic acid flavour happens when immature fruits are used, when the wrong proportion of water to fruit juice is used, or when *mukumbi* has been disturbed before it matures. This can be used by turning spoiled *mukumbi* into vinegar.

CONCLUSION

Mukumbi of acceptable organoleptic properties has been produced following the presented technology [8], in 60 h, at a temperature of 28 ^{o}C. An alcohol level of (41.3 %), a lower final residual sugar concentration (2.5 g/l) and a low pH (3.34) have been achieved. It had a slight sweet-sour taste, a fruity aroma, and a mildly alcoholic flavour. Although it is unlikely that traditional *mukumbi* producers could be supplied with starter cultures at an economical price or could easily include them in their processing, the target is the small-scale industrialist. At a small-scale industrial level, *mukumbi* can be hygienically produced in large quantities with consistent quality. Proper packaging in appropriate wine bottles would ensure an increase in shelf life. It is hoped that since the fermentation process has been optimised, there is need to disseminate it. The tree and its fruit will be turned into a viable agroforestry product that is expected to bring income to rural communities and to encourage production of other *marula* fruit products such as jam or jelly.

ACKNOWLEDGMENTS

The authors would like to acknowledge the assistance of the late T. Mugochi, W. Parawira and Mapindu villagers of Mataga, Mberengwa for their knowledge on the art of *mukumbi* preparation. The project was funded by Farm-level Applied Research Methods for East and Southern Africa (FARMESA), Swedish Agency for Research Corporation with Developing Countries (SAREC), and Chinhoyi University of Technology Research Board.

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RAPID INDUSTRIALIZATION THROUGH FLEXIBLE SPECIALIZATION

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Abstract
The paper set to give a brief introduction of flexible specialization having a foundation of technology transfer and appropriate technology. Briefly discussions on how the Japanese used technology transfer is made and where it fits in our context as a vehicle to industrialization based on appropriate technology. Then the case study design is given which has been made to support the agricultural reformation in the country while at the same time increasing the industrial base that can lead to diversification in times of drought.
Keywords: flexible specialization, industrialization, appropriate technology, technology transfer

1.0 Introduction

Flexible specialization, in simple terms, means timely development of strategic technological and manufacturing capabilities through allocative efficiency in utilizing and allocation of capital, labour and raw materials, both at government level and at company level. Direct development of appropriate technology, innovative and commercially minded techno-entrepreneurs and strong strategic and sustainable alliances with a shared vision are just but a few pre-requisites. This can be achieved by technology transfer and appropriate technology concepts which are briefly discussed as literature taking a Japanese model of approach. The paper shows a case study on a design of a Barbed-wire making machine which is expected to be faster, with reduced changeover time. This project will support industrialization in Zimbabwe and will an impact on the national economy and technology coming from a background of agriculture.

1.1 Flexible specialization

This paper sets out to briefly discuss the issues on flexible specialization. Flexible specialization, in simple terms, means timely development of strategic technological and manufacturing capabilities through allocative efficiency in utilizing and allocation of capital, labour and raw materials, both at government level and at company level.

Flexible specialisation involves a production system based on the manufacture of a shifting and diverse range of products, customised to specific market segments and produced with "intelligent" machinery and an adaptable, skilled labour force [1].

The new trend goes to flexible specialisation, through which SMEs have an important impact on economic development, rural industrialisation and social integration. In order to make use of these innate advantages, the SME culture has to be promoted and be able to formulate their necessities. Therefore, SMEs for instance have to operate in a co-operative network taking advantages of local externalities and creating a strong cluster identity, in distinctive industrial districts, with networking stretching beyond national borders. The advantage of SMEs lies in its inherent flexibility which allows them to adapt relatively easy to current market requirements. Globalisation of manufacturing demands more capital-intensive technologies and other skill-intensive production factors, which set natural entry barriers. This might restrict the number of participants at the respective markets to small group of enterprises of mainly developed and industrialised countries [2].

The introduction of new information technologies to SMEs is essential to increase their competitiveness. In contrast to large enterprises, SMEs are capable of changing their production capabilities much faster and can react therefore immediately to the trend of new flexibilisation. If they make good use of this capability, SMEs might be the winner of this trend. SMEs must be sensible towards developments on the software market and towards the process of technologies [2]. To achieve the above there is need of technology transfer.

1.2 Technology Transfer

The technology transfer concept has been one of the sophisticated issues for both developing and developed countries during last three decades. The transfer of technology is not only a matter of transferring tools, it is rather the implanting and nurturing of methods and processes. These critical elements are the knowledge set; knowledge of physical means, of related technical/technological information, of organisation, and of human skills in order to operate such means effectively [3].

The technology transfer concept has been one of the sophisticated issues for both developing and developed countries during last three decades. The transfer of technology is not only a matter of transferring tools, it is rather the implanting and nurturing of methods and processes. These critical elements are the knowledge set; knowledge of physical means, of related technical/technological information, of organisation, and of human skills in order to operate such means effectively [3]. Technology transfer, in one phrase, can be addressed as the "achievement of technological mastery"; Japan through its institutionalised policy achieved such mastery rapidly. Due to the existing inherent factors behind the transfer process, there is still the lack of a unified rational approach to technology transfer. The case of Japan, as a successful practice with its own characteristics, can make, in this connection, a sound contribution.

It is now widely accepted that both innovation, mostly in industrialised nations, and technological change, mainly in developing countries drive competition at both the corporate and national levels [4]. It has been also evident that in order to survive in a market-dependent world, it is essential to become and remain competitive. The Japanese system of technology acquisition and innovation is now symbolised as a sustainable successful example in such a technological market, especially for developing countries.

There is no doubt that Third World nations have now well understood the fundamental role of technology in their socio-economic developments. The ways by which accumulation of technical information and technological knowledge can be achieved are seen as a main requirement for technology acquisition, diffusion and development in developing countries [5,6,7,8]. This is a prerequisite basis for techno-economic progress and social growth in various aspects of national production systems. The successful Japanese experience in technology transfer and development is an important part of the literature.

When one is discussing technology there is need to understand the trend in which Japanese five stages of development (from technology transfer to self-reliance in technology) has been approached, provides an appropriate lesson for policy makers and planners in less developed countries. National consensus, global imitation and R&D, emphasising social/group activity, minimising raw material proportion in a technology or product, resource self-understanding (human resource, natural resource, knowledge and information resources), creation and accepting trial and error experience without any doubt (learning by doing), deep coordination, and on-the-job methods of skill development and sector enhancement can be identified as the main factors responsible for the Japanese style of successful technology transfer. Following these concepts applied to the need in the country was the barbed -wire machine developed.

Technology transfer in the 1960s was characterised not so much by an intention to expand the scale of production, to mechanise and rationalise, but by the aim to transform the production system itself into automated high-speed mass production. A crucial point may stem from this policy; it denies the common view about the concept of technological appropriateness for developing countries [9,10, 11, 12]. The belief which can draw on another perspective, supports this view that appropriate technology is not a technological prescription, and it depends upon related factors in the country involved which change with time, to satisfy local, regional, and international conditions. In Japan, for instance, although there had been a mass-production policy in the 1950s, it did not stress high-speed production to meet the market; rather, technologies based on much less automation were supported. It was due to the availability of a plentiful, good-quality, labour force which made automation less attractive (i.e. inappropriate technology). Based on the fact that in Zimbabwe the land has been redistributed thus the production of machinery that produces products that can be supported by the land reform becomes appropriate technology at this moment in time. Thus as people look at appropriate technology it must also be in the context of time and economic environment.

On the other hand, the Japanese style of technology transfer focused particularly on the last generation of technology, as an optimal choice, in order to make full use of the advantages of the late comer. This is based on a strategy of technology transfer that the late starter has the advantage. Generally speaking, all these inward developments were backed up by a new style of R&D within the periods of the planned technology transfer. In brief, based upon the inherent nature of the Research and Development (R&D) process, the R may be expressed as a total of small d s (i.e. $R = d1+ d2 + d3 + . . . + dn$). But for Japanese, a small r and a large D facilitated national technological development through technology transfer. This means that such a process for Japanese system has been changed to R&D. According to this fact, in recent years, Japanese industries have changed their employment structure along-with changing the nature of products. The total number of employees in the manufacturing sector is on the decline, while in the non-manufacturing sector, especially in R&D and services (e.g. sales), it is increasing. For instance, in the case of a certain calculator manufacture, 1000 out of 3500 employees are engaged in R&D at a technology centre [13].

The Japanese style of technology transfer which is now establishing a pioneer approach for technological change and industrialisation in developing countries, has been effectively copied by some the Far East countries in some aspects. To Western countries, also, there is a flow of sophisticated ideas generated from the Japanese style of technology development (e.g. associative creativity within R&D, total quality control, integrated human resource etc.).

This section highlighted the Japanese experience, which the developing countries can take instead of the fear of reinventing the wheel. Taking this as an opportunity to build a base to formulate R&D centers for other products by harnessing the funds generated from one sector and invest in a other sector that is affected but the weather.

1.3 Appropriate Technology

How can Zimbabwe adopt flexible specialization in the sectors of the national economy (manufacturing, agriculture, mining, tourism etc) and what is the role of today's engineer in this? Directed development of appropriate technology, innovative and commercially minded

techno-entrepreneurs and strong strategic and sustainable alliances with a shared vision are just but a few pre-requisites.

To achieve this a design of a Barbed-wire making machine which is expected to be faster, with reduced changeover time. This is an example of import substitution. These projects will support industrialization in Zimbabwe and how it will impact on the national economy and technology.

2.0 BarbedWire-making Machine

2.1 OBJECTIVES OF THE PROJECT

- To investigate and isolate all the cost drivers in the barbed wire supply-chain and study their relative contribution to the overall price of the wire.
- To generate possible ways of controlling or arresting cost-drivers.
- To implement the solutions generated, in the context in which they exist.

The bottom line being to provide engineering and business solutions that permanently address the problem at hand and the goal being to make barbed wire affordable to the majority of farmers, A2 farmers at least (who are mainly the working class), in addition to having a stable price [14].

2.2 BARBEDWIRE MANUFACTURING PROCESS

Barbed wire is manufactured on an automatic machine in the following steps:

i) Forwarding a pair of main line wire from one end of the machine
ii) Point wires are fed into the centre from both the sides
iii) The wires twine themselves automatically and form four sharp barbs
iv) The main wire is advanced forward by a regulated length
v) The wire finished by the barbing process is gathered on a steel spool on frame stand located at the bottom of the machine.

2.3 SPECIFICATIONS OF BARBED WIRE BRANDS

According to the Zimbabwe Standard No.284: 1984 on Steel Fencing Materials, the specifications for double strand barbed wire are as follows [15]:

2.3.1 Nominal Wire Diameters

The nominal wire diameters are as follows:
2.50 mm + 0.25 mm – 0.50 mm,
2.00 mm + 0.25 mm – 0.50 mm,
1.60 mm + 0.25 mm – 0.50 mm.

2.3.2 BARBS

The barbs should be made from wire of not less than 1.75 mm nominal diameter.

2.3.3 CONSTRUCTION

The construction requirement are as follows:

- The twist of the wires should be even and accurate, and formed in one way to ensure that the barbs are securely retained in position.
- The spacing between the barbs should be not less than 145 mm and not more than 160 mm. The barbs should be four point, the points being approximately at right angles to each other in a plane perpendicular to the line of wire. At least one of the barbs has to pass between the line wires and both have to be tightly rapped twice around the line wires. The outstand of each barb point should be at least 13 mm, measured from the nearer line wire.

Interpreted, this standard gives the following brands:

Table 1.0 Product specifications

LINE WIRE SIZE	POINT WIRE SIZE	BARB LENGTH
2.50	1.75	70.4
2.00	1.75	68.0
1.60	1.60	51.0

2.4 BARBED WIRE MAKING MACHINES IN THE MARKET

There are two major types of barbed wire making machines, varying in size and speed [16].

The barbed wire making machine by Singh Industries shown above has the specifications shown in Table 2.

Table 2: Specifications of Singh Industries Barbed Wire-making Machine

Pitch of the barb	Variable from 2' to 6'.
Power Required	7.5 HP
Motor RPM	1440
Machine RPM	200
Production capacity	500 to 600 Kgs./Shift

2.4.1 TYPE 1: Barbed wire making machine by Singh Industries

This type is illustrated in Fig 1.

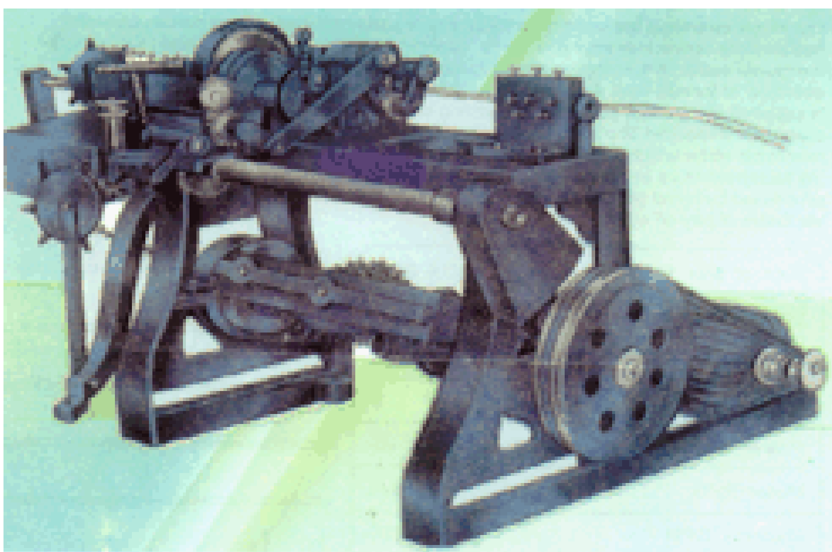

Fig. 1.0: Barbed wire making machine by Singh Industries

2.4.2 TYPE 2: Barbed wire making machine by Maneklal and Sons

This type of machine is illustrated in Fig 2.

Fig.2.0 Barbed wire making machine by Maneklal and Sons

The barbed wire making machine by Maneklal and Sons shown above has the specifications shown in Table 2.

Table 2: Specifications of the barbed wire making machine

Pitch of the barb	Variable from 3' to 4'.
Power Required	5 HP
Motor RPM	960
Production capacity	500 Kgs./Shift
Overall machine dimensions	1970 x 1360 x 1150 mm

3.0 NUST BARBED WIRE MAKING MACHINE (ILO-190 BarbmaSter)

The barbed wire making machine by NUST Department of Industrial Engineering has the following specifications shown in Table 3.0.

Table 3.0 Specifications of the NUST barbed wire making machine

Pitch of the barb	Variable from 2' to 6'.
Power Required	4 kw
Motor RPM	950
Production capacity	600 Kgs./Shift
Overall machine dimensions	2000 x 1000 x 2000 mm

The machine is a small and precise revolution offering new levels of versatility and technology to the generation of barbed wire making machines. It is a complete strand-twist-and-cut line covering everything required from pay-off to take-up, featuring the following:

- Rated speed of up to 190 barbs per minute at 6" spacing (representing a 5.6% increase in speed as compared to the existing models).
- Constant lay length and lay direction variation by swapping motor terminals
- Constant tension control for highest levels of quality

- Wire straightening pay-off system that frees the wire of kinks
- An efficient meter counter
- Shorter changeover times (load/unload) owing to the use f 15 inch collapsible reels and pintles
- Designed for ease of maintenance to include standard and/or easily machinable parts.
- Ergonomically and aesthetically pleasing
- Light but rigid and offers low noise and less power requirement

The 3D view of the machine designed is shown in Fig 3.0.

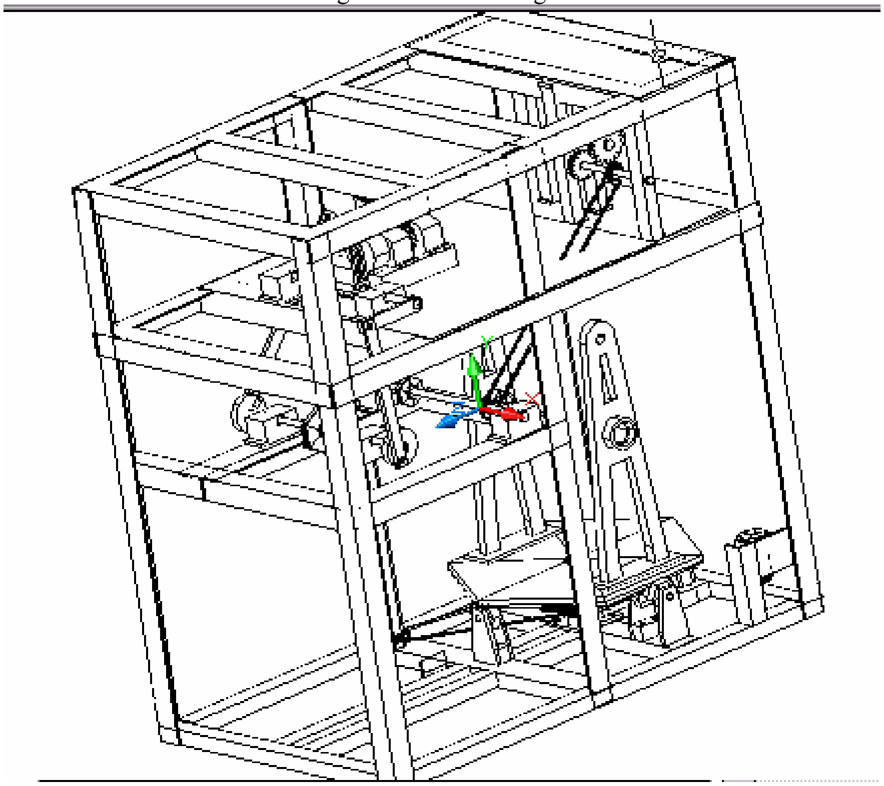

Fig 3.0: NUST barbwire making machine.

A full detail design of component by component of the machine has been done [14].

The estimated cost of the machine was $7 585 331-82 as compared with the cost of machines from India costing between US$15000 and US$25000 excluding shipping cost and duty as per early last year.

3.0 Conclusion

It is evident that the process of technological change in developing countries can take different paths depending on the characteristics of the environmental culture. Countries responsible for their own development should be prepared to proceed carefully with technological change. This paper set to show how through agricultural support industrialization could be achieved by the manufacture of a barbwire-making machine.

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ALTERNATIVE MATERIALS, KNOWLEDGE MANAGEMENT, AND WEALTH

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Abstract

This paper sets forth the results of years of practice in business – manufacturing and trading - of a former analytical chemist who converted to a manufacturing chemist.

The geography and geology of Guyana contributed to the traditional knowledge upon which the authors used their literacy in natural science. We will discuss how the technology associated with rice, bauxite and balata production guided the authors in the manufacture of new materials. The science needed for the manufacture was simple.

Details of materials manufactured and some conditions are as follows:

1. *Wood putty was manufactured from kaolin and soybean oil using a simple mixing machine. A search for an emulsifying agent led to the local manganese ore deposit.*
2. *Sodium silicate was manufactured from rice husk ash RHA and caustic soda based on analysis showing RHA having a high reactive silica content.*
3. *Sodium silicate was manufactured by fusing sand with soda ash using a furnace design out of India [5].*
4. *A refractory mortar was manufactured using local kaolin that is a fireclay.*
5. *A material to stop leaks was manufactured using hard pitch and balata based on the principle of evaporation.*

Every developed nation has benefited from the research of its citizens. The developing countries must so educate the masses that the attitude of research in indigenous materials is implanted. This zeal for research was prevalent among a group of persons who pushed for new techniques and materials when the traditional ones were not available. Thus a positive attitude to research led to increased confidence, technology transfer, and a manufacturing business. This attitude must be passed on to others.

INTRODUCTION

The National University of Science and Technology NUST, Zimbabwe, seeks to focus on science and technology as the engine of economic growth of Zimbabweans. The wealth of Zimbabweans is based primarily on farming, ranching, and mining but low productivity is hindering wealth. NUST is searching for high productivity and wealth for Zimbabweans based on available knowledge. Therefore, NUST is searching to change land-based wealth into a science and technology-based wealth.

[1] Author of the paper

[2] Author of the paper

Tom Dalgety used knowledge of science and attitudes inculcated during adolescence, to start up a manufacturing business in Guyana. Florine Dalgety is an educator. Both recognize the need for new approaches to learning. Both see the need for inculcating the discovery method at school. Alternative materials to change attitudes could easily replace materials and equipment in schools. It is attitude of a people or nation that produce wealth and improve health.

Guyana is blessed with minerals, farming soils, tropical rain forest, and many rivers yet we are poor. Only bauxite, gold, diamonds, granite, sand and loam is mined. A foreign company once mined manganese ore. Balata, timber, "irokama", coconuts, sugar, rice, cattle and pig rearing are some land-based economic activities in Guyana. In the 1960s Guyana sought to be self-reliant and politicians encouraged the populace to utilize what was produced here. This energized patriotic scientists who investigated ways in which materials, including discards, could be changed into secondary useful products. For example, cotton was planted to feed a textile mill, and the diversifying into non-traditional exports was then pervasive.

Then in the 1990s a new political climate that no longer pushed for self-reliance encouraged laziness and a dependence on imports. Collaboration between Guyanese to effect import substitution halted. It was collaboration however that contributed to the manufacture of Dalgety products. Without scientists in a nation, wealth is near impossible. You can't sell from an empty wagon.

KNOWLEDGE AND ALTERNATIVE MATERIALS

Tom Dalgety worked in the bauxite industry, 1975 – 1981, as quality control chemist and development engineer. Quality control is a before and after concept. Development is associated with diversifying resources and attitudes. In the bauxite industry quality control meant knowing the specifications of the products requested by the customers, then monitoring the analyses of the raw bauxite ores as they are processed along with the efficiency of bauxite and alumina plants to achieve the customer specifications. The bauxite industry marketed externally at that time three principal products – metal grade bauxite, calcine bauxite, and calcine alumina but no effort was made to diversify these products into an internal market. The typical chemical analyses of these products "after" and "before" were [1]:

	H_2O	LOI	SiO_2			TiO_2	Fe_2O_3	Al_2O_3	
			T	N Re.	Re.			Total	Available
"After"									
Metal grade bauxite	3.0	30.27	4.33	0.81	3.52	2.53	4.30	58.55	51.7
Calcine grade bauxite		0.26	5.78			3.21	1.59	89.16	
Calcine alumina		1.86	0.025			0.17	0.029	98.67	
"Before"									
Metal grade		29.22	8.06	1.19	6.87	2.67	3.32	56.73	46.8
Calcine grad		30.19	7.16	1.01	6.15	2.45	1.06	59.14	50.80
Bauxite feed	1.17	28.85	6.01	1.73	4.28	2.91	7.21	53.68	48.5

The machinery and equipment used to process raw ore into customer products in the bauxite plant were crushing and washing machinery and rotary kilns. To process raw ore to calcine alumina the Bayer Plant was installed. This consisted of a row of tanks connected by pipes to digest bauxite-and-laterite mix with sodium hydroxide (50%). The Bayer reaction is:

$$Al_2O_3 + 4NaOH \quad = \quad 2Na_2Al_2O_3 + H_2O$$

Simple chemistry with simple assembly of huge equipment for manufacturing products marketed external to Guyana and no effort to diversify these products into internal markets.

Bauxite, kaolin, clay, and sand belong to the aluminosilicate class of materials and in 1979 due to an interest in pottery; ceramics and the aluminosilicates Tom Dalgety did analyses on kaolin and flint clay ore bodies. The results are as follows [2]:

	LOI	SiO_2			TiO_2	Fe_2O_3	Al_2O_3	
		T	N Re.	Re.			Total	Available
Kaolin	14.12	43.89	6.48	37.41	0.18	0.62	41.19	1.60
Flint clay	15.61	42.24	0.02	42.22	0.12	0.95	41.08	3.00

What attracted attention was the high percent of reactive silica (42.22%) in the flint clay and the knowledge, that potters were using sodium silicate as a deflocculant in clay solutions known as 'slip'. This flint clay was further researched. From it was produced aqueous aluminium sulphate and silica; and this silica was the raw material for the first laboratory preparation of sodium silicate at the bauxite company in Guyana. The chemist then collaborated with local potters in further investigations. Slip was poured into plaster of Paris moulds to make cups and vases; and an experiment at glazing resulted in 'crawling'.

In later literature research it was discovered that rice husk ash (RHA) - a waste product of rice milling - was a rich source of reactive silica (93.15%). Studies undertaken in Pakistan, India, and Malaysia gave a typical chemical analysis of RHA as [3]:

	Re.SiO_2	Al_2O_3	FeO	CaO	MgO	Na_2O	K_2O	Ignition loss %
RHA	93.15	0.41	0.20	0.41	0.45	0.08	2.31	2.77

RHA was the raw material Dalgety used to manufacture sodium silicate when he converted from an analytical chemist to a manufacturing chemist in 1981. It is presently the raw material for the manufacture of sodium silicate in Guyana.

1. *Sodium silicate*

In the industrial countries, sodium silicate is prepared by melting mixtures of pure sand and sodium carbonate at about 1400 ^{o} C in ordinary glass-melting furnaces fired with gas or oil. The following reaction takes place.

$$nSiO_2 + Na_2CO_3 = Na_2O.nSiO_2 + CO_2$$

In Guyana, Dalgety heated RHA and aqueous sodium hydroxide to give sodium silicate. The following reaction takes place:

$$nSiO_2\ (RHA) + 2NaOH = Na_2O.nSiO_2 + H2O$$

Sometimes the formula for sodium silicate is written as Na_2SiO_3 or $Na_2Si_3O_8$

The batch formulation is given here:

RHA formulation (by batch)	**Parts by weight**
RHA (dry)	75 pounds
Sodium hydroxide (50%)	8 gallons
Water	16 gallons

The equipment used were 50 gallon drums over gas burners of the type used in Chinese cook shops in Guyana.

Sixteen (16) gallons of water was first poured into a drum. Next, 8 gallons of sodium hydroxide was added. Next, RHA was added with stirring. Digestion takes several hours until "mud" is detected that indicates the reaction is completed. Cool to room temperature. The mud separates from the aqueous solution, which is decanted from the mixture and is evaporated to the required specific gravity.

Calculation: "Weigh 15 grams of silica extracted from the flint clay and transfer to a calorimeter bomb. Add 20ml of 50% sodium hydroxide. Add 230 ml distilled water – this is to ensure that NaOH has a specific gravity of 1.22-1.24" [2] – W T Dalgety with K Dazzeil.
Using the above account and conversion tables from any diary we get:
1 litre = 0.21997 gallons
20 ml gives 0.21997 multiplied by 20 divided by 1000 = 0.0043994 gallons
0.00943994 gallons of NaOH (50%) react with 15 grams silica to give sodium silicate
8 gallons of NaOH (50%) will react with 8 multiplied by 15 divided by 0.0043994 = 27274.3 grams silica. Thus 27.2743 kilograms silica. Thus 60.1296 pounds silica.

Pakistan, India, Malaysia analysis of RHA gave 93.15% SiO2
93.15 pounds silica in 100 pounds RHA
60.1296 pounds silica in 64.5514 pounds RHA
15% moisture in deposit body gives 74.234 pounds RHA
20% moisture in deposit body gives 77.462 pounds RHA
25% moisture in deposit body gives 80.689 pounds RHA
The workers were told to add about 75-80 pounds of RHA to the drum containing 8 gallons of 50% sodium hydroxide.

2. Refractory Mortar:

Refractory mortars are made from plastic clays with the ability to withstand high temperatures without melting or softening [6]. Kaolin is such clay. Kaolin bricks have refractoriness under load of approximately 1340. Mixing kaolin with sodium silicate makes refractory mortar.

The batch formulation is given here:

Formulation (by batch)	**Parts by weight**
Kaolin	60 pounds
Sodium silicate	variable

The equipment used is a bucket and paddle.

First the kaolin was heated until some of it looked ‘grey’. This meant that a portion of it was dry and a portion of was calcined. The kaolin was then stored. Sodium silicate solution of 48 Baume (specific gravity) was poured into the bucket. Kaolin was weighed and added and the contents stirred to a consistency “thicker than honey”. Each batch was made to fill a 5-gallon pail, and the remainder filled tubes.

3. Putty

Putty for wood is manufactured from any drying oil to which a pigment and oxidizing agent are added. Drying oils oxidize in air to a solid rubbery condition. Iodine number measures drying oils. Oils with an iodine number of over 135 are drying oils. Those with iodine numbers 110-135 are semi-drying oils. Those with numbers below 110 are non-drying oils. The refractive index of oils is also important. Some data is given below.

	Sources	**Iodine Value**	**Refractive Index**
Coconut oil		7.5 – 10.5	1.448 – 1.450
Cotton seed oil		99 - 113	1.468 – 1.472
Soya bean oil		120 – 141	1.470 – 1.476
Sunflower seed oil		125 – 136	1.472 – 1.474
Octicica oil	Brazil	155 – 175	1.500 – 1.513
Linseed oil		~175	1.479 – 1.484
Conophor oil	West Africa	200 – 205	na
Rice bran oil		na	na

Rice bran deteriorates to give high free fatty acids if not stabilized within 36 hours.

The chemistry of the oxidation of drying oils is as follows:

(i) $- CH : CH\ CH_2\ CH : CH - \ + \ O_2 \ = \ - CH\ (OOH)\ CH : CH\ CH : CH -$

(ii) $- CH : CH\ CH : CH - \ + \ O_2 \ = \ - CH\ CH : CH\ CH -$ or $(- CH\ CH : CH\ CH -)_n$

O —— O   O O ——

It is also known that certain metal catalysts accelerate the oxidation of drying oils: cobalt, manganese, lead, and cerium [6].

Dalgety manufactured putty from soyabean oil (or rice-bran oil), manganese pyrolusite (the ore of manganese dioxide), kaolin, and napthalene balls.

The batch formulation is given here:

Formulation (per batch)	**Parts by weight**
Soya bean oil / rice bran oil	16 pints
Manganese ore	1 oz
Naphthalene balls	1 oz
Kaolin	40 pounds
Paint	1 quart

The equipment used was a Mix-Muller and 50-gallon drums cut longitudinally in half.

Kaolin was dried over an open wood fire. Manganese ore was ground into powder in a mortar and pestle and set aside. The drying oil was first poured into the grinding and mixing vessel (Mix-Muller). Powdered manganese ore, naphthalene, and kaolin were gradually added as the machine was revolving. After forty minutes the contents were discharged to stand overnight to allow the reaction to take place. The product was returned to the machine for about five minutes, for a second phase of grinding and mixing. The product was then packed and stored.

4. Products to stop leaks

Dalgety made these from balata extracted from the bulletwood tree, which grows locally, and pitch. Balata has about 50% polyisoprene and the rest resins. De-resinified balata has very long polyisoprene molecules of molecular sizes in the range of 0.1 to 1. This structural property of these hydrocarbon polymer molecules allowed penetration into the micropores of surfaces thereby preventing the entry of water molecules. The tackiness and flow of the coating are improved if added with a water repellant tackifying agent such as asphaltic bitumen. The addition of anti-oxidant enhances the age resistance and anti-skinning of the coating [4].

The softening point of pitch is given as 71 ^{o} C, and its boiling range above 360 ^{o}C. The boiling range of gasoline is 20-150 ^{o} C. The boiling range of kerosene is 102-220 ^{o} C. The local temperature range is 27-31 ^{o} C. The pitch will harden over a hole to prevent entry of water. The gasoline will evaporate. The kerosene makes the product trowel able.

The batch formulation is given here:

Formulation (per batch)	Parts by weight
Balata	1 pound
Xylene (or gasoline)	4 pints
Pitch	10 pounds
Kerosene	1pint
Very fine sawdust	handfuls

The equipment used were a 50 gallon drum cut across in half, and a glass container for the balata solution.

Zylene (gasoline is cheaper and has a slower rate of reaction) was added to balata in a glass vessel. The mixture was shaken until the balata dissolved, then set aside for further use.

The pitch was placed in a half-drum over a fire to soften. The drum was then removed from the fire and taken to a safe place. Kerosene (or gasoline) was added followed by balata solution. The mixture was stirred. The product was packed and stored in airtight containers.

Sometimes very fine sawdust was added to the above for sale to plumbers. This gave it body and made it cheaper.

TECHNICAL CONCERNS

Knowledge of processes and principles are critical for production. One has however to approach production in an investigative attitude, observing conditions and materials, changing variables, always questioning how conditions and intermediary materials affect how the main product behaves. Technology is therefore very important in manufacture.

We now address problems encountered, variations and remedial action with the manufacture outlined above.

1. With the RHA process Dalgety sometimes encountered a brown gelatinous suspension. This affected the purity and expected yield of sodium silicate. The users, mainly persons in the foundry industry, were not affected. The brown suspension was noticed when the RHA used was dug from the waste heaps which were not burnt to a white ash.

2. The refractory mortar was generally well received by masons. It was not subject to rigorous laboratory tests and standardization.
3. The availability of drying oil was a real problem for sustained manufacture. Although linseed oil has high iodine value it was not imported in large quantities. Soyabean oil was imported on an aid programme, and not always available. Although sunflower grows in Guyana no effort has been made to extract the oil. Life stock farmers demanded rice bran, and the oil mill couldn't get enough supplies to do extraction. Cottonseeds were discarded from the textile industry and the oil mill extracted the oil. A small amount of cottonseed oil was sometimes used to 'stretch' the drying

oils, but this made the putty look 'greenish'. There was also a problem about refractive index. The putty took the colour of the oil instead of the colour of the kaolin. White inorganic pigments like titanium dioxide, zinc compounds, lead compounds and others were not manufactured locally or regionally. The added manganese affected the state of the product, because too much made the putty into a grout and staff had to readjust the formulation. Some end users after a year or so complained of cracking and mildew. We added a quart of white oil paint to the mix as a remedy. This worked.

4. Safety from fire was a great anxiety. A sample of this product was prepared in Brooklyn, New York, USA for a demonstration to a manufacturer of roofing cements. He remarked that it was "top of the line." This was not surprising given the chemistry of balata. He would not use balata to make roofing cement for sale in Brooklyn because it would be too expensive for his market. We never deleted it from our formulation.

MAKING APPROPRIATE EQUIPMENT

Technology means the application of science, equipment and skills. Most of the equipment used above was fabricated in Guyana by welder-fabricators and turners. When gears were broken, EN9 steel was obtained and helical or straight gears were cut in a machine shop and the whole hardened by heating, dusting in a chemical powder and plunging into water.

BENEFITS OF EDUCATION

Collaboration between colleagues and across disciplines predominated thirty years ago. This was critical for development. More pupils participated in science fairs and exhibitions using local materials. This also inculcated desirable attitudes.

Students preparing for the science subjects at the Caribbean Secondary Education Certificate (CSEC) examinations offered by the Caribbean Examinations Council must do data analysis. Data from local manufacturing should be used for data analysis. Increasing relevance of what pupils are expected to learn strengthens motivation. When pupils were exposed to improvisations rather than textbook science, many ended up in science and technical fields.
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RECOMMENDATIONS

The powerful nations of the world, control the rest of the world through their quantum of scientists and technologist. NUST Zimbabwe must dare to encourage the people of Zimbabwe to grow economically through education and practice of science and technology. The process of education for behavioural change is slow. Strategic plans must be made now knowing that desired goals could take centuries to be materialized. Rome was not built in a day. Resolve and patience need to go together.

- Shifts in the curriculum of teacher education institutions and schools. A conscious effort to improve access to education, raise the literacy levels generally and focus on giving untrained and trained teachers knowledge skills and understanding equal to the task is the emphasis of the present strategic plan for education in Guyana. Equity must not be confused with equality. Development of the whole will be evident when each community could identify areas of growth.
- Scientists need to research indigenous materials. They need to publish their results where all could read - such as newspapers. They need to open dialogue with persons of other disciplines. Collaborative learning is powerful, leads in limitless directions and the creation of a manufacturing class.
- Managers and line supervisors need to be sensitive to initiative among staff. Red tape could stifle mental growth and creativity. Workers who are free to learn on the job are more likely to contribute to real development of the unit or company.
- The political climate must encourage investigation by patriots, manufacture of products with local materials, and marketing of products at home and abroad.

CONCLUSION

Individuals and nations that pursue technological development can accomplish great wealth. The formulations given above worked, and the results were economic growth for the family.

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THE PRODUCTION OF APPROPRIATE TECHNOLOGY FOR LAND-BASED PROJECTS BY SMALL-SCALE INDUSTRIES IN ZIMBABWE: THE PROS AND CONS vis-à-vis THE ROLE OF RESEARCH

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Abstract

With the ever changing technological advancement due to new scientific innovations as well as the knowledge explosition, it is imperative that Zimbabweans strive to use these developments to their advantage by creating technological equipment appropriate to Zimbabwe. A paradigm shift is called for in the way Zimbabweans view industrial production of equipment for use in the Implementation of land-based projects. A product unique to Zimbabwe should be developed. I therefore call for the creation and nurturing of a small-scale industry sector that will produce appropriate technology for the Zimbabwe small-scale sector with the help of research.

This paper will strive to add to the discourse on the development of appropriate technology for use in the implementation of land-based projects by small-scale industry in Zimbabwe. The paper will look at the relevance of the small-scale industry in Zimbabwe. The paper will in particular base itself on those small-scale industrial enterprises that are involved in the production of appropriate technology for land-based projects such as edible oil extraction, peanut butter making, irrigation / market-gardening etcetera. Merits of creating a small-scale industrial sector as well as challenges faced by such a sector will be discussed by the paper. Lastly the paper will discuss the role of research in the creation of appropriate technology as well as the way forward.

INTRODUCTION

This paper will unfold as follows; firstly the relevance/significance of a small-scale industry in the form of merits will be looked at. This will be followed by the challenges bedevilling such an industrial sector. Lastly, the role of research and the way forward will be looked at.

The relevance of the small-scale industry in Zimbabwe

Start-up and launch of a small-scale company depends on a number of factors. Such factors as ownership and capitalization plays a very big role. Small enterprises may be set up by sole proprietors, families, partnerships, cooperatives, communities etcetera. The owner(s) may set up a company for and expansion into larger concerns, hence will create employment if they survive the initial set-up and launch. Some are just set up and nurtured by the owner as small manageable entities solely for the owner's comfort and personal needs, hence they don't grow to anything but are permanently small. This paper will concern itself with those small enterprises related to land-based technology production and destined for growth and employment of people. Such entities are important in that they contribute to the country's economy as they enhance the gross domestic product (GDP) of the country. They also create employment. Apart from the people employed by large-scale formal employment companies, in Zimbabwe today, many people are working in small-scale industry such as peanut butter making, market gardening, scotch-cart making etcetera. Many yearn to be self employed. The other importance of small-scale companies is that they grow into tomorrow's large corporations, employing many people. In Shona we say "Nzombe huru yakabva mukurerwa" i.e. "From tiny propagules, huge Oakes shall grow." The list of merits from small-scale enterprises is endless. Some of the benefits are as follows:

- The production of cheaper products at low cost e.g. cooking oil and peanut butter, leading to improved nutritional standards. The poor in the rural areas can now afford to buy this oil (dietary fat).
- The production of useful by products such as animal feeds from seed cake
- Stimulates production of economically high value crops such as sunflower, groundnuts and Soya beans.
- Reduces poverty by creating employment for individuals and small groups of people.
- May lead to the production of cheaper, affordable appropriate alternatives in production equipment e.g. packaging and processing equipment for agro-products as well as cheaper irrigation equipment such as PVC pipes, sprinklers, boreholes equipment such as pumps and electric motors.

Challenges faced by small scale enterprises

Small-scale enterprises are faced by a myriad of challenges. They are challenged by unavailability of resources as well as competition from larger more established enterprises etcetera.

Resources availability

(i) Financial resources availability

Small-scale enterprises often experience problems of finance. They are often problems of raising capital. Relationships with financial institutions such as banks are often difficult. There is the problem of collateral. The small entrepreneur often does not have much disposable income or property to bargain with. There is S.E.D.C.O of course. However, it is sometimes difficult to access these funds as well. Enterprises are often not large enough to influence prices on a national basis. They are price takers not givers, unless the product is unique, which becomes very costly to produce. Also some of these entities are run by one or two people hence the limitation of their finance base.

(ii) Human resources

There is often a management and skills crisis at the small enterprise shop floor. According to Burns in the U.K, "It is estimated that over two-thirds of small businesses consist of only one or two people and often the second person is the spouse. Three-quarters of the rest employ ten or fewer people. Almost 97 percent of firms employ fewer than 20 people….". Important decisions are therefore often made by one or two people and at times there are no trained people in areas such as marketing as well as certain aspects of production. This scenario is true of

Zimbabwe today. The small-scale industry sector has such problems of limited knowledge / know-how in technology for example preparing food products. Often there isn't enough research and document knowledge available to this group on food production. Dawson (2002) points out to the unavailability of recipes for this group in Zimbabwe. Technical and business skills are required. Sometimes knowledge on markets and market targeting is unavailable in the small enterprise.

(iii) Infrastructure

Often the small-scale enterprise in Zimbabwe has no infrastructure of its own in terms of buildings such as workshops, warehouses and offices. Sometimes even the ground on which to build is not there. The tendency in Zimbabwe therefore is to lease some space. At times they use dilapidated city council buildings/shells or operate from some makeshift non permanent structure often without electricity, water and telephones. Sometimes they lease excess space from larger more established business counterparts, who sometimes charge exorbitant rentals. There is need to develop appropriate and cheaper infrastractural technology for the small industrial sector.

(iv) Appropriate technology/equipment

In many cases, the small enterprise does not have the appropriate equipment for their production purposes. The equipment is often imported, hence too expensive to purchase. With the current economic situation of hyper inflation, it is even expensive to purchase locally made equipment. Hence, small-scale enterprises often use old and poorly serviced equipment or lease equipment, often at high prices. Sometimes players in this sector have no access to appropriate and timely information on technology and equipment.

(v) Competition from larger firms

Small enterprises face stiff competition from larger, more established companies. In Zimbabwe, the larger companies enjoy a large market share. Their large sizes accords them larger financial bases, hence they enjoy economies of scale. Small firms have to be price takers. Often the prices set by big firms are too good to compete with. Small firms are also unable to control their distribution channels. Often in Zimbabwe, larger firms use large retail outlets as distribution channels and they produce large quantities of the product to compete with small-scale industry producers who have to try and use the same channels. There are also the challenges of advertising, packaging, branding, quality assurance as well as guaranteeing of the product. Customers often prefer products which are nicely packaged and guaranteed by the producer. Customers often suspect the products from small-scale industry are of an inferior quality (Dawson, 2002). Sometimes small-scale enterprises compete for customers with importers of similar cheaper products from the region and abroad. Sometimes customers have biases towards products from small producers as being unhygienic and unsafe, in terms of food. This fact is sometimes bolstered by the manner in which some small producers package their food products due to lack of knowledge on marketing, for example the use of old plastic containers to package peanut butter. I have come across these in some Bulawayo shops. These old containers really look old and unappealing to the buyer although the product is priced lower than the other brands. This shows that the small producer has to make do with what they can find. Access to raw-materials, appropriate technology and packaging materials as well as credit facilities is difficult. Their products are therefore seen as inferior. Azam et.al (1996) cites inconsistent quality, inferior packaging and labelling (branding), poor marketing and selling, insufficient access to quality raw materials as some of the challenges faced by small-scale industry. Another challenge, mentioned earlier is that of their inability to guarantee their products as opposed to their larger counterparts.

The role of research in the development of appropriate technology for land based projects by small-scale indu

The role of research is to establish gaps in appropriate technology requirements for the small-scale industry. Research can also provide information on the small-scale industry customer base as well as on competitor products, prices and distribution channels. Another role for research could be to provide knowledge on skills available for the small-scale sector within Zimbabwe. Researchers can also work with small-scale industry in providing the necessary research skills. Through research, suitable, marketable products and products that are viable could be produced. Research can help players in the small-scale industry find cheaper ways of production. Literature on research findings could be used to fill the gap in productivity left by large companies. Through research, the productivity and hence the incomes of players in the small industrial sector could be raised leading to a reduction in poverty.
Other roles research can play could be to:

- Identify the training needs in the small industry sector.
- Identify and recommend advice and counselling services required.
- Help in the development of new and appropriate technology through working with new small-scale industry players or innovations by existing ones.
- Provide important information on new and appropriate technologies through the setting up of research centres.
- Help by publishing research findings and making these available to this sector.
- Communications between small-scale industry players can be enhanced by research.
- Provide information on markets and marketing for the sector. That way clientele for the sector is identified.
- Help small firms to diversify their services.
- Through research, the projects linked to small-scale industry can be evaluated and their impact ascertained.
- Research can also play a role in providing information on laws and standards pertaining to products acceptability and registration.

There are many other important roles research can play apart from the above.

Conclusion and the way forward

As a way forward, research can work with the small scale industrial sector in establishing information or research centres where such enterprises can get help on development and many other services as above. According to Kapila et.al. (2001)

> Business development services refers to support other than credit. Non-financial services include training, giving technical and managerial assistance, developing, adapting and promoting new technology, assessing markets and giving marketing support, providing physical infrastructure, and advocating policy.

Such support as mentioned above can be the role of research for the future. Banks can also be encouraged to give loans to the small-scale industrial sector. Kapila et.al. (ibid) writing on a project with small-scale enterprises says that at the end of the project, it had been demonstrated that low income people could pay commercial interest rates on loans and that good practice could prompt repayment rates of 95 percent or more.

In Zimbabwe, Dawson (2002) writing about the Zimbabwe oil press project points out that the project which started as a project for the small industrial sector ended up changing its focus and working with established large companies to produce appropriate technology for the small industrial sector. I believe that as a way forward to promote the small-scale industry, such projects and others elsewhere could be studied so that projects that specifically promote the small-scale industrial sector are set up, avoiding pitfalls that might have affected other projects before them.

Finally, I believe that if researchers and would be small-scale industrialists put their heads together on a project, technology appropriate to Zimbabwe's needs will be developed for example, in drier parts of the country such as Matabeleland, there is need for the development of technologies that are usable in drought conditions such as cheaper irrigation pipes, borehole equipment (electric motors and pumps). The small market gardener and the small shop manufacture are increasingly finding it difficult to buy, replace or maintain these.

Acknowledgements

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NITROGEN GAS LASER: AN APPROPRAITE TECHNOLOGY TOOL FOR DEVELOPING COUNTRIES IN AFRICA

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ABSTRACT

This article addresses the issue of designing and fabricating nitrogen gas laser by using locally available materials. Design of switched mode power supply; trigger circuit; laser channel, Blumlien transmission line, and spark gap are discussed. The skills learned by the students should help them to build confidence in constructing integrated systems. The laser operates at atmospheric pressure with a peak power out-put of 100 kW at a pulse repetition rate of 10 pps. Selecting suitable combination of capacitance used in the transmission line and varying the supply voltage can vary the laser power. The laser has been used to study dextrinization of starch and shadowgraphy of plasma focus. Cassava and maize starch were irradiated with nitrogen gas laser. The variation of aqueous solubility (AS) water binding capacity (WBC) and absorption starch iodine complex (AIC) are reported. dextrins formed due to irradiation differ. Shadowgraphs were taken of a 3 kJ plasma focusing the presence of a flat disc of the anode and 1 mm wire target inserted along the axis of the plasma focus tube. It was observed that the flat disc target does not affect the dynamics of the focus when placed at a distance greater than the radius of the anode.

Keywords: Nitrogen gas laser, Blumlien transmission line, Spark gap, Dextrinization of starch Shadowgraphy, and Plasma Focus

Introduction

The realisation of lasing action in the nitrogen second positive system was reported by Heard [1]. Since then several workers [2-10] have proposed designs of transversely excited nitrogen gas lasers operating in the pressure range of 2.5 kPa to several atmospheres. The nitrogen laser is an important tool because of its variety of applications such as high power U-V source, environmental pollution studies, photochemistry, spectroscopy, image amplification of dyes, etc. These applications are based on its short wavelength (337.7 nm), high peak power upto several MW, short pulse duration and good stability.

Many other gas lasers can be conveniently used in some of the above applications. However nitrogen gas lasers have an edge in the following respect over its competitors.

(i) It can be operated at pressures ranging from moderately low pressures to several atmospheres. Hence, sophisticated vacuum system is not essential.
(ii) It requires no noble gases. The active medium is nitrogen gas, which is available all over the world in abundance.
(iii) It operates in super radiant mode and requires no mirrors.
(iv) The construction is simple to suit moderately equipped laboratories (especially in developing countries which have meagre resources) with locally available materials.

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This paper reports the construction of a cost effective Nitrogen gas laser, its performance and some possible applications to which the laser was applied in the author's laboratory.

Design considerations

To design a laser it is necessary to understand energy level diagram of nitrogen molecule (Fig 1a). The laser is based on the three level pumping scheme (Fig 1b). [11]

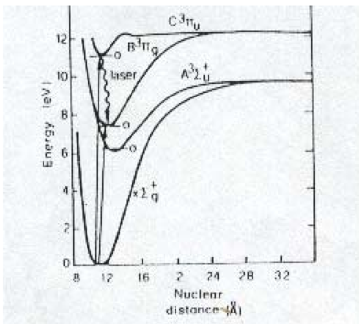


Fig 1(a) Energy Level Dia.

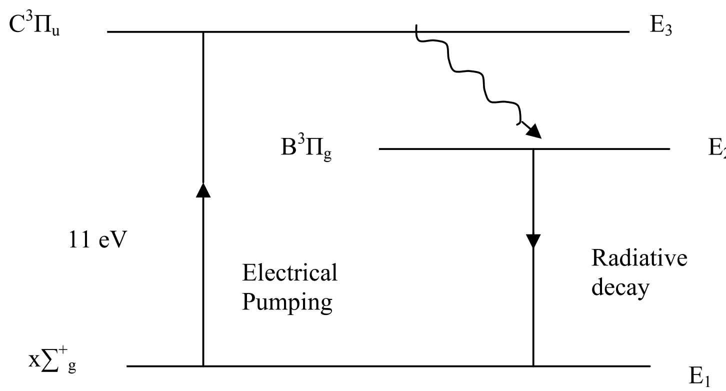


Fig 1(b) Pumping Scheme

In the above diagram, vibrational and rotational levels are omitted for the sake of simplicity. Electrical pumping is used to pump electrons form ground level $^x\sum_g E_g$ to the upper level $C^3\Pi_u$ (E_3) by supplying energy equivalent to about 11 eV per molecule. Since level $B^3\Pi_g$ (E_2) is almost empty, population inversion is achieved and transitions from E_3 to E_2 give rise to stimulated emission of energy 3.68 eV corresponding to wavelength of 337.3 nm. The lifetime of upper E_2 level is 6 - 10 µs's, which is metastable state. To avoid depopulation by spontaneous emission, population inversion should be achieved in a time less than or equal to 40 ns, the lifetime of E_3 level. It may be noted that the upper laser level can depopulate either radiationlessly via collision with electrons and other nitrogen molecules or through spontaneous or stimulated emission in the lower level E_2. The transition from metastable state $B^3\Pi_g$ to $X^1\sum^+{}_g$ (E_1) takes place by a process of radiation decay within a time of 10 µs. It should be noted that nitrogen is an exception to the rules for naming the levels. The lowest Laser State is metastable; the lifetime of B State is longer than the C State. Thus, at first glance everything is wrong yet it lasses rather spectacularly on the C $\rightarrow$ B band.[Interestingly the levels between which lasing action takes place would appear to have entirely wrong life times. Remember in an ideal situation the life-time of upper level should be longer than the life time of lower level]. Most of the excitation in nitrogen discharge would be from $X^1\sum^+{}_g$. Since the *equilibrium* position r_o of the C state is close to that of the ground state, electron impact excitation will proceed along that path rather than to the B or A states [Table 1]. [This transition is more favoured because (i) the minimum of the potential energy curves of the two states at about the same intra-molecular distance, a requisite for satisfying Frank-Condon principle and (ii) the level v = 0 in an electronic state is most populated, hence the transition is most intense].

Table 1 Data on Nitrogen

State	T (cm^{-1})	ω_e(cm^{-1})	$\omega_e x_e$(cm^{-1})	r_e (nm)	τ
$X\ ^1\Sigma_g^+$	0	2359.61	14.456	10.94	∞
$A\ ^3\Sigma_g^+$	50 206.0	1460.37	13.891	12.93	Seconds
B $^3\pi_g$	59 626.3	1734.11	14.47	12.123	10µ s
C $^3\pi_u$	89 147.3	2035.1	17.08	11.48	40 n s

For instance if an electron has 15 eV of energy, it will excite all the states of Table 1. Then by experiment, excitation to the C state is twice as likely as to the B or A state.

However, the real critical issue associated with nitrogen laser has nothing to do with spectroscopy, atomic physics, stimulated emission or any other esoteric subject, but has to do with the electrical discharge *circuit.* It should be capable of switching very high voltages ≈ a few kV with a very fast rise time ≤ 40 n s. [That is a nontrivial job!] The speed is required to sustain the electron *temperature* at a high enough value to take the advantage of favourable excitation route. If all the requirements are met, N_2 laser lasses quite spectacularly in the near U-V on the C-B band. Gains are so high [50 – 75 dB m^{-1}] that the cavities are superfluous. Sometimes one mirror is used to merely not to *waste* power from one end.

It is interesting to note that for the nitrogen gas laser, optical resonant cavity is not essential, because the gain of the medium is sufficiently high to produce intense laser radiation even in only one pass. Hence the name *Super Radiant Laser.* The pulse widths are very narrow. As soon as lasing begins, the population of the terminal state increases rapidly and after a few nanoseconds population is reduced to a level where lasing cannot be supported. Such a laser is termed *self terminating.*

Main Requirements

For the satisfactory operation of the laser, the following conditions are of paramount importance.

(i) Uniform discharge should occur through the length of the discharge channel. This requires fast rise of voltage across the channel. The rise time of the voltage pulse should be ≤ 40 ns, and
(ii) Sufficiently high rise of absorption of energy in the laser gap plasma during the main discharge of the laser channel. A parametric model by Lee et. al. [12] proposes the rate of rise of voltage across the gap

$$\frac{dn_e}{dt} = \alpha v_d n_e$$

The above requirements guide us to design the laser channel and pulse forming circuit. We must meet the following conditions,

(i) A spark gap of very low inductance.
(ii) A laser cavity with low inductance because higher inductance will favour arc formation and output degeneration,
(iii) Capacitors should have low inductance but should have high capacitance to enhance the output,
(iv) The laser electrodes should have large gap to increase the amount of nitrogen gas within the cavity but this introduces beam broadening, and,
(v) A suitable high voltage power supply with low inductance to initiate uniform discharge in the channel.

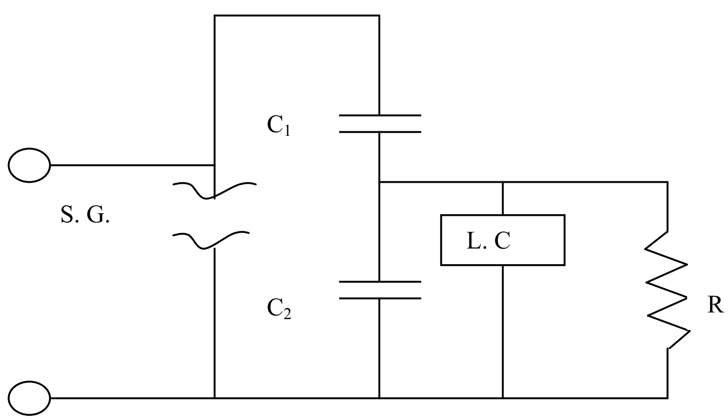


Fig 2 (a) Transfer of Capacitance

Two types of designs, viz. Longitudinal or transverse mode of excitations can meet the above considerations. We have used transverse mode. In this mode generally two designs are in use.

(i) Capacitor transfer line Fig 2a. This circuit offers small peak power, utilises commercially available capacitors, low efficiency but laser pulses are long with high energy per pulse, and

(i) Blumlein Transmission line Fig 2b. This circuit is characterised by high peak power, utilises locally constructed capacitors and has better efficiency with short duration laser pulses. For obvious reasons we have preferred the later design.

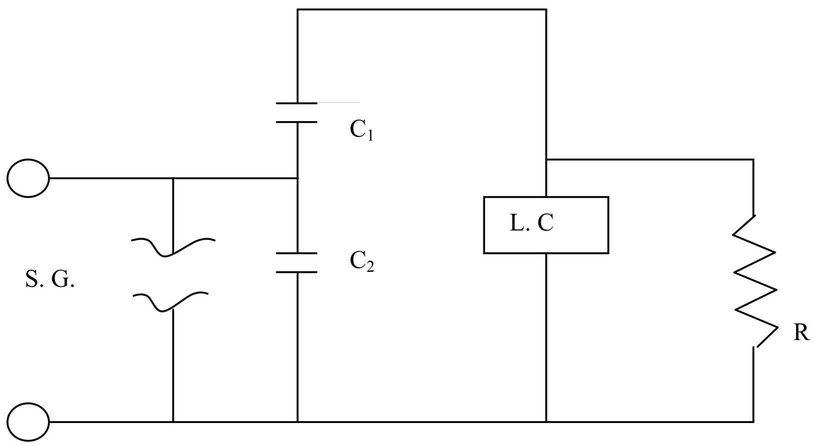


Fig 2 (b) Blumlein Transmission Line

The output of the laser is usually increased by increasing the nitrogen pressure, the discharge voltage and by reducing the discharge rise time. However, the development of arcs in certain parts of the discharge volume prevents the desired population inversion rate and limits laser power and stability. Thus, the pressure and voltage increases are limited by the onset of the arc formation. It seems quite reasonable to decrease the supply voltage to prevent the arc development and to increase the capacitance to compensate for this decrease in order to have the same output power. For the parallel plate configuration, the inductance and the capacitance are given by:

$$L = \frac{\mu l d}{w} \quad \text{and}$$

$$C = \frac{\varepsilon w l}{d} \tag{1}$$

where, μ is the permeability of the medium, *l*, the length of the plates, *w*, the width, d, the separation between the plates and ξ, the permittivity of the medium.

Thus, the decrease in the value of the thickness of the dielectric would increase the capacitance and decrease the inductance of the circuit. This in turn would enhance the power output of the laser cavity. The present paper considers some practical aspects which limit the reduction in the thickness of the commercial grade mylar dielectric. Another important contribution is the use of swinging cascade spark gap of low inductance in place of dielectric or thyratron switches [12, 13]. The design reduces the cost of the laser and avoids the dependence on other countries for its production.

Theory

A theoretical model proposed by Lee et.al. [14] was used for the computer analysis. The nitrogen gas laser circuit essentially consists of laser gap of inductance L_{go} and resistance r_g, two parallel plate capacitors C_1 and C_2 with very low inductances L_1 and L_2 charged to d.c. voltage V_o. L_{g1} and L_{g2} are the laser channel inductances on either side of the gap.

The equivalent circuit of the nitrogen gas laser is shown in Fig (3)

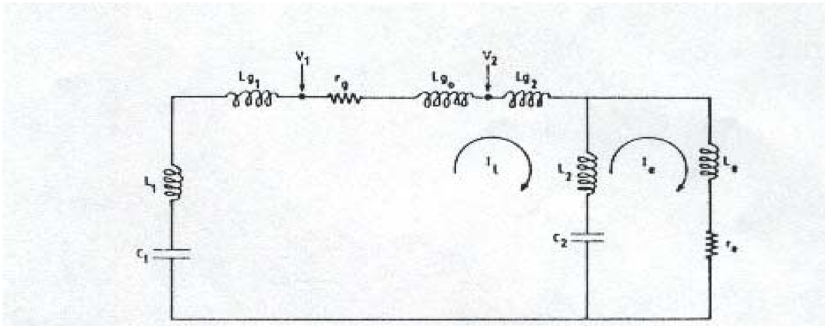


Fig 3 Equivalent

At t=0, the external spark gap breaks down and the voltage swings down from Vo towards -Vo with a time constant $\approx[L_eC_2]^{1/2}$, $L_2 << L_e$ and is, therefore, neglected. Here L_e is the spark gap inductance of the external circuit. The rate of rise of voltage, $\dfrac{\boldsymbol{V}_0}{\sqrt{\boldsymbol{L}_e\boldsymbol{C}_2}}$ is usually sufficient to cause a uniform breakdown all along the laser channel at time $t = t_s$. At this time the main discharge occurs and current start to flow through the laser gap. This forms a series circuit. Therefore the time constant of this circuit is around

$$\sqrt{\left\{L_1 + L_2 + L_g\right\}\left\{\frac{C_1C_2}{C_1} + C_2\right\}} \qquad (2)$$

where, $Lg = L_{g1} + L_{g2} + L_{go}$.

The main discharge is modulated by the slower discharge of time constant $\sqrt{L_eC_1 + C_2}$ which is responsible for removing all the stored charge through the external spark gap resistance r_e.

The average power absorbed by the laser gap is $I_L^2 r_g$, where I_L is the current flowing through the laser channel. This power is normalised to the average power of the discharge circuit consisting of C_1-L_1-L_2-L_g-C_2 and is given by

$$\frac{1}{2}\frac{\left(C_1V_o^2\right)}{\sqrt{\left(\dfrac{C_1C_2}{C_1 + C_2}\right)\left(L_1 + L_2 + L_g\right)}} \qquad (3)$$

Normalised power absorbed by the laser is given by:

$$\Pi = 2I_L^2\alpha_1\alpha_e\delta\sqrt{\frac{1 + \beta_1 + \beta_g}{\left(1 + \delta\right)}} \qquad (4)$$

where, $I_L = I_L/I_o$, the normalised laser gap current,
$I_o = V_o/\sqrt{(L_1/C_2)}$, the peak current,

$$\alpha_1 = \frac{r_g}{r_e}, \quad \alpha_e = r_e\sqrt{\frac{L_2}{C_2}}, \quad \beta_1 = \frac{L_1}{L_2}, \quad \beta_g = \frac{L_g}{L_2}, \ \text{and} \quad \delta = \frac{C_2}{C_1}.$$

The normalised laser gap current is obtained by the numerical integration of the following circuit equations:
Case (1) $0 \le \tau \le T_s$

$$\frac{di_e}{dT} = \frac{\left[1 - \int i_e d\tau - \alpha_e i_e\right]}{\left[1 + \beta_e\right]} \qquad (5)$$

With the initial conditions:

$$\tau = 0 \ ; \ i_e = 0 \ ; \ \int i_e d\tau = 0 \ ; \ \frac{di_e}{d\tau} = \frac{1}{\left(1 + \beta_e\right)}$$

where

$$i_e = \frac{I_e}{I_o} \ \text{Normalised external circuit,}$$

$$\tau = \frac{t}{t_o} \ \text{Normalised time, where } t_o = \sqrt{L_2C_2} \ \text{and} \ \beta_e = \frac{L_e}{L_2}$$

Case (2) at $\tau \geq T_s$

$$\frac{di_e}{d\tau} = \frac{\left(1 - \int i_e d\tau + \int I_L d\tau - \alpha_e i_e + \frac{dI_L}{d\tau}\right)}{\left(1 + \beta_e\right)} \tag{6}$$

$$\frac{dI_L}{d\tau} = \frac{\left(\int i_e d\tau - \left(1 + \delta\right)\int I_L d\tau - \alpha_e \alpha_1 I_L + \frac{dI_L}{d\tau}\right)}{\left(1 + \beta_1 + \beta_g\right)} \tag{7}$$

With the initial conditions:

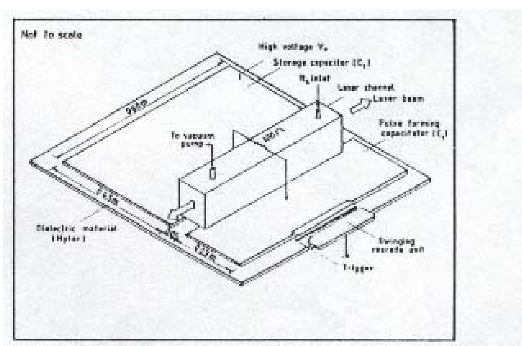
$$\tau = T_s \quad i_e = (i_e)_{T_s}\ , \ \frac{dI_L}{d\tau} = \left(\frac{di_e}{d\tau}\right)_{\tau = T_s} ; \ I_L = 0 \text{ and}$$

$$\frac{di_e}{d\tau} = \left(\frac{di_e}{d\tau}\right)_{\tau = T_s} ; \ \frac{dI_L}{d\tau} = \frac{\left(\int i_e d\tau\right)_{\tau = T_s} + \left(\frac{di_e}{d\tau}\right)_{\tau = T_s}}{\left(1 + \beta_1 + \beta_g\right)}$$

For the present study the scaling parameters are:
$\alpha_e = 1.25$; $\beta_1 = 2$; $\beta_e = 154$, $\beta_g = 49.2$ and δ was varied from 0.25 to 1 and α_1 from 1.47 to 1.96.

CONSTRUCTIONAL DETAILS

The schematic diagram of the nitrogen laser used in the present work is shown if fig [4a]



The Fig 4 (a) Schematic nitrogen gas Laser

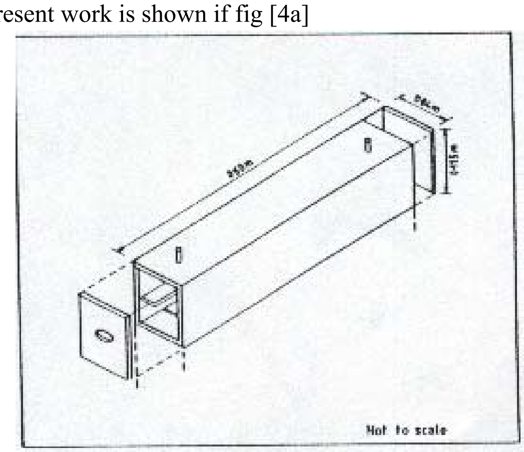


Fig 4 (b) Design of Laser channel.

Vacuum Assembly

It consists of a conventional two stage rotary pump capable of giving a base vacuum of 10^{-4} kPa. Initially the system was evacuated by running the pump for an hour.

Nitrogen gas was then flushed into the system and the system was brought to the atmospheric pressure. It was again evacuated. This method of alternate evacuation and filling was repeated for several times to ensure that the system was charged with pure nitrogen gas with minimal impurities. The pressure in the system was monitored by the Edward vacuum Gauge in the range 0 to 15 kPa. To obtain adequate discharge conditions, a continuous flow of nitrogen gas at an appropriate pressure was maintained.

The laser channel

The laser discharge channel; was constructed by fixing two aluminium slabs of thickness 0.009 m, width 0.115 m and length 0.600 m to which aluminium plates 0.003 m thick, 0.100 m wide and 0.500 m long were attached. These plates provide good electrical contact of the electrodes to the transmission line. The edges of the electrodes were rounded off to avoid corona discharge. To keep uniform inter electrode separation of 0.016 m, the electrode system was held firmly by fixing two perspex plates one at the top and the other at the bottom all along the length of the electrodes. The top perspex plate was provided with two ports for the inlet and outlet of the gas. The laser beam was brought out from the channel through the quartz window 0.020-m in diameter, attached to the perspex end faces at either ends of the channel. The various parts of the system were screwed together into the perspex plates through a thin layer of silicon rubber to ensure a good vacuum seal. Figure 4[b] shows the design of the laser channel. Alternatively with little modifications the laser can be operated at atmospheric pressure [15].

Blumlein Pulse Forming Network

It consists of two parallel plate capacitors C_1 and C_2. These have a common earth plate of 0.640 m X 0.724 m. An aluminium kitchen foil 0.450 m X 0.600 m was uniformly spread over the earth plate to ensure good electrical contact. 4 sheets of 2.5x10-5 m commercial grade Mylar covered the aluminium foil. The sheets were placed very carefully to exclude air from between the various sheets. The Mylar extends 0.080 m beyond the edge of the conductors all round. The high voltage plate of the storage capacitor has a surface area of 0.270 m^2. The Mylar sheets were oiled with transformer oil. The capacitor plates were held firmly together by mechanical means to avoid mechanical flexing during the charging and discharging of the capacitors and to maintain the uniform spacing. The high voltage capacitor plates were separated by a gap of 0.050 m over which the laser channel sits. [Fig 4]. Each side of the channel made a pressure contact with one of the high voltage plates. A 100 Ω 10-watt resistor was connected across C_1 and C_2. This keeps the voltage across the channel near zero during the charging of the storage capacitor and maintains uniform electric field inside the laser cavity during the early developing stages of the discharge and prevents arc formation in the cavity. The pulse forming capacitor C_2 was connected to the swinging cascade spark gap switch. The network was capable of generating a fast rising oscillating pulse across the channel. The oscillations started at the instant the spark gap broke down.

Swinging Cascade Spark Gap

The laser described in this work incorporates three-electrode parallel plate swinging cascade spark gap. Its advantages are low inductance, low cost and avoid the dependence of the operation of the laser on other countries. The configuration is shown in fig 4 (a). It was made from two copper plates 0.15 m long, 0.04 m wide and 0.005 m thick. The distance between the plates could be adjusted and the plates could be fixed maintaining the desired separation from the trigger rod. The trigger rod was a 0.003 m diameter and 0.18 m long copper rod mounted between the copper plates.

The earth plate was separated from the high voltage points by providing perspex sheet insulation. The gap ratio in the present work was adjusted to 3:2. It was triggered by a high voltage pulse transformer with a step up ratio of 1:30 connected to a SCR unit with an output of 800 V via an isolating capacitor of 100 pF made from 1 m long UR 67 coaxial cable. The spark gap with an inductance of 10 nH to be maintenance free in the range of operating voltage of 5 kV- 10 kV.

The Power Supply

The power supply was locally designed by using a 10 kV-30 mA transformer. Half wave rectification of the high voltage was achieved by using BY 127-diode chain of 20 diodes connected in series and immersed in transformer oil to avoid corona. Two 100 kΩ - 100 W resistors connected in series with power supply limits the current. The output was monitored by adjusting the input voltage to the high voltage transformer through a variac. Many other variations are possible; one of which is shown in Fig 5.

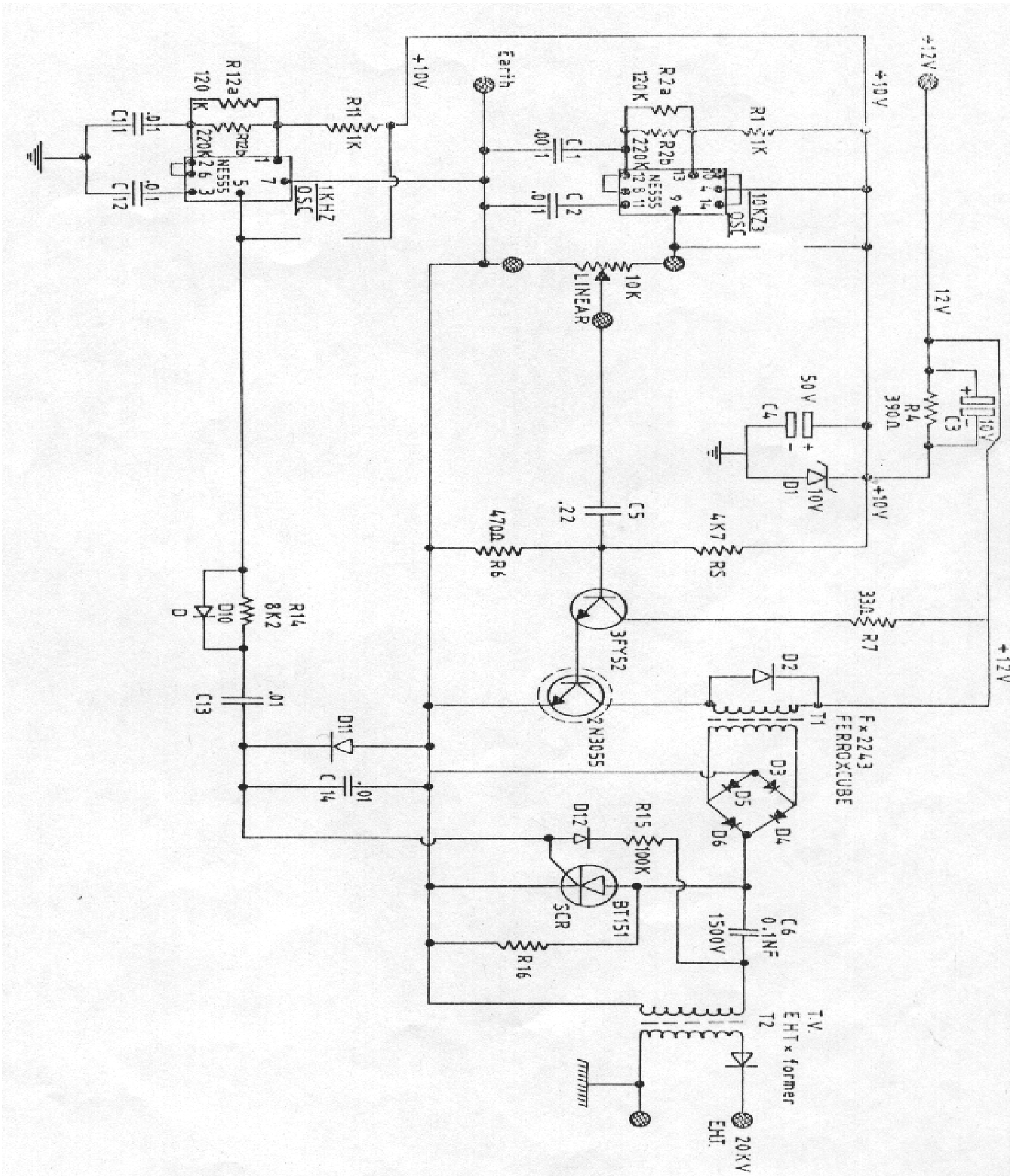


Figure 5 Power Supply for Nitrogen Gas Laser

The Detecting System

The output energy was measured by the broadband energy meter model 13 PEM 001 and the peak power was calculated by noting the pulse width and the pulse repetition rate of the laser.

Laser Performance

The laser performance can be improved if a few of its operating parameters like charging voltage, pressure of the gas, design parameters of the channel and the transmission line etc. Can be optimized. The experiments were designed to study: the variation of the output power with pressure and the values of the transmission line capacitances. It is worthwhile to mention here that the nitrogen laser works in superradiant mode and hence no mirrors were used.

The characteristics of the laser operating at the pulse repetition rate of 50 pps are listed in Table 2.

Table 2 Characteristics of N_2 Gas Laser

Capacitances		Pressure Of Nitrogen	Pulse Duration	Peak Power	Efficiency
Storage	Pulse Forming				
53.3 nF	25.6 nF	7.45 kPa	7.4 ns	163 kW	0.050 %
25.6 nF	12.3 nF	9.58 kPa	3.5 ns	95 kW	0.040 %
10.7 nF	5.1 nF	8.78 kPa	2.5 ns	76 kW	0.048 %

(i) The Pressure Dependence:

The variation of the output with the pressure of the nitrogen gas is shown in fig (6). It may be noted from the figure that the maximum peak output power of 163 kW occurs at a pressure of 7.45 kPa, above and below this pressure the power falls. At about 10.0 kPa and 10 kV operating voltage, the laser action ceased because of arcing in the channel. The values of the capacitors for this set up were C_1 = 53.3 nF and C_2 = 25.6 nF.

The Capacitance Dependence

The experiments were also performed by varying the values of the capacitances. Three transmission lines were constructed with the following parameters:

C_1 = 53.3 nF, 25.6 nF and 10.7 nF
C_2 = 25.6 nF, 12.3 nF and 5.1 nF

Fig [6] shows that the laser output power tends to increase as the transmission line capacitance is increased. It was, therefore thought of interest to double the value of the capacitance C_1 to 106.6 nF by reducing the thickness of the Mylar dielectric between the capacitor plates. Mylar sheets of thickness 1.25 X 10^{-5} m were introduced between the capacitor plates to enhance the capacitance of the system. It was observed that the dielectric punctured at voltages much below the rated value. The shot to shot performance was very unsatisfactory. The main reason for this failure of the dielectric to sustain the appropriate voltage may be attributed to the presence of very minute dust particles between the sheets. The avoidance of these particles was not possible under the present environmental conditions of the laboratory. Thus, within our environment the optimum value of the thickness of the dielectric was 2.5 X 10^{-5} to have trouble free shot to shot performance of the laser.

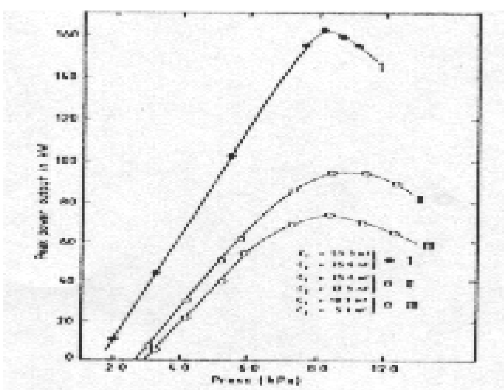


Figure 6

This figure also shows that increasing the capacitance of the circuit decreases the optimum operating pressure of the laser. The main reason being that the increase in the capacitance is associated with the corresponding increase in the rise time of the voltage across the laser cavity. It may be argued that the conductivity of a gas depends on the electron density, n_e. The multiplication of the electron density is given by the Townsend ' equation:

$$\frac{dn_e}{dt} = \alpha v_d n_e \qquad (8)$$

where, the drift velocity [16], $v_d = 2.9 \times 10^{-3}$ E/p m/s (9) and the Townsend coefficient, $\alpha = 1.4 \times 10^{-6} (E/p)^{3.7}\ m^{-1}$ (10)

Thus, both these parameters α and v_d depend on (i) the voltage across the laser cavity, (ii) the inter electrode separation and the pressure in the cavity. Moreover, for the operation of a typical nitrogen laser the rate of rise of the voltage across the gap prior to breakdown must be of the order of 0.5 kV /ns. Thus any increase in the rise time of the voltage across the cavity should be accompanied with either increase in the voltage V_g and the inter electrode separation was constant at 10 kV and 0.016 m respectively, hence it is reasonable to expect a decrease in pressure to get optimum performance of the laser.

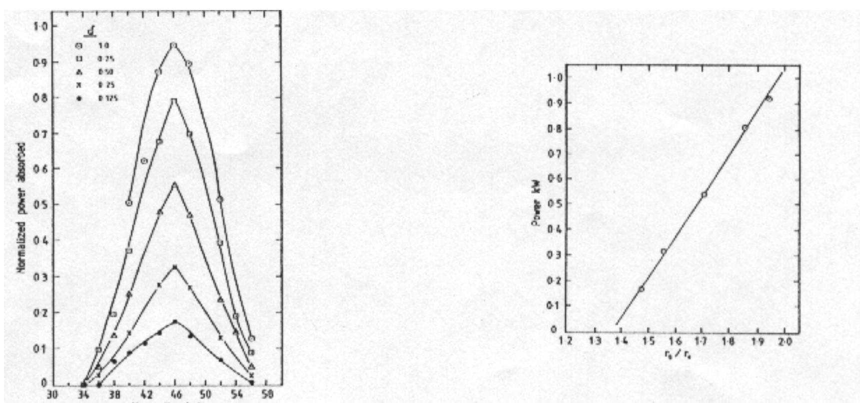
(i) The efficiency of the laser:

The last column in Table 1 gives the efficiency of the laser. The efficiency was estimated from the ratio of the optical energy per pulse to the electrical input energy 0.5 CV^2. The percentage efficiency varies between 0.040 to 0.050 with a mean value of 0.046. These values are comparable to those obtained by Fitzsimmons et. al. [17] [0.04 to 0.08 %] and Herden [6] [0.08 to 0.3 %]

(ii) The computer Analysis:

The results of the computer analysis for the variation of the power absorbed by the laser with parameters like δ, the ratio of the capacitance and α_1, the ratio of the time varying resistance of the laser gap to the resistance of the spark gap are shown in Figures [7a, & b]. These results also show that the power absorbed by the laser increases with increase in the value of δ. However, by increasing the value of δ, the power output cannot be increased without limit as C_2 also affects the rise time of the voltage pulse. The value of C_2 must satisfy the relation

$$\boldsymbol{t_r} \leq \sqrt{2\boldsymbol{L_e C}_2}\ .$$



(a) **(b)**

Figure 7 Power Variation

Set up for the Wavelength Estimation

A simple experiment as shown in Fig. 8 was set up to determine the wavelength of the laser. The light from the laser after collimating through the quartz lens of focal length 0.30 m and a slit was allowed to fall normally on a grating with a spacing of 3.38×10^{-6} m. The photograph of the diffraction pattern is shown in Fig. 9. The wavelength was determined by noting the angular separation between various maxima and employing the formular,

$$d \sin\theta = n\lambda$$

where n is the order of diffraction maxima.

Table3 THE WAVELENGTH OF THE NITROGEN LASER

Order, n,	Separation	θ_n	λ
1	0.01017 m	5.72 ^{o}	337.56 nm
2	0.2.65 m	11.49^o	339.24 nm

3	0.3148 m	17.23°	338.88 nm
4	0.4272 m	22.80°	336.64 nm

The distance of the Photographic plate from the grating = 0.1015 m.

The mean wavelength estimated in these experiments was 338.08 ±0.04 nm which compares well with 337.7 nm measured by sophisticated equipment.

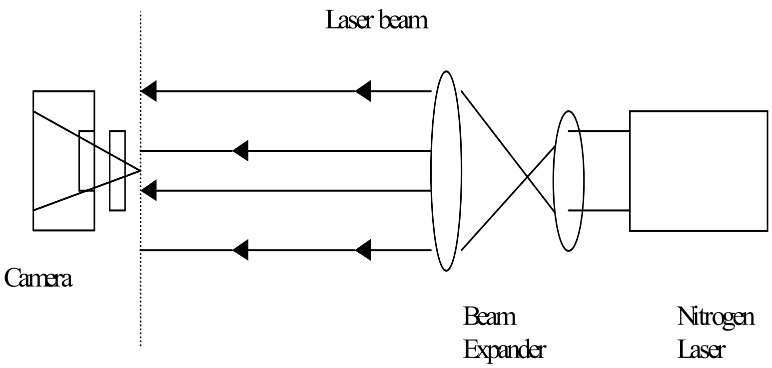


Fig 8 Setup For wavelength estimation

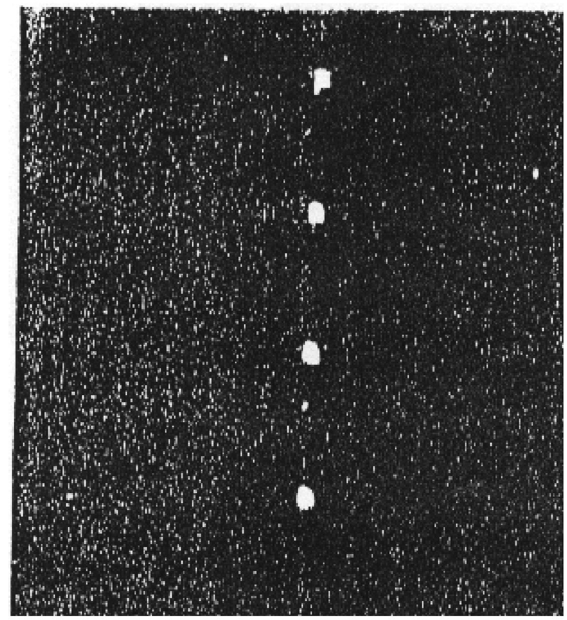


Figure 9 Diffraction Pattern

APPLICATIONS OF LASER

The nitrogen laser can be applied for pumping dye lasers [19], shadowgraphy of plasma focus [20], excitation of fluorescence in plants and oils [21], detection and treatment of malignant tumour [23], etc. In our laboratory we have applied it to study the dextrinization of starches [24].

The samples of maize and cassava starch were blended with magnesium, zinc and titanium IV oxides of analytical grades. The oxides were added in the proportion of 1 5 (w/w) per dry substance. The samples were irradiated in 1-mm quartz cell for 30 s, 600 s, 1200 s and 1800 s by a beam from 100 kW nitrogen laser. The standard methods for measuring aquious solubility, water binding capacity and reaction with iodine were used to analyse the effect of laser radiation on the samples.
The variation of the aquious solubility, water binding capacity and the absorbance of iodine complex for these starches are shown in Fig [10 a, b and c].

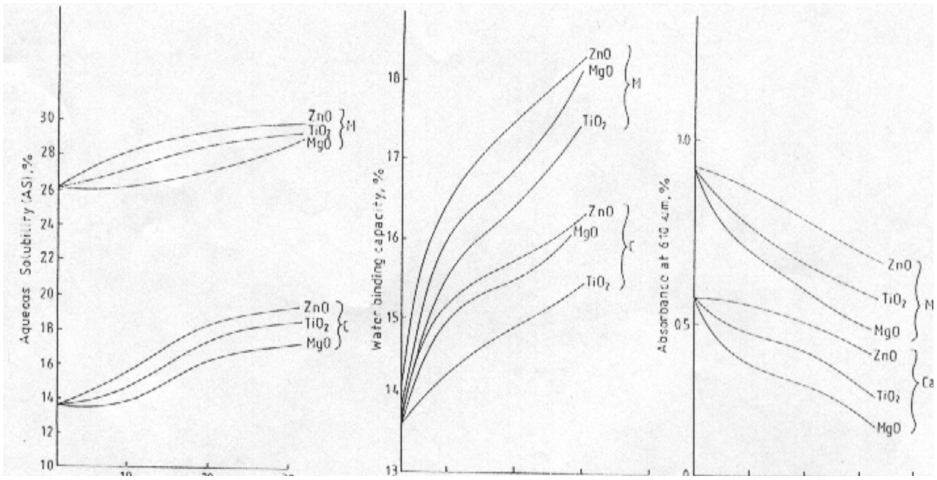


Figure 10 Variation of (a) aqueous solubility, (b) water-binding capacity and (c) absorption of iodine complex for promoter added maize

Maize starch had high content of amylopectine than cassava and therefore the effect of radiation in the first case was more pronounced. The decrease in the intensity of 610-nm absorption band in the case of maize starch was sharper by approximately a factor of 1.5. These results show that UV radiation from nitrogen laser produces rather subtle changes in the irradiated starch giving products corresponding to white dextrines of low solubility.

Shadowgraphy of Plasma Focus

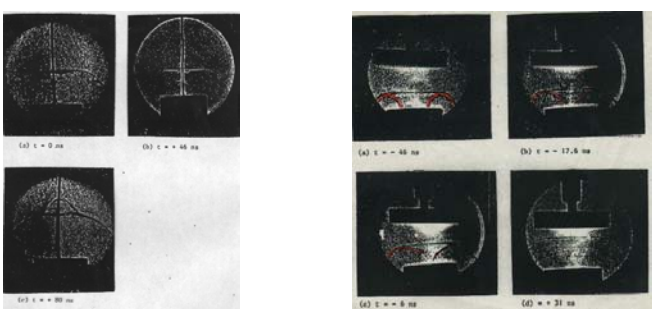


Figure 11 Shdowgraphs of Plasma Focus by Nitrogen Gas Laser

Plasma focus is a device, which produces hot and dense plasma for a period of about 50 ns. To enhance the production of neutrons, deuterised targets were irradiated. Nitrogen gas laser was used to scan the phenomenon, which occurred in short duration. The results obtained are shown in Figure 11. The details of this work can be obtained from the reference (20).

The main findings show that there is no interaction between the target and radially collapsing current sheet up-to 6 ns. Even after 31 ns, the current sheet does not reach the target at 1.5 cm from the focus region . When the target is at 7 mm, current sheet reached the target almost at the same time as the focus compression. The current sheet climbed over the target and advances with a speed of 5 cm $(\mu s)^{-1}$. The sheet collapses over the glass tube to which the target is attached.

Conclusions

A simple cost effective [estimated reduction in the cost is about 30 5 as compared with a similar imported laser with an added advantage of maintaining it locally] nitrogen laser using locally available materials has been constructed. The performance of this laser have been studied experimental and theoretically. It may be concluded that the laser channel operates optimally at a pressure of 7.48 kPa giving a peak power of 163 kW at 10 kV charging voltage. The pulse width of the laser was found to vary from 7.4 ns to 2.5 ns as the pressure was varied from 7.45 kPa to 9.48 kPa while the efficiency of the laser was found to vary from 0.040 to 0.050 in the same range pressure. The efforts to enhance the power output by increasing the capacitances using thinner dielectric gave unreliable shot to shot performance. The optimum thickness of the commercial grade Mylar sheets for the capacitors in the present environment was 2.5 X 10^{-5} m to get reliable and trouble free performance of the laser.

The wavelength of the laser light as determined by a simple grating gave a value of 338.09 ± 0.04 nm. Thus the home-made nitrogen gas laser experiment can compliment imported He-Ne laser. The laser has been successfully applied to study the effect of UV radiation on the maize and cassava starches and the shadowgraphy of plasma focus.

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Harnessing the Tenets of Green Architecture for the Sustainable Development of the Rural Environment.

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Key words: natural ecosystems, rural environment conservation, sustainable development, appropriate technology, green architecture, holistic design

Abstract

Following centuries of development, human settlements have expanded, especially the urban. Consequently the rural counterpart has diminished. Suffice it to say that human activities are depleting the diversity of the earth's natural ecosystems, in the country, nature reserves and tropical forests. Although contemporary urban planners/architects employ zoning principles, which enable the spatial arrangements of residential, industrial, commercial, etc. buildings, interspersed by open spaces, to achieve salubrious environment, harmony between ecosystems remain largely unrealized.

Thus, developments have been largely unsustainable as design decisions are informed by economic pragmatism. According to Simonds, "Man's effect on the world environment has been so great that virtually no pristine conditions exist today, not even in the depths of the sea or in the upper stratosphere".

This paper focuses on the growing concerns about the adverse environmental impacts of human activities fuelled by the hi-tech syndrome. The paper focuses on the rural environment, and considers it endangered. Using the case of Zimbabwe, currently in the process of a major rural environment transformation, the paper advocates appropriate technology policy and design guidelines, which guarantee environmental conservation in tandem with development processes. It acknowledges the role architecture could play in this regards and calls for a holistic design approach, discovered in green architecture paradigm.

INTRODUCTION

In the most recent history of human settlement development, two daunting challenges confront developing societies of the so-called global "village". The first is that of "the development of the rural settlements to enhance quality of life of the rural folks and in-tandem reduce the disparity in social and infrastructure provisions in rural and urban communities". The second is "the need for the conservation of the rural environment through the protection of indigenous flora and fauna and the geological features of the landscape", which form part of the people's heritage. These two challenges, though seemingly contradictory, are complementary aspects of sustainable development process assuming appropriate environmental planning and management programs are employed.

For the high-income countries, which embarked on rural planning and development projects in the early years of industrial revolution, environmental conservation paradigm was hardly envisioned. Development projects were undertaken, but in a manner that was largely environmentally unfriendly. Thus the earth and its nature reserves were avariciously consumed for over two centuries. This was the case with countries such as Britain, which only started making discernible efforts towards the protection of the nature reserves of the countryside and the urban environment in the 20th and 19th centuries respectively. For instance, although pollution-related deaths reported in London in 1873 and 1880 reached 500 and 2000 marks respectively, serious measures to enforce environmental protection and pollution control measures were put in place only in the mid 20th Century [1].

The United States took the first tentative steps to control air pollution with the passing of the Air Pollution Act only in 1955. Later, the umbrella Environmental Protection Agency was given sweeping powers and mandate to deal with issues of environmental protection nationwide, with attention on the urban rather than the rural centers [1].

The same, or even worse scenarios existed in those countries already industrialized by the time of the two World Wars. This was the period after which the urge for reconstruction of towns and cities, destroyed as a result of the ravages of the wars, and as a result of the need to accommodate the human surge to the cities due to trends in urbanization process, overshadowed any calls for environmental sensitivity in human settlement development activities/plans. Consequently, there was the consistent irrational exploitation of the land and its natural resources. The catalyst, which fueled the actions, was the 19th Century industrialization vogue resulting in unprecedented levels of air and water pollution.

It should be noted here that this same industrial revolution, which signaled technological advancement and the enhancement of the rate of advancement in human settlement development has today spelt doom for humanity following the cumulative adverse environmental impacts.

In the case of the industrially under-developed societies in general, and the developing countries of Africa, in particular, focus on rural settlement development was a later, post independent reality. The question of the environmental consequences of human activities was to be a much later event, even for the urban centers. Indeed environmental conservation questions for the rural areas other than those earmarked by pre- independent Governments as nature reserve areas for recreation and tourism are yet to be seriously asked. Due to various reasons such as the urge for the "modernization" of the rural areas, lack of adequate communication and information dissemination systems, pre- and post independent governments ignored or failed to appreciate the threat which human actions pose to the natural ecosystems. Yet they ought to have learnt some lessons from the long history of bad practices in Europe and North America, now fore runners in 20th Century rural development ideals.

Meanwhile, with the population of rural dwellers standing at 70% [2] and with signs of "modernization" seen only in very few urban centers, rural-urban migration was an inevitable consequence, leading to a very high rate of urban population growth.

Again, the environmental consequences were damaging but hardly attended to, although policies were on paper to stem the negative effects of rapid urbanization process. This was the first in policy shift in the 1970's with resource allocations for study initiatives in the rural areas substantially increased especially for the areas identified for nature reserves/national parks (eg Matopos National Park in Zimbabwe, The Rift Valley in Kenya). Through such studies, a number of qualified similarities between the rural entity in the developing and the industrialized countries were identified. These include: distortions in the demographic structure of the rural settlements; the "dualism of abode" phenomenon [3], [4]. Others emerged ranging from socio-economic, political and settlement patterns to uniqueness of landscape, nature reserve and tourism potentials. Therefore, there is much to be shared between the indigenous and contemporary practices.

THE RURAL ENVIRONMENT QUESTION

In post-independent African countries, south of the Sahara, policies for rural settlement development vary depending on the currency of the traditional system of land ownership. For instance, the well-established traditional system of land ownership in most West African countries did not encourage foreigner (white) settler communities. On the contrary, in most Southern and East African countries, European/Asian settler communities are a common and difficult to reverse social and politico-economic order. Whereas in the former, the struggle for independence was based more on political and national resource management question, in the later, "land" was clearly the bone of contention. This is the case in Zimbabwe, where the revolutionary song – "AKUNGIHLEPHUNELE MBIJANA" ("share with me a little") tells the whole story behind the rural land question. Therefore, community development policies are, and should be such, as to accommodate both the indigenous and the settler communities.

The need for equity in land ownership as well as means of production and economic empowerment of the rural communities was realized in the eastern and southern African regions long before independence. This is widely recognized as the second and perhaps the latest major factor of paradigm shift in development policies of governments and operational strategies of their allies.

In contemporary Zimbabwe, the cardinal policy of the Government since the early 1980's has been the mobilization of all available human and material resources to establish a sound infrastructure in the rural areas [5]. In a recent interview, the Minister for Science and Technology in the Office of the President, Dr. Olivia Muchena pronounced her vision to see a developed and beautiful Zimbabwean countryside.

The 2004 Budget, in which over 600 billion dollars is allocated for agriculture and rural community development, especially in the newly resettled communities, is a clear testimony to the commitment of the Government in this regards. Besides, in 2003, the National Housing Delivery Program was established to provide affordable housing to the low-income communities in the peri-urban areas. Stands are allocated to those who wish to build. 55 billion dollars is made available for the servicing of the stands. Also loan facilities and construction brigades are in place to facilitate the realization of the targeted 1,5 million housing units by the end of the year [6].

Whereas these are indicative of people-centered development policies of Government, there is the need to be mindful of the fact that today, the rural entity remains the only vestige of the delicate pristine environment, which we must guard jealously and conserve selflessly. Suffice it to say that human legislated policies and intervention actions, which are people-centered may not necessarily be conservation based. Thorough studies, employing impact assessment tools are necessary for a most rational executive action if we are to achieve the goal of environmental conservation in the course of implementation of noble rural development aspirations.

In most countries – developing or developed, the primary objective of rural environment development had been the provision of basic infrastructure and services and the consequent reduction of the disparity in living and working conditions between the urban centers and the countryside. Such ideals often ignore the issues of the impact assessment of development programs, the appropriateness of the evolved built ecosystem and architecture. Hence little, if any traces of the natural ecosystem has survived the onslaught in the rural zones. In recent years however, a growing awareness amongst government agencies and NGO's responsible for the planning and management of human settlements has reached the stage of recognition of the fact that sustainable rural development is paramount and dependent on sustainable use of the earth's resources [7], [8]. Regrettably, it is only the awareness, which has improved but not the implementation. Consequently, the traditional perception that the rural environment is "a place of danger, … of poverty and disease, … a place to escape from" [9], remains indelible in people's subconscious minds. Concerning the architecture of the rural settlements, the scenario remains inadequate. The vital role sustainable architecture can play in rural environment conservation is yet to be duly acknowledged [10]. Indeed, we are yet to settle scores on the issue of appropriate technology for taking rural architecture to an enviable height without putting into jeopardy the integrity of the natural ecosystems.

As the product of a society's solution to its habitation problems, architecture plays a central role in the modification of the inter-relationship between the natural, social and the built environments. Therefore for a sustainable rural development, the architecture must be culturally suitable, environmentally sensitive and economically viable. In these aspects, there is more to learn from the contemporary practices of countries such as Britain, South Korea, Germany and others, where the term country or countryside connotes "…a place of beauty, … a place of relaxation…of leisure, a place to escape to", from the often routine urban way of life [9].

THE TESTED AND TRUE

Human development activities have been widely recognized as the main cause of the most ecological damage to the environment globally. Although it is unrealistic to imagine the earthscape without changes in the environmental systems, it is also a truism, that these changes can and should be carefully planned and managed to ensure sustainable living.

All over the world, indigenous peoples have a clear knowledge of a sustainable living. But the wave of modernization has persistently eroded it. Through centuries of experiences with nature, they acquired "traditional wisdom"/"science" which guided them in their practical everyday life. Unfortunately, formal educational systems have distorted this tested and true way to sustainable living, all-be-it temporarily. Suffice it to say that sophisticated knowledge of the natural world is not only confined to conventional science.

Human societies all across the globe developed rich sets of experiences and explanations relating to the environments they live in which we refer to today as traditional ecological knowledge. These encompass the sophisticated arrays of information, understandings and interpretations that guided them in their innumerable interactions with the natural milieu: in agriculture and animal husbandry, hunting, fishing and gathering; struggles against disease and injury, naming and explanation of natural phenomena, and strategies to cope with fluctuating environments" [11].

It is logical and true to infer that in the process of these " innumerable interactions with the natural milieu", the indigenous people evolved their architecture. That was a "true architecture" because it evolved with nature and is not in conflict with it. It is the architecture of sustainability and environmental conservation. As we shall see later, the protagonists of the latest movement in architecture dubbed it "green".
The urgent need for paradigm shift in the development of the rural built forms arose out of the conscious recognition of the damaging effects of contemporary architecture of the hi-tech appeal on the environmental systems.

The current high-tech architecture, just like all the other products of human advancement in technology, is generally known to have failed the acid test for sustainable development and environmental conservation. The move back to the people's folk architecture approach is recognizable as a positive development. It may have taken us ages of adverse ecological consequences to realize our folly but it is better now than never.

THE STATUS QUO

For the rural areas of Zimbabwe, the responsibility for physical planning falls under the rural District Councils and Town Boards. The department of Agricultural Extension (Agritex) under the Ministry of Agriculture alongside the Agriculture and Rural Development Authority (ARDA) also has responsibility for physical planning, especially in the resettlement areas. Normally, the planners are involved in the policy-making issues of environmental management. Also involved are ecologists who play the role of interpreters at the policy/regulatory levels. Through research, professional ecologists are involved in the collection and interpretation of data on organisms as well as environmental conditions [12].

Empirical studies have shown that these key players and agencies in rural development spheres often have their specific individual objectives, which make it difficult to realize the national goal of environmental conservation. Although they may be aware of the need for sustainable agriculture and appropriate architecture, the user communities are usually not adequately consulted, and hence not involved in the development process.

In theory, land-use planning is acknowledged as an effective tool for managing changes in the rural environment. It recognizes the inter-relationship between the environment and the social, economic and political factors of change. However, land-use planning as a tool, can only be effective if all stakeholders are determined to make it work to achieve the common goal of sustainable development. In most countries, this is not so because it is traditional for the legal instruments to see the environment in terms of property rights with environmental decisions made primarily in favor of "development" but hardly conservation. This is particularly grave in countries where development control is still guided by the age-old Regional, Town and Country Planning Act of the former colonial countries. Normally, the Master and Local Development Plans guide the shaping of the built environment whereas more detailed land-use plans, with subdivisions are produced by the urban and regional planner. Hereafter a range of actors come to stage including the engineers for roads and bridges, sewer and drainage systems, energy networks, etc., architects, contractors, landscapers, for the design and construction of the buildings, etc. At this stage the guidelines on ecological conservation (if any) are thrown overboard as a result of the designers' inordinate ambition to cut corners and create their own "world" of built forms [12]. As a result, the built ecosystem is neither community sensitive nor conservation based while the evolved architecture is inappropriate.

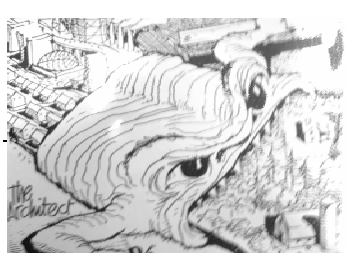

Fig. 1 Caricature of the Contemporary Architect by Malcom Wells

In his caricature of the contemporary architect, the American architect, Malcom Wells illustrates him as the "Land-hungry monster, T-square in one hand and copy of planning consent in the other. The illustration (Fig.1) demonstrates the inner passion of the professional architect, who exploits the new industrial base, new construction materials and technology, growing economy and a physical planning act, which only pays lip service to the issues of sustainable development. For the architect therefore, the sky is the limit as he satisfies his passion for wealth and in the process, replaces nature with ecologically "unfriendly" built forms. Thus architecture is brought into "collusion" with nature. The scenario has remained largely so especially in the urban centers. The rural environment itself is quickly catching up in the opium of unsustainable development tendencies. As a consequence, man is increasingly alienated from his natural habitat.

APPROPRIATE TECHNOLOGY

The advent of Luddites school of thought in the mid 20th century questioned the rational in the extravagant exploitation of earth's limited natural resources for irrational advancement in technology. Arguments were put forward for the new concept of "needful and sustainable technologies" – a concept variously termed alternative or appropriate technology in building production. The concept has since spread like wild
fire, fueled by the initiatives of such proactive non-governmental organizations as the United Nations Environmental Program (UNEP), the World Conservation Union (IUCN), the World Wide Fund for Nature (WWF) and a host of others.

The attributes of appropriate technology are globally acknowledged, especially with regards to the energy concerns of the environment. This is more pertinent for the low-income countries, where chances abide for some pristine environmental conditions.

It will not be prudent for these countries to spend the little money they do not have in technologies, which benefit neither the suffering masses nor the integrity of the natural ecosystem. Meanwhile, minimal tangible progress is made on the question of appropriate technology for sustainable human settlement development. The conflict stems from the inordinate urge to acquire hi-tech knowledge and demonstrate its speed in mass production without regards for the adverse environmental impact.

Thus 'speed' and the urge for corporate image encourage the proliferation of irrational technology. As it became fashionable, very few are bold enough to criticize the apparent conflict between hi-technology and the environment.

Of serious concern especially for the developing societies, is the conceived idea that alternative or appropriate technology implies low-cost buildings for the poor. Consequently, affluent members of the society would not subscribe to the concept. And even the middle and low-income classes are not psychologically prepared to venture into the "experiment" because of the stigma attached. Currently serious efforts are being made by the protagonists of appropriate technology, courtesy of the UNCHS(Habitat), to replace the word "low-income" with "affordable", but the resistance remains stiff. This is the quagmire, which rural development efforts in Africa must overcome to achieve the desirable goal of sustainable human settlement development.

While this empasse drags on, researchers have revealed some correlation between the architecture based on the principles of appropriate technology and that, which is ecological. Both of them place people at the center of development efforts. Both comply with the rules of the natural systems, which sustain all life. Most importantly, they adhere well to the design-with-nature approach of the rural folks.

As Ryn and Cowan [13] put it, "… the environment crisis humanity faces is a design crisis, a consequence of how things are made, buildings are constructed and landscapes are used".

In recognition of this, many designers, planners, developers are gradually becoming more and more conscious of the environmental consequences of their actions – hence the frequent occurrence in conferences and published works, of such vogue words as: "green design", "sustainable architecture" "sustainable design", "ecological design", "organic architecture", "permaculturalism", "bioregionalism" etc. [14]. In all these gamut of concepts, ecology comes out clearly as a common denominator. Using ecology as the basis for design, five principles for shaping the built environment are identified as follows [15]:

- Design with nature: This enables designers as well as all players in the building industry to acknowledge the delicate structural components which constitute the environment and exploit the interactive processes between them without depleting any.
- Ecological auditing: This enables the monitoring of the environmental impact of design and its use in assessing the ecological viability of the project before the development starts.
- Environmental modeling: This enables us to understand the natural cycles and processes, which sustain all lives and our place within nature and the environment.
- Place as a form giver: As we gain intimate knowledge of a place, its small scale, local conditions and people, and being sensitive to the special features of the place, then we can inhabit without destroying our habitat.

- Collective design: recognizing that everyone's voice must be accommodated in the design and decision making process.

Fig. 2 Hundertwasser's Concept of Designing with Nature.

Since environmental conservation is seen as a central question in the debate, a main strategy is that the built ecosystem must be structured using a community sensitive approach. Here, "community" means a collection of interacting organisms within an ecosystem (and not a community of human beings). This approach is often described as holistic. After a long search for a distinctive, yet all-embracing nomenclature, researchers were bold but tactful, in moving from the concept of appropriate technology to that of "green buildings", a precursor to "green architecture", regarded as the appropriate architecture for a conservation-based built ecosystem.

Fig. 3 Frank Lloyd Wright's "Falling Water". Edgar Kaufmann House, Pennsylvania, 1936, - A Case of Organic Architecture.

The implied hypothesis is that the inordinate quest for often needless and unsustainable technological advancements is a major threat to the survival of the earth's resources.

Contrary to the "organic" architecture credited to Frank Lloyd Wright in the early 20th Century, "green architecture" is a relatively new movement whose core concept of holism is yet to be fully defined and realized.

Although "green" and "organic" architectures recognize the need to "design with nature", the difference is fundamental and lies in the depth of the definition of the environment. For "green" architecture, the definition goes beyond the realms of the physical manifestations of the natural environment to the level of communities in the ecosystem and the interactive processes, which sustain regeneration. On the contrary "organic" architecture is a philosophy of architectural design, which asserts that a building should, in structure and appearance harmonize with its natural environment using organic forms. No one doubts the fact that Wright's "Falling Water" is an embodiment of the "organic" architecture movement but it surely lacks the holism ideal of a "green" architecture, whose tenets should be exploited for a sustainable rural built environment.

The core argument is that the harnessing of the qualities of the natural processes could bring about a sustainable built environment [16]. Such natural ecosystems recycle their materials, permit change and adaptation and make efficient use of ambient energy. When fully developed, green architecture will be meant for the masses instead of the affluent few. In green architecture, the setting is given due respect by making sure that the site is not over-ridden by the architects' urge to satisfy the intellectual ideals of the developer. With a rational mix of art and appropriate technology, green architecture is capable of reinterpretation by each new set of user cultures. Consequently, it is capable of responding to physical changes as are required by new generations.

At the end of its lifespan, when its relevance is so little, the "green" building is capable of demolition and reuse, or can be allowed to become a ruin without harm to the environment.

Closely related with the green architecture ideals is permaculture – a contraction of "permanent agriculture" and "permanent culture" [12], [17]. It factors in many of the tenets of green architecture. It is particularly useful in rural environments, which is largely of the cultivated ecosystem. Permaculture promotes the symbiotic and synergistic relationships between site components and thus enhances ecologically balanced food-production ecosystems. The acknowledged effectiveness of permaculture in land-use lies in its potentials for exploitation of ecological knowledge to design integrated built ecosystem, which is in harmony with agricultural activities, as well as the use of biological resources and appropriate technology in rural community development.

Fig. 4 Hundertwasser's environmentally sensitive architecture

CONCLUSION

In his summary of the environmental audit of the earthscape, Simonds (1978) posits that man's effect on the world environment has been so great that virtually no pristine conditions exist today, not even in the depths of the sea or in the upper stratosphere [17].

Although not in the same level of devastation as in the industrialized countries, the rural environment of the low-income countries cannot be totally exempt from Simond's position. This is demonstrable using the ecosystem classification based on their environmental state and their potential for sustainable use, as follows: Natural, Modified, Cultivated, Built and Degraded ecosystems [15]. Listed in a descending order of their potentials for self-regulation, the "Built" ecosystem, followed by the "Cultivated" is next in line to the "Degraded". Therefore, in line with the mainstream thinking, the specific strategies for sustainable rural environment development in Zimbabwe should be those of the principles of green architecture as follows:

- The sustainable cultivation of land for food as well as aquaculture (from cultivated ecosystem).
- The development of built ecosystems, which are sensitive to both human and ecological communities).

These strategies should also be used for the growth points and the outskirts of the towns/cities. Recent empirical research shows that these areas are still characterized by high ratio of native species to the introduced. As built and cultivated ecosystems, they lie at the brink of degradation in the classification lineage, a fact, which demands conscious legislative and timely executive actions. To this end, human settlement patterns, together with the forms of the built ecosystem must be seen as an adaptation to the biogenic system and not a destructive "parasite" to it.

In the past, architects and urban designers, involved in the shaping of human settlements had preferred the use of typological approach to design, with adverse environmental consequences. The time is long overdue for change. Furthermore, recent empirical studies show that very few of the people involved in environmental design research, especially within an ecological framework, are themselves designers. Yet the issues in question involves, not only addressing the problems of everyday life, but also making conjectures about the particular patterns of development of the built environment, which guarantees sustainability.

Here one must acknowledge the fact that landscape architects have since taken up the challenge and it is expected that the architectural profession should move into step with them and the rest. Empirical studies suggest that the answer to the appropriate architecture question is in the new green architecture paradigm. For the benefit of doubts, green architecture does not demand a return to the vernacular traditions. It is the attitude to materials and resources, expressed in the vernacular approach that shouts for recognition.

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ALTERNATIVE TECHNOLOGY FOR DEVELOPING COUNTRIES: CONSTRUCTING MORE DURABLE, COST-EFFECTIVE HOMES FASTER BY USING BUILDING PANELS COMPOSED OF A PROPRIETARY COMPOSITE CONCRETE OR CEMENT BOARD COMBINED WITH AN INNOVATIVE CONNECTION AND LOCKING SYSTEM

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Abstract

Most local government councils strive to create opportunities to develop their communities in an integrated manner, providing opportunities for mixed land use and to accommodate the whole spectrum of residential, agricultural, and commercial accommodation. Universal Community Developers, Inc. (UCDI) is committed to partnering with working men and women around the world (especially those involved in the worldwide labor movement) and to walk together in the direction of economic democracy. We believe such individuals will share our commitment to safe housing, stable neighborhoods, and the satisfaction of the daily needs of underprivileged people. We will implement GloPac's ***ReZist-It®*** *technology for composite concrete structural panels. By using the* ***ReZist-It®*** *systems, homes are 25% less expensive to produce, have a very short "factory to completed structure" time, and provide a significantly higher quality level than traditionally constructed units. The end result will be a respectable home affordably priced with open-ended construction to allow for personalization and individual enhancements. Additionally, UCDI's development philosophy is geared towards sustainable and rational community models specifically tailored to South Africa's and other African counties' unique needs and competitive advantages. This philosophy in planning extends to the supplementary related ventures to support these communities (i.e. local labor over massive heavy industry infrastructure, alternative small-scale power generation, etc.) This type of new technology has become globally accepted and is predicted to become the mainstream way to construct new homes as opposed to the exception. The entire globe will be forced to use this and similar technologies to stay competitive.*

INTRODUCTION

It is the vision of most local government councils to develop their communities in an integrated manner, providing opportunities for mixed land use and to accommodate the whole spectrum of residential, agricultural, and commercial development.

Given the historical disparities in African communities, there are, on the one hand, very strong social needs and, on the other hand, very strong economic imperatives.

We will use our developments to tackle problems such as increasing cost for residential and public buildings, inappropriate use of building materials and underutilization of current construction technology, which are common across the continent of Africa.

For example, housing provision in urban areas in Ghana has been characterized by high and ever-increasing cost for both residential and public buildings. Experts have advanced many reasons that include the following

- Over-dependence on imported building materials
- Non-utilization of appropriate construction management techniques
- Defective implementation of housing policy by government
- The excessive cost of land
- Lack of political will
- Inadequate financial resources

Policy makers are also saddled with the problem of lack of credible databases upon which to develop appropriate policies. Many a government has sought to solve this problem via various means such as the formation of an organization geared towards effective private participation in the delivery of housing units. Their efforts notwithstanding, in the year 2000, out of a total of 304,000 housing units demanded by urban settlements only 43,000 units (14%) were supplied. Quite apart from the inadequacy of their efforts, the prices of their products are not affordable to the average Ghanaian. [1]

Our goal is to make quality housing affordable across the continent!

OBJECTIVE AND PHILOSOPHY

The philosophy underlying the origin and implementation of Universal Community Developers, Inc. (UCDI we are guided by the love and respect among our fellow men and women, rather than by the love of money. has a place, certainly, but not at the top of our list.

Therefore, we will be able to produce affordable housing because it has be proven that when a family is fac the issue of dedicating a large proportion of their income to housing, they often cannot afford to pay fo necessities. [2]

The founders and managers of UCDI recognize that around the world there is an accumulation of vast wealtl few and the sharing of enormous misery by the majority. UCDI endeavors to level the playing field by pr opportunities on a wider scale. Our goal is humanitarian – we want to reduce the misery and poverty of a people as possible globally, especially throughout the African continent.

However well intentioned our motives, every project must stand on its merits. We have a vested interest in securing our humanitarian focus and are engrossed in each project. The most up-to-date management and business principles, techniques, and tools will be employed to guide each project.

UCDI is committed to partnering with workingmen and women around the world (especially those involved in the worldwide labor movement) and to walk together in the direction of economic democracy. We believe such individuals will share our commitment to safe housing, stable neighborhoods, and the satisfaction of the daily needs of underprivileged people.

In the United States, there is a great need for affordable housing across the country within the urban centers. Therefore, UCDI is working with locally-based, residential development companies to provide affordable housing for working families in these areas and throughout the developing world, especially Africa.

UCDI sees unique opportunities to create an infrastructure to re-assert and liberate urban dwellers' self worth and self-esteem. It is our belief that providing jobs, training and skills development in many disciplines, and by providing affordable housing will help in the solution to many other problems. The result, our investment will build and strengthen the African and African American community.

UCDI in concert with its associate firms [Universal Structures, LLC and Universal Builders and Construction, Inc. (UBCI)] provide development, engineering, housing design, construction, and panelized manufacturing for housing construction, solar energy and a broad array of community development services. This united core group of professionals and existing agencies share like missions and jointly work on this shared agenda; this group is determined to bring this dream, embodied in our mission statement, to fruition. Our mission is to the development of affordable housing for low-income workers, to the creation of jobs, training and skills development for the unemployed and underemployed.

Our overall objective is to provide homes, jobs, business ownership and opportunities for residents in communities throughout the African Continent. Our primary objective for this project is designed to provide permanent and affordable housing and expand homeownership opportunities for residents in our target communities. We are currently working on project in the USA and have researched and identified several Projects, specifically in South Africa and Nigeria that we are applying for financial assistance from the USA Overseas Private Investment Corporation (OPIC).

The new housing and neighborhood facilities will require production facilities for building materials and initial markets for new low and medium technology industries. UCDI envisions the creation of new joint ventures with local entities to meet these needs, including facilities for the manufacture of structural building panels; plants for the fabrication of solar water heating and distributed solar voltaic systems, assembly of roofing systems, and the procurement of other materials and supplies. These joint ventures will create jobs within the African economy and the initial setup costs will be amortized over the cost of developing housing for predominantly low-income residents. We want to set up these ventures with various like-minded development and training entities, including faith-based non-profits, labor organizations and for profit developers throughout the target countries.

Our venture already has competent, experienced and proficient experts in their respective crafts, but more importantly, committed to the bottom line cause of this project. The bottom line is that we are permanently changing history for the future.

Each entity performs specific and significant tasks outlined below:

- UCDI serves as the program and real estate development planners and managers for our projects. UCDI will develop the architectural plans for single-family homes for the infill of new large-scale development projects, it is the technical arm of the team and will provide the project management, engineering, surveying and construction management expertise to complete each project.
- Universal Structures will manufacture the panels for housing construction. Universal Structures is licensed to manufacture Global Pacific Technologies, LLC's (GloPac's) ***ReZist-It®*** building system.

Utilization of the wall panels will allow us to construct a house in 60% the time of a stick built house at a savings of approximately one fourth the cost.

- UBCI will serve as construction contractor or construction manager on in-house and client projects. UBCI is responsible for the erection of the manufactured panels. Every house built with our panels will have assistance from UBCI during the erection phase of the construction.

The power of the business model can be seen in the sequential implementation of our business plan for low-income housing across the African continent.

Initially, UCDI will provide equity leadership in the development of new neighborhoods for low- and very low-income households. This venture, being carried out in partnership with our development partners will produce in excess of 1,000,000 new dwellings throughout Africa. Neighborhood physical and social infrastructure will also be provided to make the neighborhoods good and desirable places to live.

The new housing and neighborhood facilities will require production facilities for building materials and initial markets for new low and medium technology industries. UCDI envisions the creation of at least several new joint ventures to meet these needs, including facilities to manufacture structural building panels; plants for the fabrication of solar water heating and distributed solar voltaic systems, assembly of roofing systems, and the procurement of other materials and supplies. These joint ventures will create jobs in conjunction with the labor movement across the African continent. The initial setup costs for the manufacturing facilities will be amortized over the low and very low-income dwellings. Where appropriate, UCDI will initiate the development of sustainable new towns.

Related ventures will include the private operation of community services such as water and wastewater management, mass transit, and neighborhood-based education and health facilities. As progress is made on the humanitarian front, UCDI will create other joint ventures to provide market-oriented housing for a small but growing minority middle class.

UCDI will also facilitate cooperative neighborhood re-investment trusts that will serve a variety of purposes. These purposes include community control of down stream capital for major re-investment requirements (roofs replacement, water and power maintenance, and repair or replacement of public infrastructure systems, schools, and neighborhood health facilities). They will also provide locally generated source of funds for micro-capital investment banking and new commercial enterprises (e.g. garment manufacturing). Through emphasis on community control, UCDI believes that its activities will foster political stability as well as better living environments.

When people have a stake in the future, they are much more likely to dream and work to make the future a better place for their families and their children.

METHOD

Central to the plan is UCDI and Universal Structures' efficient implementation of GloPac's ***ReZist-It®*** technology for composite concrete structural panels. By using the ***ReZist-It®*** systems, homes are 25% less expensive to produce, have a very short "factory to completed structure" time, and provide a significantly higher quality level than traditionally constructed units. The end result will be a respectable home affordably priced with open-ended construction to allow for personalization and individual enhancements. Additionally, UCDI's development philosophy is geared towards sustainable and rational community models specifically tailored to South Africa's and other developing countries in Africa unique needs and competitive advantages. This philosophy in planning extends to the supplementary related ventures to support these communities (i.e. local labor over massive heavy industry infrastructure, alternative small-scale power generation, etc.)

THE TECHNOLOGY

Although it seems contrary to common sense to produce a more superior quality product in less time with lower cost, consider the experience of the San Diego Building Industry Association, which set a world record in 1983 for completing an entire house in less than four hours; however, it is worthwhile to note how much the construction cycle can be compressed. This was done by a group of leading builders and product manufacturers who met in St. Petersburg, Fla., to create a technology roadmap around whole house and building process re-design. In summary, the group focused on a vision of "building better homes faster and at lower cost." Their vision also states, "By 2010 home design and construction is efficient, predictable, and controllable with a median cycle time of 20 working days from groundbreaking to occupancy with resulting cost savings that make homeownership available to three-quarters of the population." [3]

Global Pacific Technologies, LLC, **"**GloPac**"**, has developed an innovative panel system, which addresses the major needs of the majority of prospective homeowners worldwide. GloPac accomplishes this by offering a safe, easily constructed panelized building system that is efficient, strong and affordable. A special capability and service of GloPac is to review the project culture and weather conditions necessary to adjust and provide viable answers to specific problems. We then adjust to the need through alteration of connections, design or materials used in the makeup of the panel. When necessary we can provide thermal breaks to alleviate damage from extreme hot or cold temperature conditions. The ***ReZist-It*®** system is truly tailored to the specific needs of its customer.

***ReZist-It*®** Building panels combine several component systems based on a proprietary composite concrete or concrete fiberboard faced structural panel that mates with an innovative connection and locking system made of medium gauge steel. The system was developed by Frank and Susanna MacDonald, the inventors and principals of GloPac. GloPac's management intends to expand its innovative yet basic and familiar system through global licensing and the establishment of factories across the United States and throughout the world.

The ***ReZist-It*®** system is virtually unlimited in its building applications, equally practical for high-end residential and commercial structures in the U.S. and Canada and ideal for disaster relief housing in developing nations. The system was originally designed for the inclement weather conditions of Guam in the Pacific and for tribal housing on American Indian reservations. These two directions assure the accomplishment of GloPac's goal of safety at lower cost.

The system is known by its registered trademark ***ReZist-It*®** due to its resistance to all kinds of disasters, including earthquakes, hurricane / typhoon winds, fire, rodents, mold, termites and other infestation.

The basic panel assembly is comprised of cement fiberboard or GloPac's proprietary fast-setting cementatious slurry, sheetrock and insulating foam. The facing materials are set or poured into a G-60 galvanized frame encapsulating a lightweight core of insulating two-part injected, environmentally safe, urethane. The panel cures in one hour or less, and when used with the ***ReZist-It*®** foundation and roofing connection systems, forms a structural building assembly that is more rapidly constructed at lower cost.

At the present time the ***ReZist-It*®** system has two panel thicknesses. The **"*Slim Line"*** version is 2-3/4" thick and has an R-13 (insulation value), which when combined with the framing system, provides approximately three times the strength of 2'x 6' frame construction. The thicker **"Energy Plus"** ***ReZist-It*®** panel measures 4-1/2" thick by 2 feet wide by 8 feet long and is surrounded by structural steel. The panel core section is Class 1 environmentally friendly, fire-rated urethane foam. When two panels are placed together, two 16-gauge studs surround a concrete column with a threaded steel post-tension rod, anchoring the roof to the foundation, thereby increasing its structural integrity. The typical panel can be easily handled by one or two workers and at approximately 180 pounds, weighs considerably less than standard concrete panels. No lifting equipment is required and simple rapid construction is possible with only a torque wrench and a screwdriver.

The exterior walls of a 500 square foot unit can be assembled and locked in place with windows installed in less than eight hours by two men at a cost which, in a conservative estimate, will range 15 to 25% percent less than a comparable site-built home of standard wood frame.

Excellent sound deadening qualities are prevalent due to the panel makeup and insulation in both the exterior and interior walls.

Construction of a ***ReZist-It*®** home is based upon a post-tensioning system typically unavailable in residential structures. This provides higher compression, increased tensile strength and higher racking shear, while eliminating the usual "tie-downs". Major damage from earthquake, high winds, fire and freeze-thaw are virtually unknown to the system. The ***ReZist-It*®** system is less costly, stronger and does not require skilled labor. The materials are readily available and can be used in all types of construction. A ***ReZist-It*®** building can be erected as quickly as a site-builder can complete standard wood framing. Only the finish details are left to complete. Sheetrock as well as the electrical chases, are inserted into the panel during manufacturing, as specified by the Designer or Architect. When building with ***ReZist-It®*** Technology, noticeable advantages are:

Speed — Cost — Ease of construction — Quality — and Structural Integrity.

The ***ReZist-It®*** system includes a floor plan for a disaster relief model that runs from 150 to 400 square feet and can be assembled in approximately one hour and is known as a "***PermaTemp"*** structure.

It is GloPac's intent to provide technology for high quality affordable housing throughout the global community through technology transfer, service, design, and project management.

Research has shown that the use of this and similar types of technology produces the following benefits:

- Homebuyers are pleased with their purchase because of reduced costs with the same or higher quality.
- Builders and subcontractors maintain or improve margins by
    - Reducing costs to construct a home
    - Decreasing time to construct a home
    - Producing more homes
    - Selling more homes [3]

These strategies and technologies should be implemented taking into consideration the "whole building." The "whole building" approach recognizes that the components and systems of a house are interdependent; therefore, one component or system could positively (or adversely) affect another. For example, building 2x8 exterior walls will result in increased insulation, which may downsize heating/air conditioning equipment and result in material reductions for the developer and utility bill reductions for the homeowners.

This technology has been proven to

- Reduce labor, or use of materials and other resources
- Allow for the inclusion of cost-effective alternative material
- Reduce living expenses to the owner (i.e., more durable, saves energy, reduces water use, easy to maintain, etc.) [4]

CONCLUSION

The entire globe will be forced to use this and similar technologies to stay competitive.

This type of new technology has become globally accepted and is predicted to become the mainstream way to construct new homes as opposed to the exception. This is because it has proven strategies to reduce costs if companies will implement this or similar technology. Most developers are proven to benefit if they will

- **Begin to include these types of technology into current methods**: Establish and manage a well-described framework for speeding the process of adopting the new technologies and putting them into use.
- **Create an Environment in the Home Building Industry that Facilitates Systems Solutions**: Change the Paradigm - Recognizing that the fragmentation of the industry requires collaboration and alliances to apply systems sciences to designing and building homes, create an environment that encourages working together.

- **Industrialize the Home Building Process**: Apply manufacturing processes and technologies, many of which have already been proven in other industries to achieve higher levels of production efficiency.
- **Improve the Constructability of Houses**: Develop the system science and perform analysis and engineering that will make houses easier to construct, reduce labor cost, reduce material costs, and improve quality, durability, and safety.
- **Move More of the Home Building Process into the Factory**: Perform more of the building process in a factory where it is easier to control the process and to use information technology. [3]

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APPROPRIATE LOW COST BUILDING MATERIALS IN ZIMBABWE

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Key words: low cost, building materials, appropriate technology

Abstract

Micro-Concrete Roofing and Rammed Earth Technology are low cost, simple and sustainable appropriate technologies in resolving the housing, construction and resettlement challenge in Zimbabwe. Works in resettlement and peri-urban areas acquired for urban development demand huge capital. Cost-savings construction methods and building materials initiatives are welcome. SIRDC, through Building Technology Institute has proffered standard development for building materials. Standards enable building product/material quality measurement, standardisation and control. Building/construction materials/products backed up by standards are acceptable, sustainable and have integrity within the built environment fraternity. Safeguarding technology collapsing due to non-standardisation errors of omission and commission is an important. Consequently Micro-Concrete Roofing Standards (SAZS 863:2002) and Rammed Earth (SAZS 768:2000) exist and are registered with the Standards Association of Zimbabwe. Experimentation and gamma testing executed with satisfying returns. The scientific approach though specific to Rammed Earth and Micro-Concrete Roofing Tiles can be applied to the wider building and construction industry related materials such as Stabilised Soil Bricks (SSB), Compressed Bricks (CB) et cetera. Research and development optimisation of scientific methods of Rammed Earth and Micro-Concrete Roofing Tiles remain important. This presentation serves as a guideline in possible appropriate building materials applications in resolving the resettlement and housing challenges in Zimbabwe.

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INTRODUCTION

Scientific & Industrial Research & Development Centre

The research institutes[4] are the operational arms of SIRDC. The research staff (scientists and engineers) in each institute report to their Director from whom they receive the work assigned. SIRDC, mission statement is to provide Zimbabwe and the region with technological solutions for sustainable development. The Vision of SIRDC is to be the leading Centre for the development of Zimbabwe and the region through reduction to practice of technologically developed products and processes.

SIRDC upholds the following values , namely integrity in all activities we are involved in; is an equal opportunity employer; comply with government policies and regulations; recognise the value of our employees; encourage teamwork; is a learning organisation and recognise ethical business relationships. SIRDC broad strategy is to produce high value, high quality and competitive products and services

Building Technology Institute (BTI)

The Building Technology Institute (BTI) is the national focal point of science and technology research and development, technology transfer and consultancy services in the areas of design construction, building materials, housing, planning engineering and related services. The work programme of the institute encompasses the whole technology spectrum of the built environment.

Building Technology Institute's primary mission is to give Zimbabwe a better future by strengthening and improving the building industry competitiveness and ensuring the well planed development and maintenance of the country's buildings and infrastructure. Building Technology Institute's primary goals focuses on the development and strengthening of national capacity through research and development (R & D) in the following areas:

- Infrastructure creation, maintenance and refurbishment
- Provision of cost effective technology based solutions for the building industry
- Devising innovative shelter delivery strategies and mechanisms
- Provision of technical information and advisory services on the built environment
- Training in the construction field

Building Technology Institute is made up of six core division comprising, Structural and Geo-Technical Engineering division; Building materials Division; Housing and Infrastructure Development Division; Design Systems Division ; Environmental Engineering Division and Roads and traffic Engineering Division.

Building Technology Institute's Skills And Expertise

In the Designing, testing and analysis of the building materials, buildings and structures, Building Technology Institute offers technology for testing

- Concrete and reinforced concrete structural elements and products
- Foundation soils
- Masonry building materials.

[4] Biotechnology, Food and Biomedical, Food Nutrition, Building, Informatics, Electronics, Energy, Metallurgy, Production, Environment & Remote Sensing, National Metrology, Business Operations

Building Technology Institute also offers skill in the following work areas;

- Designing and constructing timber, steel, concrete and reinforced concrete structures and buildings
- Researching and technically diagnosing buildings and structures in service (building pathology)
- Carrying out engineering – geological investigations i.e. soil investigations
- Reconstruction designing, structural analysis and methods of strengthening weakened elements (fault analysis and building maintenance)
- Designing and implementing integrated transport artery network planning and management for easy flow of transport.

In addition, Building Technology institute also offers expertise in the following fields;

- *The application of new structural solutions (technologies) and building materials in construction, e.g. walling, partitioning and ceiling panel boards*
- *Perspective utilization of indigenous, effective and low-cost building materials, e.g. rammed earth technology*
- *Utilisation of low–cost rural sanitation technologies appropriate for locally available building materials, e.g. Kalahari sands for blair toilets*
- *Developing technological basis for improving criteria and standards for evaluating, selecting and monitoring building materials*
- *The area of structural and / or foundation engineering (geotec), construction, civil and industrial application*
- *Carrying out detailed analysis and evaluations of new construction technologies before their adoption in the country, e.g. low-cost MCR roofing tiles*
- *Traffic and transportation planning and management for efficient freight/passenger transport; Wood and wood waste application, e.g. upgraded Marimba units, brickets and boards.*

BTI, aims at scientifically and technologically enhancing the construction industry.

BACKGROUND TO HOUSING CHALLENGE IN ZIMBABWE

Generally, urban centers in Africa experience massive rural to urban migration. Consequently the growth of the urban centers has been fastest in Africa recently. In Zimbabwe as depicted by the table that follows, urbanization has followed similar footsteps as those imprinted in other African cities. What this underscores is the growing demand and pressure on social facilities or amenities e.g. schools, clinics, urban infrastructure such as sewerage and water reticulation systems, pressure on housing demand for the high, medium and low density housing schemes. In the rural environments the majority of the houses are built of pole and dagga, poor workmanship, and their durability in the face of strong winds and bad weather such as cyclone Eline of 2000 becomes weak. It is for this reason that utilizing alternative tried and tested low cost materials that are affordable and easily accessible for the rural people becomes important.

"The government of Zimbabwe has an aim to build houses for all by the year 2000 (Goal Shelter by year 2000) [1]. The year is now 2004 and approximately 50% of the population in Zimbabwe now lives in Urban Areas. Inflation in August 2002 was now pegged at 200 %. Inflation in September 2003, is now pegged at 400%. Cement was priced at Z$15 (1991); Z$450 (2002); Z$9000 (June 2003); Z$30 000 (December 2003) and Z$40 000 (May 2004). The government aims to deliver 1,2 million housing units by the year 2008 in order to alleviate the housing backlog as pronounced by the housing delivery programme (2004-2008) approved by government in November 2003. The government aims at acquiring 310 406.6 hectares of peri-urban land to achieve the planned target [2]. Such a task is not only gigantic but also impresses on the need for stakeholder integration and participation. Research Centres such as SIRDC, ITDG, Universities can play instrumental roles in catalyzing the realization of such goals. Developing science and technology solutions to increase the rate of housing units delivery at affordable costs while not compromising urban quality housing units become key issues especially reduction in dependency on cement.

The Ministry of Local Government, Public Works and National Housing expect the local authorities to build 245 000 units per month to cut down housing waiting list. At the same time, the cost of building "modern" houses have skyrocketed. In as the addition to "modern" building materials based on "modern" European standards takes its tall. In 1990 Architect David Ismail, Zambia commented:- "Many countries in Africa have to import many of their building materials for the most basic house and due to the crippling foreign exchange problems these costs are enormous. Materials such as cement, glass, tin, roofing, plastic floor tiles or piping cannot be used in low cost housing. Environmental restraints exclude others like timber, as deforestation of great areas of the continent rules wood for either burning bricks or for structural purposes. This leaves earth and, to a lesser degree, grass, reed, lime and some small timber sections as the available construction materials."[3] Further back in the late 1980s Dr J Nyerere, Tanzanian President commented frustratedly:- "The widespread addiction to cement and tin roofs is a kind of mental paralysis." Again David Ismail, Zambia in his 1990 paper titled "Retention of the traditional values of Africa Earth Architecture" wrote: "The critical shortage of housing countries in Africa today. Severe economic restraints, coupled with unimaginative and ill-directed policies by developers have created hectares of sterile concrete block units unaffordable to the average worker."

THEORETICAL FRAMEWORK

It is important to define what a structure/building or house is if one has to gauge the importance of any low cost technology in assisting the resettlement and land reform programme in Zimbabwe. The biggest question to be answered before one tackles the issue of low cost, alternative building materials/structures is the definition of the end product a structure/facility or house/home.

There is more to a house than just shelter or enclosure i.e. protection from the wind, sun and rain. Issues not adequately addressed in Zimbabwe and the sub region have been for example, comfort/comfort zone refers to constant temperature and humidity; noise transmissions; energy consumption e.g. electricity, transport et cetera; usage versus design; environment and topography/landscaping. A structure/building/house / homestead is made up of components (elements), which can broadly be given as the foundation, walls and the roof. The forms and functions of these components are important in defining a low cost building/construction technologies/projects/programmes. Low cost, alternative environmentally friendly building materials and technologies should be adopted. The components can also safely be called construction sections mostly defined by rigidity/stiffness and resistance to any force from wind, sun and rain. Combining the two definitions makes it easy to assess building materials, products, structures and technologies for their suitability as low cost/alternative environmentally friendly options. A wide range of alternative/low cost building materials, products and technologies do exist in most developing countries these are:-

Table 1: Alternative Low Cost Building Materials Matrix in Zimbabwe

Material	Use/Product
Slags (Zisco)	**Tiles, Paving slabs, BFS Bricks, Boards, Extender**
Fibres/Pulp Waste	**Boards, Tiles (Ceiling & Partition Boards)**
Volcanic Waste	**Tiles, Slabs, Bricks**
Ferrochrome Slag (Zimasco)	**Concrete Aggregates, Firing Bricks, Pavers, Extenders, Boards (**
Gypsum	**Boards (Partition/Ceiling)**
Mine Waste	**Bricks/Slabs**
Earth	**SSB, CB, Rammed Earth**

Key: SSB – Stabilised Soil Bricks (Earth bricks)
CB – Compressed Earth Bricks

EXPERIMENTAL SET UP

The BTI of SIRDC had done a lot of research and development works on the 7 materials listed in table 1. The results of such work are only awaiting funding for a commercialisation process. For many products BTI in conjunction with SAZ has come up with Standards.

A perfect example is the building material Earth where Rammed Earth Technology has been released. The following has been done. The same holds for Micro-Concrete Roofing Tiles (MCR). The respective standards are Rammed *Earth (SAZS 764:200) and Micro-Concrete Roofing Tiles (SAZS: 863:2002)*. In terms of Rammed Earth Technology the following activities in a nutshell were done; Setting up of Standards (Dec, 2001); Designing of a tool kit (Jan, 2002); Setting up of training course for 10-20 people ; Purchase of tools and equipment and Costing i.e. Business Plan for commercial Successes recorded include the Construction of a Teacher's house, Rukanda, Mutoko/August 2003 funded by Department of Science and Technology (MCR roofed); Construction of Multi Purpose Hall, Insiza funded by Africa 2000 (UNDP) (September 2003); SIRDC house (1999); Training of 15 Youths in Mutoko, Mashonaland East and National Pilot Project - Initiated by Ministry of Science and Technology in Mutoko Mashonaland East.

ALTERNATIVE BUILDING SYSTEMS/TECHNOLOGY

A plethora of alternative building systems and technology exist worldwide. Various systems / technologies have been introduced or are known in Zimbabwe and other developing nations. However, in Zimbabwe technology introduction is faced with tripartite issues revolving on the absence of a systematic and coordinated approach in technology development, sustainability and management:

i. Acquisition of the technologies
ii. Introduction of the technologies
iii. Implementation of technologies

This being so despite the presence of such institutions and organisations such as Building Technology Institute of SIRDC; Intermediate Technology Development Group; Standards Association of Zimbabwe and interested groups such as the Housing People of Zimbabwe, The Zimbabwe Institute of Engineers et cetera. The table below highlights technologies available in Zimbabwe for use by the construction industry.

Table 2: Matrice of Low Cost Technologies in Zimbabwe

SYSTEM	COMPOSITION	DIS/ADVANTAGES
1. Frametech	Gypsum panel boards	Standards / Easy, fast construction
2. Frametech	Concrete / Wire Mesh (durawall)	Standards / Easy, fast construction
3. Frametech	Wood panels	Standards / Easy, fast construction
4. Wood Cabins	Wood planks / boards	Standards / Easy, fast construction
5. SSB / CB	Earth cement / Earth	Quality of product
6. SFB	Earth, Agric waste, (Saw Dust, Bagasse, cement, Pozzolana)	Quality / Easy, fast construction
7. Rammed Earth	Earth / Cement	Quality / Easy fast construction
8. MCR Tiles	Cement, Sand, BFS	Quality, Cheap
9. Earth Domes / Vaults	Earth Bricks	Quality, Climate Stability
10. Reinforced Earth	Grass, Bamboo, Wood, Earth	**Standards, Easy, fast construction**
11. Concrete Blocks	Cement, Sand, PFA	Quality / Easy, fast construction

Most of the systems are available in Zimbabwe, and some / most have been condemned because no pro or system is in place to:

- Implement the alternative low cost technology
- Test and evaluate the low cost alternative technology
- No standards are available locally on such an alternative low cost technology

LOW COST TECHNOLOGY DESIGN STANDARDS, PROBLEMS, CRITERIA?

It is vital to answers questions regarding who sets low cost technology design standards and problems or opportunities with such an approach. This clarifies whether the environment provides incentives for easy adoption of low cost technologies or tends to punish low cost technology entry into the construction and building industry. Who sets the standards for building/construction products, systems, and what role do housing co-operatives/house owner or seekers, building contractors and national science and technology institutions and local and central government organs have in the whole process?

Most stakeholders in house building/construction industry in Zimbabwe have a wait and see attitude, waiting for SAZ, Consumer Council, and the Ministry of Local Government, Public Works and national Housing and centres of research and development excellence to change the system to their advantage, and this is wrong. Most Local Authorities have existing laws (by-laws) but still do offer sufficient room to meet some goals and aims of housing co-operatives/building contractors and land developers albeit the process is rigid, cumbersome and difficult.

CHOICE OF LOW COST DESIGN TECHNOLOGY & PARAMETERS

Anchoring low cost buildings and structures requires a clear vision from the onset. Discrete parameters covering such elements as form, shape, type, design, orientation and style of the structure and building will have great impact on the total costs of a project. It therefore becomes critical to set out clear guidelines in delivering low cost structures and buildings for any area. Group design works of building/structure models development has been affected by problems. Specific design models not on the basis of low cost principles but typical "modern" design style or fashionability are fashionable.

Housing cooperatives/building contractors exhibit tendencies towards obsession with just accessing or constructing a structure/building irrespective of the economics and ergonometrics of the whole design and development process. Low cost as a parameter although considered in theory, in practice has limited scope for application under such circumstances. Clear parameters have to be set by choosing a particular low cost design for a large group of house seekers/land developer. Often the adopted design model is not based on a low-cost system but mainly on the typical "modern" design style. It is based purely on building/structure development for housing co-operatives/land developers and has not been based on the number of units to be built e.g. 2 rooms / toilet and number of members and contribution or amount of capital available to the project. Such an approach excludes considering low-cost construction/building materials, low-cost energy construction/building principles application and climate conformance and the thermal comfort of the structure/building

Consequently, Holm came up with 6 design strategies for houses/building construction. One, planning: rural and urban setting of structures/buildings is important. The layout plan form, position of functions, rain and wind protection aspects of designing are an important cost cutting or cost fuelling activity. Secondly, building envelope: thermal mass or roof, walls and floors; insulation, properties of materials. Thirdly, Solar Control: sun angles, equatorial window. Ventilation, Management: open and close windows and Systems: evaporative cooling mechanical, active complete the criteria list [4].

Most technologies can be combined to come up with a beautiful, comfortable, but low-cost house/building e.g. rammed earth with MCR tiles or even thatch. Emulation is made of house/building designs from Europe and America who have not only different climates but also different building materials. Building products are imported from Europe elsewhere whereas the same or similar products can be produced/acquired locally.

IMPLEMENTATION OF LOW-COST BUILDING TECHNOLOGIES

Challenges abound in implementing low cost building technologies in Zimbabwe. A series of questions need to be answered if low cost technologies positive impact is to be harvested. Can one then implement low-cost technologies in Zimbabwe, if so then how. The term low-cost has to be clearly defined. With the expansion of cities there are very few areas where low cost technologies can be successfully implemented. Some of the reasons are that Building/Construction companies rarely choose the sites for the construction of structures/buildings/houses; available planned land is allocated to them according to local authority master and local planning indications. Allocated space rarely comes with uniformity for all members but still costs of such stands remain the same. Allocated space and time taken for allocation is rarely used to adjust a design into low-cost design. All infills in cities are mostly problem areas either mashy, have high water table, black cotton soils, poor foundation soils. Good foundation soils are now mostly found on the outskirts of cities meaning longer distances to work places and amenities

More decisive planning is now demanded for housing co-operatives, land developers associations, property and estate developers, central and local government, building contractors and consultants *et cetera* to collaborate and partner together with professionals, research institutes, NGOs, etc. in order to guarantee land and building development. Research Institutes such as BTI, ITDG et cetera can offer services to homebuilders to enable them to implement low-cost housing schemes in terms of a wide range of aspects. Designing of housing/building plans according to existing low cost technologies and materials is one potential area. So too, is designing of construction phases / plans to execute the project according to the co-operative's savings or low cost technologies. Advice on choice of ground for building low cost buildings/structures as well as the supervision of implementation phase to ensure that the goal of low-cost is not lost along the way is also another area where technology can assist. Such institutes can also play a role in sourcing and mobilizing of funds through existing networks for the implementation of low cost technologies in the construction sectors

CONCLUSION

All alternative technologies are not necessarily new technologies, but recycled technologies and therefore need to be treated with caution and respect. *The late Mrs Indira Gandhi, Prime Minister of India said: "All the new houses are built for energy consumption. They are hot in summer and cold in winter, whereas our old houses are not. So we have not only to have new technology, but to look to the old technology. There is much sense in what people have evolved over the years to suit their climate, their environment, their way of living. You can not keep all of it, because our way of living has changed, but I think a lot of it can be adopted and made different."* Hassan Fathy "The father of contemporary Islamic Architecture" remarked on the cost of affordable housing: *"The cost of building present ugly town developments will drive us to build more beautiful homes in mud as this all we can afford."* The onus is on all of us to define or redefine, implement and improve on low-cost building/construction/housing appropriate technology to suit our needs e.g. the resettlement programme and national housing backlog challenge while at the same time being in harmony with the local climate.

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Construction of Advanced Solar Cooker and Solar Concentrator with Tracker System and Data Acquisition and Analysis

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Keywords: concentrator, cooker, heater, model

Abstract
An advanced solar box cooker and parabolic concentrator as well as a solar heating system are desig fabricated to determine optical parameters. A solar tracking device to enhance the performance of tl concentrator is also designed and constructed. A set of heat transfer rates and temperatures of the components with time are obtained and presented. Graphical representations are made for cooking time agai thickness and temperature against time of the day. The optical efficiencies of both the advanced box cooker parabolic concentrator were in the region of 76% and 86% respectively. The solar heater with double glaze used to boil five litres of water in less than one hour and a half. Also a simulation method is employed to component temperatures and heat transfer rates.

1. Introduction

Solar energy is the alternative source of energy to fossil fuels that are finite in nature. Nuclear fission and magnetic or inertial fusion are capital incentive and potentially hazardous to environment. The production of hydro-energy alone cannot satisfy the energy demand of land-locked country like Zimbabwe. The continual use of wood will lead to deforestation and its associated problems like siltation. Also the fact that the release of carbon dioxide is the main cause of the depletion of ozone layer.

Zimbabwe enjoys more than 300 days of sunshine with the annual irradiance of over 2450 W/m^2. Therefore, there is need to utilize this solar energy for domestic purposes to reduce the possibility of accelerating desertification and environmental degradation. This is the main reason this experimental investigation has been made to design and construct the solar advanced box cooker, parabolic solar cooker and solar water heater.

Das et al (1994) has presented a method for simulation of the solar box-cookers loaded with one, two, or four vessels. In Part I, they have presented mathematical models for these cookers. In Part II, they have studied the effect of parameters such as the thickness and size of the absorber plate, emissivity of the vessel, insulation thickness and cooking time. They have also obtained the heat transfer coefficients required for the simulation. The authors have pointed out that Grupp et al (1991) has presented a design on glazing vessel type solar box-cooker. This design, according to them, has improved the thermal contact, access to the vessel, and less frequent maintenance of the cooker.
Medved et al (1998) has designed a solar heater model which is shaped as an inflatable hemisphere. Their objective was to develop a mathematical and a numerical model to analyse solar radiation and heat transfer in

such a heater. They have used the numerical model for the parametric analyses to establish the time required to heat water for different meteorological data such as size of reflector, optical properties of transparent cover, reflector and absorber surface. Their investigation shows that the typical optical efficiency and heat transfer coefficient of the solar heater are between 0.45 to 0.5 and 0.6 to 1.6 W/m^2 K respectively.

Olwi et al (1988) have designed and constructed solar oven using a vapour tight pot and developed a mathematical model that uses lumped analysis. They have solved the resulting equations arising from the heat balance equations using the fourth-order Runge-Kutta method. According to their report, they have found that a considerable improvement has been made of the oven performance if the oven is airtight.

In this paper, a comparison of different experimental results obtained by different investigators and ourselves have been made to show the improvements that can be made.

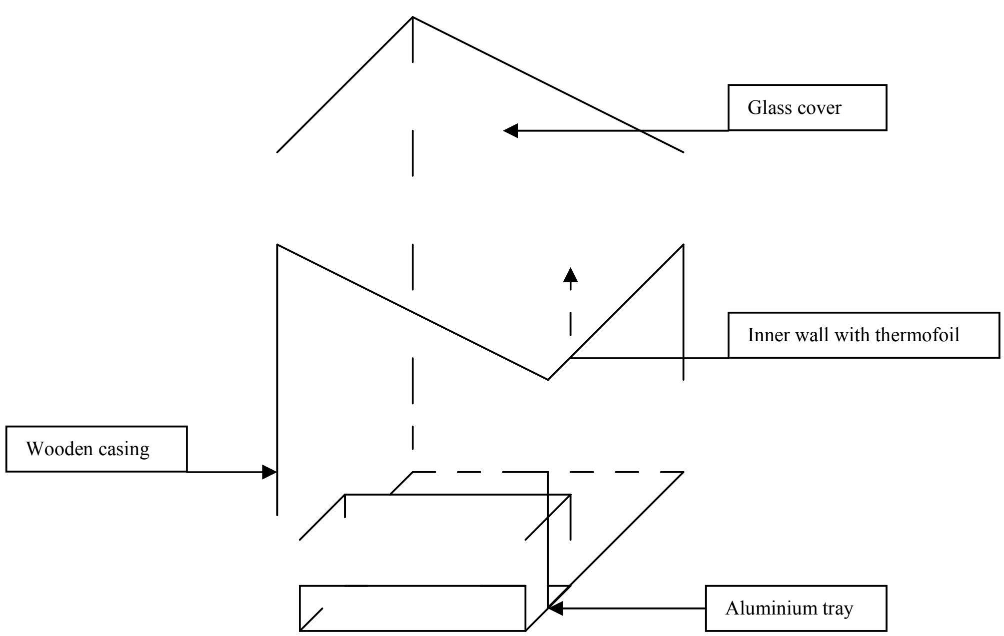
The paper is organized as follows. Section II gives the design and construction details of advanced box-cooker and parabolic concentrator with tracker system and heater. Section III presents the simulation model and theoretical results. Section IV presents experimental results and analysis of data and concludes the paper.

2. Design and Fabrication of Solar Cookers, Auto-Tracking Unit and Heater

Design of advanced solar box cooker, parabolic solar concentrator and heater are carefully done following specifications for absorber plate, cover, casing or enclosure, seals, insulation materials, orientation and location. For parabolic solar concentrator, reflector parameters, materials, optical parameters, fixing devices, pipes and connections and storage vessels have been selected in such a way as to satisfy design specifications.

2.1 Design and Fabrication of Advanced Solar Cooker

An aluminium sheet of thickness 3 mm was used to construct solar box cooker as shown in Figure 1. The sidewalls were aluminium welded together and inside wall of the tray was coated with bitumen black paint resulting in an aluminium tray of the dimensions 0.65 m $\times$ 45.6 m $\times$ 0.1 m.



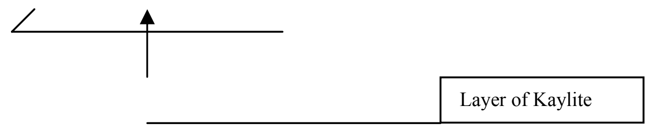


Figure 1: Schematic diagram of solar box cooker.

The casing for the solar box cooker was made out of wooden plank of 2 cm thickness after cutting into pieces and joining using super contact adhesive and wood nails. A glass sheet of thickness 3 mm and 79 cm $\times$ 52 cm hinged onto the casing was mounted as shown in Figure 1. A layer of 2.5 cm thick kaylite was used for insulating the all sides of the aluminium tray except the topside. The inner walls of the casing were covered with thermo-foil with ρ = 0.9.

2.2 Design and Fabrication of Parabolic Solar Concentrator

The parabolic solar concentrator was constructed using 1 mm thick aluminium sheet. The aluminium sheet was cut into sectors with rim radius of 0.5 m, perimeter of ~ 42 cm and 45^0. These were then riveted, as shown in Figure 2, onto an equal number of L-shaped aluminium bars. These bars were annealed and curved to fit a radius of curvature of 1.25 m. Each edge of a sector is riveted onto one half of another sector. The riveting of the sectors was done by clamping to the bar the pointed ends of the two different sectors and keeping that clamped at that position until riveting of all the sectors is complete. Also clamping of the wide ends at the top position is done so that each sector follows the curvature of the bar.

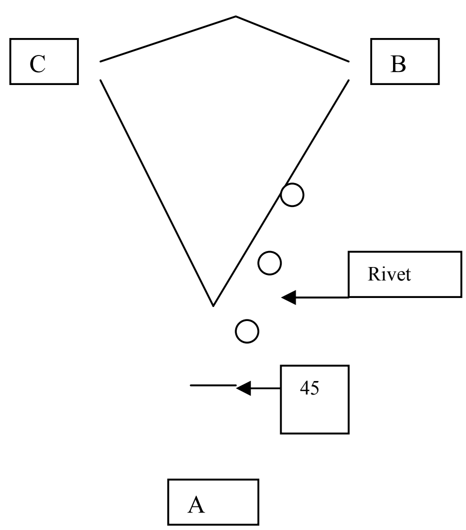


Figure 2: Schematic diagram for a sector of parabolic solar concentrator.

After all the sectors had been joined, a circular plate was then riveted at the bottom of the parabolic-shaped concentrator. A similar one was also riveted at the top so as to keep the sectors in position and maintain the curvature. The resultant shape was annealed and panel-bit into a parabolic shape. An iron rod was then put right round the back of the rim so as to prevent the collapsing due to stress.

Two axes, N-S and E-W and the mounting unit were then constructed as shown in Figure 2. The mounting unit was welded onto a cast steel bar. This was then welded onto a metallic plate to rest. Two rectangular iron tubes of equal size were cut and drilled holes a cm apart from one end. They were welded in the upright position onto each side of the E-W shaft and joined together by welding a rectangular plate on top of those tubes as shown in Figure 2.The parabolic unit was then joined to the mounting unit. A ring of 18 cm diameter was made and secured at a position with three rods. This ring was used to place a pot onto the position for cooking purposes.

2.3 Design and Construction of Tracker system

The parabolic concentrator's performance can be greatly enhanced if a correct solar tracking unit is used. This has well known advantages over fixed angle collector. Therefore, a single-axis tracking system was designed and constructed as shown in Figure 3.

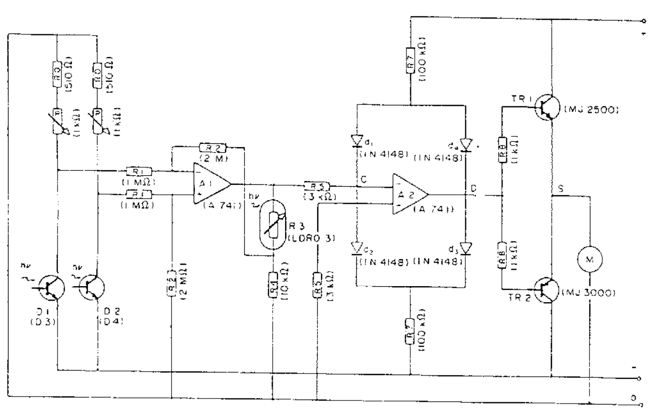


Figure 3: Auto-tracker circuit for parabolic solar concentrator.

The sensors D_1 and D_2 are phototransistors. Their outputs were fed into the primary differential amplifier A_1. The resistor R_3 is a light dependent resistor (LDR) fixed on the same plane as the sensors. As its value decreases when illuminated, the gain of this first step may vary between reasonable light illumination $G_0 = R_2 / R_1$ and low illumination $G = G_0 \; R_3 \; / \; R_4$. In this way, sensitivity of an amplifier is kept quite constant whatever the illumination is and thus the stability of the sun tracker is improved.

The error signal is injected in the A_2 amplifier. When the sun tracker is pointed at the sun, the error signal is balanced. The bridge is in equilibrium and the potentials at C and D become zero. R_7 and $R_{7'}$ determines the current such that diodes operate at the end of the logarithmic part of their characteristics. For a strong dc voltage output of A_1, A_2 amplifier sets up the current in the base of T_{R1} and T_{R2} transistors according to the polarity of the error signal and activates the motor in a suitable sense. When the tracker is not pointed at the sun, the error signals at the output A_1 increases the conduction in one of the two diodes of an arm of the bridge without any important change for the second one. However, for error signals lower than a fixed threshold V_s, this system acts in semi-logarithmic feedback fashion and A_2 is locked in equilibrium. Small fluctuations of error signals are not taken into account and this system provides a step-by-step displacement of the sun tracker.

3. Simulation Model and Theoretical Results

3.1 Simulation Model

A computer simulation model was designed and a program was written to calculate temperatures for the various components of the solar box cocker. The generated time and temperature values are then used to plot the temperatures. In programming the temperatures of the components were first initialised at the ambient temperature at the time the cooker is loaded. The model was set northwards for maximum illumination at the start up time. This was done following the equation given by Das et al (Part I, 1994) in part I of their two-part papers. The energy balance equations were decoupled to suit the Euler approximation method. The equations are then solved to obtain the component temperatures and heat transfer rates. Again, the initial temperature was used as ambient temperature. Transfer coefficients were given as that of Das et al (Part II, 1994). The temperature variations with time were then evaluated.

Temperature decrement or increment for each time step was added to the previous value for a period of 8 hours, i.e. from 8 00 hours to 16 00 hours. To gain insight of the working of the cooker, we require temperatures attained by the various components of the cookers as well as the heat exchange rates among the components with time.

For solar concentrator, computer simulation was done using 'LU' decomposition by Crank-Nicholson method (Curtis et al, 1997) in order to characterise the performance of the parabolic solar concentrator. A flow chart and Pascal programming language used to find the optical efficiency of the concentrator. The solution space for this problem was the vector space, [T], the temperature of the absorber plate, the reflector and the air surrounding the concentrator. Based on the computer simulation, modifications were carried out with a lot of bias on improving the reflectivity of the surface.

3.2 Assumptions

The following assumptions were made in determining the heat transfer rates and efficiencies using energy balance equation:

- the various components of the cooker are initially at the ambient temperature. Thereafter, they are at different temperature.
- heat conduction between the absorber plate and side plates and that between the vessel and vessel cover is negligible.
- there is no radiative transfer from the sidewalls onto the vessel cover since the height of the vessel is the same as that of the walls.
- the temperature of the absorber plate is the same throughout its surface area.
- irradiance falling onto the cooker components does so at normal incidence and so does the radiation reflected off the components.
- the absorption of radiation by the reflective surface, i.e. thermo-foil is negligible.

Theoretical results presented in the following sections are for ready reference.

3.3 Solar Box Cooker

The energy balance equations used for glass cover, air inside, vessel cover, vessel and contents, side plates and for the mean plate temperatures of the solar box cooker as shown in Figure 1 are considered to be the same as reported by Das et al (1994). These heat transfer rates and optical efficiencies are determined for the various times of a typical sunny day.

The energy output from a collector is given by the energy-mass flow relationship given as:

$$Q_c = mC_P(T_{abs} - T_{amb}) \tag{1}$$

where m = mass flow rate through the collector (kg/s).

The energy output is also given by Hottel-Whiller-Bliss (Twidell, 1995) equation as:

$$Q_c = A_c F_r S\tau\alpha - UA_c(T_{abs} - T_{amb}) \tag{2}$$

where,

A_c = collector surface area (m^2)

F_r = collector heat removal factor

U = collector heat loss coefficient (Wm^{-2}/K)

T_{abs} = collector average temperature

3.4 Parabolic Collector

The optical efficiency of the parabolic collector is given by

$$\eta = \rho\tau\gamma\alpha \tag{3}$$

The useful energy gained by absorber plate is given by:

$$Q_u = A_a S(\alpha\gamma\rho\tau) - UA_{abs}(T_{abs} - T_{amb}) \tag{4}$$

The transient heat transfer is given in terms of concentration ratio and optical efficiency as:

$$mcdT_{abs}/dt = CS\eta - U(T_{abs} - T_{amb}) \tag{5}$$

Overall efficiency of the collector is given by:

$$\eta = \eta_o - U(T_{abs} - T_{amb})/(C_e S) \quad (6)$$

Where,

$C_e =$ concentration ratio, i.e. (A_a / A_r)

A_a = surface area of the absorber

A_c = surface area of the reflector

3.5 Solar Radiation Calculation

Let the beam irradiance S_b is incident on the horizontal surface at zenith angle θ_z and the diffuse irradiance is S_d. The zenith angle is the angle between the incoming beam solar rays and the normal to the horizontal surface. The hemispherical irradiance S_h is obtained from the equation:

$$S_h = S_b \cos\theta_z + S_d \quad (7)$$

Since concentrating collectors accept only a negligible amount of diffuse radiation, the effective irradiance is

$$S_i = S_b \cos\theta \quad (8)$$

Where θ is the angle of the beam solar rays on the aperture of a concentrator.

Flat plate collectors accept radiation from the entire hemisphere and also receive radiation reflected by the ground. Being tilted the collector accepts a fraction of the diffuse sky radiation and fraction of the radiation reflected by the ground. Therefore,

$$S_i = (S_h - S_d)\cos\theta / \cos\theta_z + S_d(1+\cos\beta)/2 + S_h \rho_g (1-\cos\beta)/2 \quad (9)$$

ρ_g is the reflectivity of the ground and β is the coefficient of the volumetric expansion in (K^{-1}).

4.0 Experimental Results and Analysis of Data

The inlet and outlet pipes were legged to prevent heat losses between the collector and storage tank for the thermo-syphon collectors. One of the experiments was set up for the domestic water heating system and had four PT100 resistance temperature sensors to determine the temperature of water.

One thermo-syphon collector had mercury in glass thermometers as temperature sensors. Two thermometers measured the inlet and outlet temperatures to the flat plate collector. There were three other thermometers to measure the bottom, middle and top temperature in the storage tank. Both domestic water-heating systems used mercury in glass thermometers to determine ambient temperatures. For concentrating collectors two mercury in glass thermometers were used for each collector to measure the heated water temperature and ambient temperature.

To measure the intensity of radiation on the aperture for a collector a black and white pyranometer was mounted besides the collector. The sensor gave a milivolt output. At 1000 W/m^{-2} intensity, the sensor voltage was 15.95 mV and at zero intensity, the voltage was nil. The output is converted to intensity by using the relationship:

$$S_i = (mV/15.95) \times 100 \quad (10)$$

The cooker was loaded with full black iron pot of water at 0800 hours. The initial temperature and subsequent temperatures were then recorded in (^0C) at hourly intervals until 16000 were measured. The Table 1 shows the results. The thermal conductivity of aluminium pot was taken to be 211 $W/(m^2K)$ and that of the black iron pot was taken to be 77 $W/(m^2K)$.

The measured and calculated parameters of the solar concentrator are as follows:

Rim diameter = 1m

Depth of the concentrator = 0.12 m

Focal point = 0.49 m from the vertex along the optical axis

Top area of the absorber, A_{top} = 0.02 m ^{2}

Cylindrical area of the absorber, A_{cyl} = 0.04 m ^{2}

Aperture area of the reflector, A_{ap} = 0.79 m ^{2}

Mass of the absorber = 0.29 kg

Volume of water used = 350 ml

Area of the reflector = 0.84 m ^{2}

The characteristic length that varies with flow geometries are as follows:

$X_{top} = 0.04$ m $\qquad X_{cyl} = 0.04$ m

$X_{air} = 0.17$ m $\qquad X_{ref} = 0.23$ m

The calculated effective geometrical concentration ratio C_e was 9.29 and the acceptance angle was 19.15 ^{0}. The calculated concentration ratio was high. The calculation of focal point agreed well with the theoretical value computed that of half the radius of curvature. The overall heat transfer coefficient and efficiency as well as the heat transfer coefficients were determined for the solar concentrator as shown in Table 2.

The subscripts represent mode and surfaces involved in heat transfer. The heat transfer coefficients and view factors agree well with the ones obtained by Das et al (Part II, 1994). The view factor F_{n-m} is defined as the fraction of the radiation leaving a surface *n*, which is intercepted by surface *m*. It depends n the configuration and shape of the surfaces involved.

The overall heat transfer coefficient, *U* and temperatures such as T_{abs}, T_{air} and T_{ref} are calculated using the theoretical model of Incropera et al (1981). Radiation and convection coefficients values required for the equations are obtained using measured temperature on a particular day taken over 4 minutes interval of time as shown in Table 3. In the analysis for the absorber, the top and bottom surfaces are taken to have the same surface areas. Also T_{cyl}, T_{top} and T_{bottom} are taken to be equal to T_{abs}. Therefore, by solving the system of equations the following values are obtained:

$U = (0.75 \pm 0.03) Wm^{-2} K^{-1}$ $\quad$ $T_{abs} = 651.17K$

$T_{air} = 316.73$ $\quad$ $T_{ref} = 316.31K$

The theoretical model predicts much higher temperatures for the design parameters of parabolic concentrator than the experimental values.

For calculation of optical efficiency for the parabolic concentrator, the values for the absorber's absorptance and reflector's reflectance used are 0.95 and 0.9 respectively. The absorptance at the cylindrical surface have been taken to be maximum- a condition that can only be satisfied if the incident rays strike its surface normally.

$$\eta_o = 0.86 \pm 0.02 Wm^{-2} K^{-1}$$

The optical efficiency is high compared with that obtained by Medved et al (1999) for the hemispherical solar water heater.

The overall efficiency of the concentrator are not determined because of the lack of solarimeter and a flexible solar cell to measure irradiance required for the calculation.

4.1 Thermo-Syphon Collector and Water Heater

The thermo-syphon collector was loaded with 10 *l* of water. The readings of the water temperature were taken every thirty minutes. For determining the mass flow rate the tank was disconnected and two containers were used, one as the driving head and the other as the collecting can for the heated water. The readings of the inlet and outlet temperatures to the tank were taken in every ten minutes interval. The Australian design (1995) of the thermo-syphon collector was loaded with 50 *l* of water. The readings were taken in every thirty minutes interval. For our design and Australian design of thermo-syphon collectors, the collectors were tilted by an angle of 20^0 to the horizontal for maximum heat collection because more heat is collected when the collectors are tilted at the location's latitude. The top glass cover was cleaned carefully to remove dust, which would otherwise have absorbed and scattered radiation.

The storage tank for the design of the domestic water heater was made using two buckets that were of the same size. The smaller bucket was put inside the larger bucket. The two buckets were separated by kaylite paper that provided the insulation to reduce losses. The mass flow-rate was determined using flow meter indirectly. The Australian design (1995) was different in that the tank was made out of asbestos. The Australian design assumed 10% loss of energy output. It was also assumed that the tank heat loss coefficient is constant. In our design, heat loss coefficient was taken realistically to be a variable quantity. The heat loss coefficient was the highest for the flat plate collector and the lowest for the box collector. Wrapping the absorber for the solar concentrator in a transparent plastic bag reduced the collector loss coefficient by creating a miniature green house.

4.2 Cooking Time

The cooking time is different for every material to be cooked and depends on the temperature history of cooking. The physical and chemical changes that take place while cooking do not require significant energy. Experience with solar cookers indicates that we may consider the cooking time to be the time taken to attain boiling point. This is about 96^0C in Bulawayo, Zimbabwe. The time required for cooking rice in a small 1.0 mm thick iron pot using solar concentrator was 20 minutes. This, we believe, is satisfactory when compared with the conventional methods used.

4.3 Conclusion

Satisfactory results for overall heat transfer coefficients and optical efficiency have been obtained with the current design for advanced box cooker, parabolic solar concentrator with auto-tracker system and flat-plate collector and solar water heater. The calculated values of heat transfer coefficients obtained using the energy balance equations agree well with what are given by Das et al (Part II, 1994). Two computer simulation models designed to calculate the temperature components for solar box-cooker and to solve diffusion equation applying Crank-Nicolson method (Courtis et al, 1997) gave satisfactory results. The results compare favourably well with the Australian and Kenyan designs (1995).

Increasing the insulation thickness for solar box-cooker can make improvements. To reduce the loss to the surroundings, honeycomb covers are recommended and using selective absorbers. There is a need to improve the performance of the auto-tracker system used for parabolic solar concentrator. Investigation was also done to determine the effect of temperatures with increasing thickness of an iron pot. It was observed that the temperatures decreased with an increase in plate thickness. This was due to the heat capacity of the absorber plate and consequent decrease in radiative and convective heat transfer. But the heat transfer due to conduction increased.

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Nomenclature

a = air; aperture; *amb* = ambient; A = surface area; crosssectional area; A_c = collector area
C = convection; cover; collector; conduction; C_p = specific heat capacity
g = glass; E = energy
h = convective heat transfer coefficient; h_{rad} = radiative transfer coefficient
I = intensity; i = insulation
K = thermal conductivity; extinction coefficient; m = mass
r = radiative; radiation; absorber radius; *rs* = reflective surface
S = irradiance; *sp* = side plate; s_l = side/back loss
T = temperature; t = time; T_i = temperature of surface I
Q = rate of heat flow; P = plate; dT/dx = temperature gradient
x = thickness; v = vessel and its contents; v_c = vessel cover
U = heat transfer coefficient; u = useful; v = wind velocity
ρ = reflectivity; τ = transmitivity; α = absorptivity
σ = Stefan- Boltzmann constant; ε = effective emissivity; emissivity; θ_a = acceptance angle
η = efficiency; η_o = optical efficiency

Table I: Temperature components for a loaded solar cooker at different times of day.

Time/Components	0800	0900	1000	1100	1200	1300	1400	1500	1600
T_{amb}	20	21	22	24	26	27	28	30	28
T_a	20	23	27	34	37	42	47	50	45
T_g	20	22	24	29	33	37	43	37	33
T_{vc}	20	24	30	37	51	55	59	50	42
T_v	20	23	38	45	66	80	86	84	78
T_p	20	25	36	42	60	64	70	61	57
T_{sp}	20	24	31	40	56	62	64	53	48
S	7.9	15.5	21.9	26.9	34.6	27.5	24.7	19.8	13.2

Table II: Calculated heat transfer coefficients of the solar concentrator.

Convection heat transfer coefficients $(Wm^{-2}K^{-1})$	Radiation heat transfer coefficients $(Wm^{-2}K^{-1})$	View factors
$h_{c,top-air} = 7.78$	$h_{r,cyl-ref} = 0.62$	$F_{top-ref} = 0.18$
$h_{c,air-top} = 2.11$	$h_{r,ref-cyl} = 0.03$	$F_{cyl-ref} = 0.08$
$h_{c,ref-air} = 3.27$	$h_{r,top-ref} = 1.36$	$F_{ref-top} = 0.004$
$h_{c,air-ref} = 1.64$	$h_{r,ref-top} = 0.03$	$F_{ref-cyl} = 0.004$
$h_{c,cyl-air} = 7.90$	$h_{r,ref-a} = 0.296$	$F_{ref-air} = 1$
$h_{c,ref-a} = 3.27$		$F_{air-ref} = 0.32$
$h_{c,air-a} = 3.57$		$F_{ref-a} = 1$
$h_{c,air-cyl} = 2.05$		

Table III: Observed temperature components for different times of day on a particular day.

$T_w(^0C)$	$T_{air}(^0C)$	$T_{ref}(^0C)$	$T_a(^0C)$	Time of day
19	18.5	19.5	18	0920
50	23	23	20	0924
67	27.5	27	20	0928
80	27.5	27	20	0932
85	28.5	28	21	0936

TRANSPORTATION AND ITS STRATEGIC CONTRIBUTION TO LAND REFORM IN ZIMBABWE

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Abstract

This paper seeks to discuss transportation in Zimbabwe from the point of view of appropriate technology and its contribution to land reform. Transport services any economic activity in any country and brings together the four factors of production , that is land, labour, capital and entrepreneurship. Transport in Zimbabwe has generally been declining in terms of efficiency and there are many factors contributing to this scenario. These are the factors that this paper sets out to investigate and highlight and then to suggest recommendations on the way forward. Transport is the arteries and veins of any national economy and therefore needs to be well looked after if any country desires to succeed in farming and other economic sectors and compete effectively on international markets. That is the main reason why this paper set out to research on that strategic issue. Transport is an economic, social and state security issue.

1.0 Introduction

- This paper seeks to discuss transportation from the point of view of Zimbabwe and third world countries, which are landlocked.
- Transportation and its effect and contribution to business and society in general.
- Transport brings together the four basic factors of production, that is land, labour, capital and entrepreneurship/enterprise.
- Physical mobility and its effiency as a basic determinant of corporate and national efficiency, success, world class competitiveness, business goodwill and credibility, access to high yielding and lucrative markets, opening up of new and distant markets [1].
- A sophisticated transport network and how it enabled the British to conquer and rule three quarters of the whole world thus giving birth to Great Britain.
- American economic and military supremacy brainpower and its most sophisticated and largest diverse transport network (i.e. road, rail, sea and air transport network.)

2.0 Transport and Land Reform

- The success of land reform and availability of adequate tractors, combine harvests, lorries and other capital equipment that drives.
- Transport as a critical success factor for land reform
- Private sector and donor support
- The anti- Zimbabwe campaign.
- A strong transport network to provide administrative, security and specialist support e.g. AREX, Department of Veterinary Services, the Police, the Army and State Security agents
- Provide logistical support to the farmer to offload his final product onto the desired market segment timeously
- Invoicing/billing of the customer takes place on delivery
- Invoicing versus payment of operating expenses, loan obligations, reduce/eliminate bank overdrafts

- Invest any surpluses in lucrative financial securities or property, infrastructure or capital capacity
- Prudent settlement of obligations creates goodwill with bank managers and other financial providers
- Customers, bankers and creditors as trade references
- Goodwill creation [2]
- Efficient and reliable suppliers with state of the art reliable delivery vehicles
- Condition of road network and skilled technicians servicing this fleet – this is a reality in the transport business
- A sophisticated road, rail, air and sea transport network that is efficient and cost effective

3.0 Rail Transport

- Moves most of the inputs and outputs to and from our vast mining, industrial and agricultural sectors
- Perennial shortage of coal and a critical shortage of foreign currency to purchase spares and other input supplies
- Vandalism of railway copper cables for the signals communications systems
- Dealing with offenders
- Symptoms of genuine underlying causes[3].

To sum up problems faced by the railways in Zimbabwe these are:

- *A shortage of foreign exchange to buy new locomotives, plant, equipment and other input supplies*
- *The grounding of a lot of rolling stock with a negative ripple effect on railway customers and railway revenues*
- *A shortage of diesel fuel which is slowly stabilizing with the introduction of more players in the oil industry*
- *Gold panners and the dangers they cause to railway operations especially in Kwekwe, have badly damaged the railway line such that its now very risky for the trains to move there due to serious underground gold panning activities which have made the surface very unsteady and porous*
- *A shortage of coal to fire railway steam engines*
- *A high degree of dishonest and theft/looting of commercial cargo by NRZ employees – refer to cases recently confirmed by NRZ general manager to the Herald; cases of whole wagons worth Z$360million being stolen, diverted and offloaded by NRZ employees*
- *System reliability and credibility - how can people send their commercial cargo by NRZ with this kind of risk?*
- *Downstream production disruptions as the effects of the thefts take their toll on downstream industries*
- *Increases costs and fuels inflation besides making the affected firms uncompetitive and creating job losses*
- *Frustrated firms may (where possible) blacklist the railways and opt for road transport, which is readily available in this country*

4.0 Air Transport

- Air transport mainly services the the busy business executive and the horticultural industry (of course and other industries) whose highly profitable final product is sold on international markets
- Speedy delivery, efficiency, reliability and conveniency are the chief competitive factors

The main problems facing this sector are: -

- Most airlines have deserted Zimbabwe and this has affected industry, commerce and tourism
- Foreign airlines charge for cargo and air tickets in foreign currency, which is not readily available, and end up getting very few customers and becoming uncompetitive
- The local flag carrier, Air Zimbabwe, has a dwindling fleet, which has fallen from 15 to 5 aircraft
- This compromises and reduces its capacity to service local industry and business community
- Delivery lead-time for the local business community becomes too long thus reducing competitiveness, profits and goodwill
- Air Zimbabwe is currently unable to build its fleet of aircraft by buying new aircraft. The foreign exchange to do this is just not there
- Its competitors are flexing their muscles with skies awash with state of the art aircraft e.g. South African Airways, which has captured Africa by storm
- People prefer using new, reliable and predictable airlines
- Most of our airports cannot land large aircraft like Boeing 747 jets
- Some of these airports are now being upgraded to enable them to be able to court Boeing 747 jets
- Meantime we are loosing business to our proactive neighbours and international competitors
- Negative media reports and sanctions have badly damaged local businesses and the local economy, especially tourists, investors and donors.

5.0 Transport & Multimodal Transport

The Zimbabwean fleet of trucks is reasonably large but comprises second hand big trucks bought mainly from the USA and the UK. Although this fleet is doing a good job, obviously it cannot have the same efficiency levels as that of brand new trucks used in other countries e.g. in South Africa and Botswana[4]. That handicap has a negative multiplier effect on local business.

The brief status and analysis of the Zimbabwe road transport sector's successes and failures are as follows: -

- an aging fleet that now requires replacement
- dwindling cargo volumes as a result of the general decline in economic activity in the country
- cut throat competition between road and rail transport as a result of 5.2 above
- difficulties in planning long term due to the hyper inflationary environment combined with a grinding recession and drought
- the absence of adequate foreign exchange reserves to meet national import requirements
- inability by local transport employees to speak common regional business languages i.e. Swahili, French, Portuguese
- in Angola and Mozambique they speak Portuguese while in the DRC the common business medium of communication is French
- Local university business degree programs must address this problem

- Zimbabwe is a landlocked country and is serviced by the Port of Durban and Beira and to a lesser extent Port Elizabeth, East London and Cape Town
- Indirect access to the sea is a disadvantage as that denies us enjoyment and having maritime industries and a naval defence force
- It is also a major competitive disadvantage as it is very difficult to compete on price and delivery lead times with countries like South Africa.

6.0 The Way Forward

If Government is really serious about revamping the transport sector to support the land reform exercise for the benefit of the generality of the Zimbabwean populace then the following issues need to be addressed urgently:-

- Customs duty on new vehicles, vehicle kits, spares and consumables must be zero rated until the transport fleet in this country has stabilized and a crisis situation is over[5]
- This concession could be restricted to commercial and transport vehicles only to protect local car assembling plants
- **At the moment more than 70% of public transport vehicles are down due to shortage of spares**

6.1 Most third world countries are not offering degree programmes in Automotive Engineering, Railway Engineering, Aerospace Engineering Transport and Logistics Management, International Purchasing and Shipping and Forwarding

6.2 Some local universities engage in cut throat competition recycling the same degree

6.3 Chinhoyi University of Technology has moved in to partly solve this by breaking new ground and introducing unique, stand alone degree programmes that address skills deficiencies in the nation

Since Zimbabwe is a landlocked country when selling or buying to/from international markets it has to use multinational transport systems.

The biggest problems with multimodal transport systems are:

- Higher insurance costs.
- A higher risk to pilferage and theft.
- Goods may go bad in transit.
- Goods getting damaged in transit as they transit in changing modes of transport.
- There may be heavy hidden costs which make it very difficult to pre-cost multimodal consignments
- The need to use extra strong packaging which can withstand the rigours of the long journey in terms of sunshine, rain and thunder, mist and very cold weather
- Some transit countries may be politically unstable which may expose the cargo.
- There is a need for serious and thorough political and economic risk analysis for all transit countries as well as the final destination for the cargo.
- Mutimodal transport operators tend to engage in serious profiteering.
- In South Africa cargo risks being high jacked like what happened to the Zimplats truckload worth US$2 million.
- Negative country of origin effect affects the cargo in its
- There is a need to include relevant foreign languages in local degree programmes

- The European Union succeeded because all major common languages are taught in University degrees in all the member countries
- The course transport economics must be taught in all diplomas/degrees in agriculture and related areas
- 3rd world countries are failing to modernize their fleets as the bulk of their forex earnings are being channeled towards debt servicing at the expense of upgrading standards of living at home.
- The long term solution to this is to vigorously fight for debt cancellation at most international fora.
- The African continent owes the first world more than US$300 billion in debt
- But the truth is that there is an invisible hand siphoning wealth and money from Africa by force
- Until these economic monsters and parasites are tamed and restrained we will continue to suffer and can never truly modernize our transport system to superior levels found in the first world.
- **The debt burden dates back to the days of colonisation and must be written off once and for all.**
- **No lasting and meaningful development in transport and other sectors can ever take place with this kind of debt unresolved.**
- **In Africa the general pattern is for standards of living to be falling at a very fast rate as each year passes – why?**
- **The deep secret, which is the cause for this poverty trap, is the monstrous debt burden of $^{+}$US$300 billion, which has a long history right up to colonization. It was forced on African countries.**
- **A diplomatic war of words by Africans is necessary to at least reduce the unbearable debt burden through voluntary debt cancellation by the international community[6].**
- Successful transportation in cities and towns in the first world is done by governments and not private companies
- Poor servicing of farmers results in farm produce going bad with heavy losses for farmers.
- Government must build, service and maintain roads leading to all farming areas and fully support farmers
- The road, rail and air network and infrastructure must be maintained and upgraded.
- The potential in agriculture is huge and could provide a permanent economic, social and political solution for the country's populace.
- There is need for government to step up the fight against many underhand deals in the transportation sector (especially where cross border cargo is involved) which are disrupting and destroying the economy
- These include the following: - under invoicing, transfer pricing, failing to remit export proceeds, smuggling, underpaying and non payment of customs duties, use of wrong product tariffs to evade or pay less duty

A vigorous public relations campaign at national level is necessary to retain and create new friends.

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ENHANCING MOBILITY & ACCESSIBILITY IN THE LAND REFORM PROGRAMME IN ZIMBABWE

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Key words: mobility, accessibility, low cost, appropriate technology

Abstract

The paper is based on Zimbabwe's transport and poverty study. Main study findings are that intermediate modes of transport, local level transport solutions for example labour & animal based technology offer great scope in enhancing mobility and accessibility in resettlement areas. Appropriate low cost transportation technology travells greater mileage compared to high-technology transport and road engineering prescriptions. Exploring scope for scaling up production of low cost transport technology need factoring. Building capacity of locals in appropriate transportation technology construction, maintenance and repair works remains a challenge. Peri-urban areas acquired for urban expansion justify the case for appropriate mass, non-motorised, design and information transportation models. Research and Development works and re-engineering transportation institutions and systems is equally important. Field audits and observations of transport and roads engineering projects, programmes and activities formed the backbone of experimentation. The concept of Integrated Rural Accessibility Planning is an alternative approach to restructure and fabricate resettlement environments. The paper calibrates key highlights of an appropriate resettlement transportation agenda indicating gaps requiring sealing. It is capped by a roadmap appropriate transportation agenda with broad parameters of matrices being marked. The presentation is a barometer in implementing an appropriate resettlement transportation model in Zimbabwe.

INTRODUCTION

Agriculture is a widely acknowledged cornerstone of economic development in Zimbabwe. Over 80% of the population lives in the communal areas and, their lives revolves around agriculture [1]. Colonial transportation infrastructure was skewed towards the white settled commercial areas and urban areas at the expense of the rural and communal areas. Post independent Zimbabwe has attempted to redress the anomalies with varying levels of success through programmes such as ;

- Rural Service and Growth Centre Policy
- Transportation Rehabilitation of feeder roads and
- Resettlement of landless people.

THEORETICAL FRAMEWORK

Defining Mobility And Accessibility

It is imperative at the outset to define the terms of "mobility" and "accessibility" in transportation. Mobility is succinctly defined as a "measure of agency with which people choose to move themselves or their goods around".[2] Mobility involves two components. Firstly, mobility depends on the performance of the transport

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system. Secondly, it is concerned with the characteristics of the individual in terms of whether s/he has a means of transport or s/he is liquid enough to afford public/private transport, or s/he is capable of transporting him/herself, that is able to walk. Accessibility incorporates mobility as well as physical proximity. Accessibility depends on spatial distribution of services/facilities and available and affordable means of transportation. Greater mobility and/or improved proximity can enhance accessibility. Travel is minimised by appropriate distribution of facilities that is enhancing access.

The paper calibrates mobility and access issues in the resettlement agenda in Zimbabwe. Entry points and an improvement nodes checklist is displayed. Any meaningful discussion and evaluation of the transportation resettlement and rural areas challenge requires a review of the development of the rural and farming communities in Zimbabwe.

EXPERIMENTAL SET UP

Transport audits, field observations and studies were conducted of both a qualitative and quantitative nature. Case studies of Zaka, Rushinga and Mberengwa were used as anchor sample study control units. In addition, key informants as well as secondary documents on the transportation condition in Zimbabwe were also consulted. Data was analysed making use of software run on computer before being distilled to the existing pool of information outcome.

RESULTS AND DISCUSSION

Rural Travel and the Poor

The transport problems experienced are not very different from those obtaining in resettlement areas. Some of the findings of the Rural travel patterns study included inter alia:

Most trips undertaken, (approximately 86%) were short and within the vicinity of the village. Women carried a considerable high proportion of the burden (approximately 80%) and predominantly of foot [3]. Majority of trips made were to fulfill basic needs. Travel time was excessively long despite the short distance traveled. The use of intermediate modes of transport was generally found to be lower than the level of ownership indicative of a higher breakdown frequency. Public transport was mainly used on long distance travel for trips to hospital, commercial centres, sourcing farm inputs and crop marketing. In general, the availability of conventional transport e.g. road infrastructure and services appeared not to be an important explanatory variable to determine travel and transport patterns. Instead access to services was found to be a better explanatory variable.

The bulk of rural trips and travel includes short distances but are imperative trips such as going to fetch firewood, collect water etc. The majority of the load is borne by women and the girl child indicating the gender aspect to the rural transportation and travel burden. Using intermediate modes such as scorch carts, bicycles and wheelbarrows can alleviate the plight of rural and resettlement farmers. However, the problem with the modes is that they are slow and the wheelbarrow places the bulk of the burden on the user given the fulcrum concept. Intermediate modes of transport enhance mobility and accessibility of rural facilities and activities than any other transport alternative.

Appropriate Siting of Services within Rural Areas

One of the most critical observations is that facilities in rural areas are discretely sited. This defeats combining trips during one journey and encourages double or split, circuitous trips increasing the travel burden and time spent on travelling and walking instead of producing and working in the farms. It is difficult for example for a child/person in a rural area to combine a trip to dip cattle at the dip tank with a visit to the clinic and an errand to mill maize meal. Adopting the Integrated Rural Accessibility Tool in planning is one possible way of resolving this challenge. Is it always necessary for a grinding mill to be located at a business centre? Do the type of foodstuff or goods sold in rural areas always require a location at the business centre where access to electricity is maybe guaranteed? A case for re-looking at physical planning standards with a view to relaxing them so that they enhance mobility and accessibility of services and facilities beckons. Other rural dwellers have adopted transportation strategies where they pool resources and send one person either on a bicycle, scortchart to do bulk buying to avoid problems caused by poor siting of facilities. This also affects the use levels of the services and facilities.

Local Level Transport Solutions

Sometimes, solutions required for local level travel, which exists in resettlement areas is improvement of existing tracklines/cutlines than new road constructions. These normally follow desire lines and improving the grade or profile without necessarily constructing a standard gravel road is what may be feasible. Also building low cost bridges to facilitate connectivity of areas is also crucial. This can be done with locally available materials such as strong trees in the area. These are areas requiring strengthening. It is therefore argued that the improvement of footpaths, tracks, and river crossing may be appropriate and beneficial interventions.

One commentator has observed that transportation interventions in rural areas *"seem targeted towards sustaining the life of poor people and not improving them".* Another closely related challenge to the transportation problem in rural and resettlement areas is deforestation. How do we handle deforestation? The more trees are removed the greater the need to travel to far off woodlands and the more the transport burden on women, girl-child and children. Alternatively a need for subsidies to facilitate the buying of IMT by rural dwellers is born. This may also entail the need to build a local capacity to repair and even manufacture such IMTs in the rural and resettlement neighbourhoods. This would entail the creation of locally sustainable appropriate transportation technologies for rural villagers and resettlement schemes. The Road Fund has no provision for dealing, handling and accommodating transportation needs of roads below the tertiary roads.

Labour-Based Transport Technology

This is important in empowering locals and encouraging sense of ownership as well as sustainability of the road network. This is crucial to keep the communication and movement supply lines open. With adequate supervision, standards that are achieved through utilising modern machinery and technology are also attained. This is in addition to benefits of saving foreign currency that is in short supply to import the front-end loader, tipper, grader et cetera. This also saves on the recurrent maintenance costs since the spare parts are also a reflection on the import bill, as they are not manufactured locally. Knowledge and skills transfer ensure that communities can maintain and repair their roads on their own with little or no outside assistance. The amount of money paid to the communities though small also plays a part in poverty alleviation.

Low Cost Footbridge Construction And Animal Based Transport Technology

These are important to facilitate movement of people from interior remote areas of rural and resettlement areas to main route corridors as raw materials and products are traded. It is also crucial in ensuring that clinics and schools are at least all weather accessible. Animal based technology has greater scope in industrial and agricultural growth than traditional high-technology orthodox transport engineering solutions.

Beasts of burden such as donkeys can come in handy especially in difficult terrain such as Zaka area. A donkey can carry up to 100kg of cargo, which is reasonable for rural travel transportation load transfer needs. However, the problem is that donkeys do not want to cross a river. That entails that there is need to construct bridges. In Uganda studies have indicated that empowering locals with donkeys and cows has impacted positively in terms of movement and transportation rather than constructing the conventional roads and introducing the bus service. The majority of rural trips and demands are suited for the animal based technology. Animal powered transport is a cheap and appropriate non-pollutive and non-fuel consumptive mode. It is also environmentally friendly and can penetrate the rural areas better than the conventional transport.

Scaling Up Local Level Transport Technology

The need to scale up mass production and maintenance centres or rural workshops and industries to manufacture, assemble, repair, maintain and sustain intermediate modes of rural and resettlement transport modes/technology is fundamental. The factories will reduce costs of maintenance and repair of IMT modes. Huge savings in this regard increase profits levels for rural and resettlement farmers. *C*apacity building of locals in appropriate transportation technology maintenance and repairs works is vital.

Scope for Other Transport Modes Such As Motorcycles With Side Cars *Et Cetera*

Movement on the resettlement farms and beyond will require efficient transport networks as well as appropriate transport modes. The most logical approach is to utilise existing farm road infrastructure with a view to upgrading it as resources become more available over time.

However, it is important early enough to develop traffic and transportation master plans that the centres will grow into rather than leave the activity to chance. A resettlement traffic and transportation land use comprehensive plans is therefore crucial if transport planners and engineers are not to be reactive in years to come.

Given the fact that transport modes such as tractors, combine harvesters et cetera are a reflection on foreign currency, developing science and technology to substitute the need for importing such gadgets becomes critical. Even developing local capacity to produce/manufacture spares parts locally is fertile ground. At the same time utilising alternative transport modes that can meet resettlement farmers needs and entailing lower foreign currency demands is also important. Using for example off-farm motorcycles, countryside motorcycles that are able to move in the rural and resettlement ungraded roads/tracks is a viable alternative. The other advantage is the engine fuel efficiency of such where a litre can cover between 25-70 km distance. Motorcycles with a side car can be handy for a resettlement ambulance service. Utilising same in urban areas would save foreign currency to import fuel, liberating more funds for plowing into the land resettlement programme.

Capacity Building

An underlining transportation theme throughout transport environment review is the building of transportation capacity in rural and urban areas. This could be in terms of utilizing labour based cheap and locally available resources and methodologies in road rehabilitation or opening. This could also be in transportation technology transfer for RDCs and UCs plus government officials on how best to use labour based technologies as compared to high-technology. Staff turnover and changes in transportation technology and the dynamism of all professions require an in-house capacity building programme to avoid the unfortunate risk of employees becoming museums.

Peri-Urban Transportation Technology Mosaic

Peri-urban areas were annexed for urban expansion as part of the resettlement programme. At the same time produce from resettlement areas are shipped for processing and marketing in urban areas. Ensuring that the urban engines of transport movement are well oiled is important for raw material value addition. The mobility in urban areas versus resettlement and peri-urban areas is complementary and simultaneous improvement of the transportation functionality is important if the full benefits of the synergies are to be harvested. This entails developing pilot projects and models in areas such as , Appropriate mass transportation models ; Appropriate non-motorised transportation models; Appropriate design transportation models; Appropriate information transportation technology models anchoring any initiatives; Fast tracking and re-engineering transportation technology agenda in

Zimbabwe and Fabricating and re-engineering of transportation institutions and systems to comply with the appropriate transportation technology agenda.

Transport And Resettlement Model In Zimbabwe

Figure 1 indicates a transport and resettlement technology model consequent to the article. If adopted and utilized it is submitted that positive transport intervention and implementation will be realized. The ultimate outcome would be an appropriate transportation technology for resettlement in Zimbabwe.

The model underscores the importance of collaboration and partnership; synergies being weaved in the resettlement and transportation challenge. Relationships crosscut while ordering and patterning is not indicative of flow, linkages and relationships in the resettlement and transportation context. Processes are dynamic and complex. Sectors are wedge formed. Divisions between wedges are transitional and not arbitrary. The multiplicity of sector reorientation required as a precondition for the transport environment to address transport and resettlement emphasizes the complexity and vibrancy of the transportation field. Indicated compartments are artificial and are not boundaries to communication. Informed dialogue is the order of the day.

There is need for transport and resettlement research funding budget to address various transport and resettlement challenges in Zimbabwe. The fact that there is no specific NGO in Zimbabwe championing specifically transport and resettlement points to the low priority being regarded the issue although evidence from the ground suggests that the reverse is true. A transport and resettlement pregnant research agenda exist. Budgeting and funding for R & D leads to the development of resettlement transport programmes, projects, systems, institutions and processes in Zimbabwe. Research Institutions such as SIRDC, NUST, UZ, ITDG could champion research themes in light of funding availability.

CONCLUSION

This paper has calibrated major elements constituting an appropriate transportation agenda in Zimbabwe through indicating gaps in appropriate transportation technology. In conclusion a roadmap on appropriate transportation technology agenda for Zimbabwe in particular is advanced and provided inclusive of broad parameters defining the matrices of appropriate transportation technology.

Tackling transport and resettlement is a complex equation. A comprehensive package that maximizes on software and hardware aspects to transportation and resettlement intervention will lead to integrated and comprehensive planning. Through such a holistic approach does scope for resolving transport mobility and accessibility lie. It is also of paramount importance that research areas such as transport, resettlement, poverty and the physically challenged be tackled in Zimbabwe. Another theme ripe for exploration is gender, transport and resettlement in Zimbabwe. Topical issues such as urban poverty and rural poverty need to be anchored in transport and resettlement development studies in Zimbabwe. Ultimately, models and best practices of handling the transport, resettlement and development challenge will be pursued and addressed. Optimisation of transportation resettlement models will anchor industrial and agricultural prosperity in Zimbabwe.

ACKNOWLEDGEMENTS

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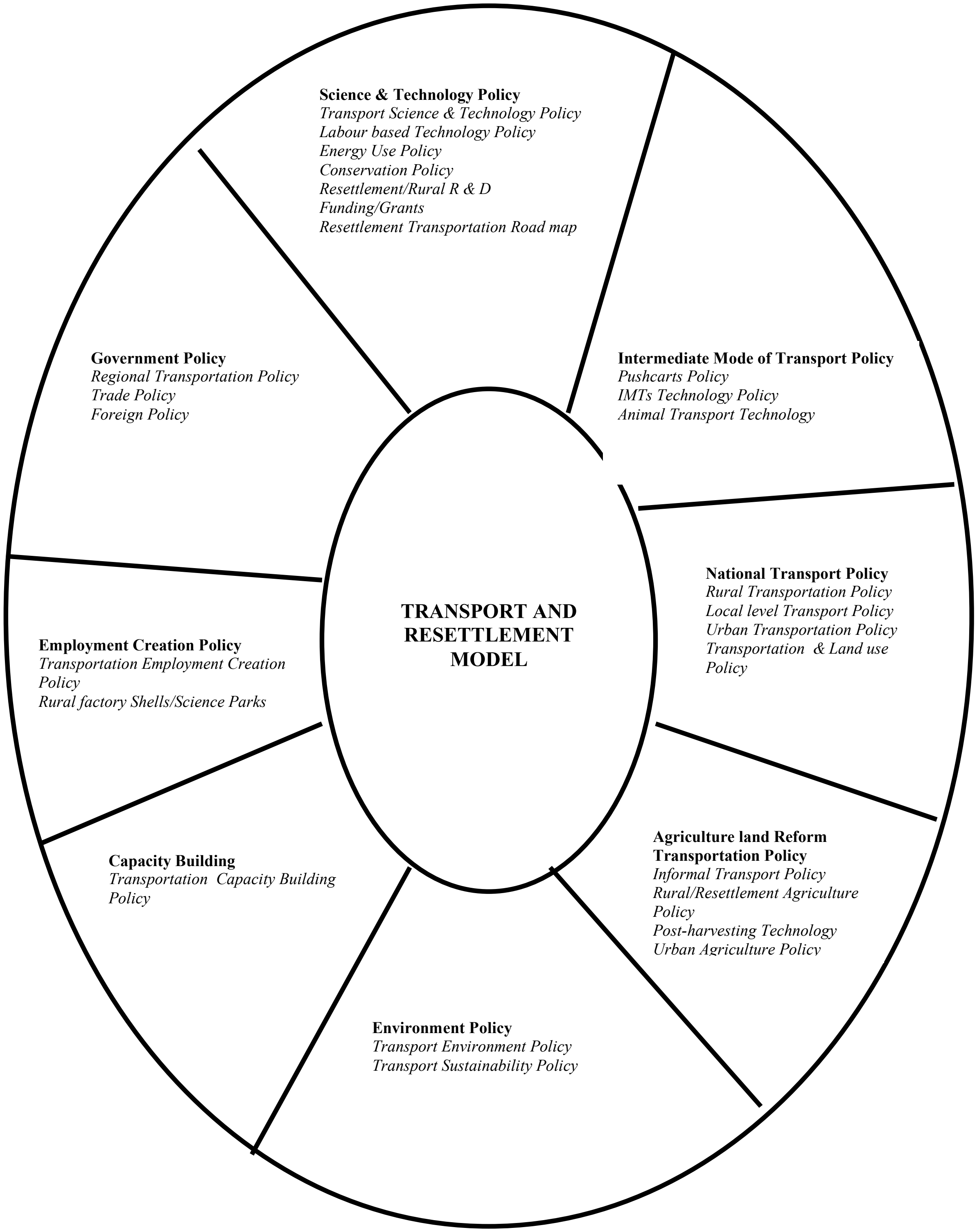

Figure 1: Resettlement and Transport Model

Appropriate Technology and Water Availability and Use: Impact on, and Implications for Land Reform

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Abstract
This paper addresses appropriate technologies for sustainable water use and reuse. Water access and availability, distribution, and water quality are critical issues for development and land reform. Appropriate technologies, such as rainwater harvesting, drip irrigation and other sustainable and locally controllable water use and reuse technologies can have a positive impact on land reform efforts. This paper presents some of these best available appropriate technologies and discusses their application in, and pertinence to, a sustainable and productive land reform program.

INTRODUCTION

Water is life. Must secure access to safe water be a basic human right? This is one of the fundamental questions facing people, governments and think tanks as populations grow and development efforts continue. Industrial and agricultural water use has increased dramatically while water availability is becoming the critical issue for maintenance of standards of living in the developed world and for improvements of living standards and quality of life in the less developed world. The importance of water access, availability and cost cannot be minimized as land reform programs are implemented.

The importance placed on water and water issues is underscored by the many "world forums" on water convened recently. 2003 was declared International Year of Fresh Water and the 3rd World Water Forum (WWF) was held in Japan (March 2003). The Ministerial Declaration[6] of WWF noted water, as the driving force for sustainable development and the eradication of poverty, must be managed with good governance, with stronger focus on community-based approaches addressing equity, with technical and knowledge capacity building and empowerment, and with attention to creating an environment for financial investment. The tenor of much of the discourse, promulgated by multilateral and private institutions, focused on privatization. There was substantial opposition to this from community and non-governmental organization (NGO) activists who took to the Kyoto streets as "water warriors" publicizing the negatives of water privatization. In mid-January 2004, the People's World Water Forum (PWWF) convened in New Delhi, India[7]. The PWWF opened stressing the need for recognition of water as a human right, and with strong opposition to privatization of water and recognition that local community control of water resources was critical to development and social empowerment[8].

Two continents away and two weeks later, the National Council for Science and Environment (NCSE) held its 4th National Conference on Science, Policy and the

[6] http://www.world.water-forum3.com/jp/mc/md_info.html
[7] http://www.pwwf.org/events&programme.html
[8] Vandana Shiva's *Water Wars: Privatization, Pollution and Profit* (2002) has critically examined water rights arguing that the "market paradigm" for water use and distribution is flawed, and that corporate control over water erodes not only the water resources but also democratic structures that have historically governed community water use[1].

Environment, this year on Water for a Sustainable and Secure Future. Representatives from the UN, the US Government, non-profit and non-governmental organizations, corporations and prominent academics and intellectuals, presented a wide and representative cross section of current thinking on water use and policy from a U.S perspective. Many questions were asked: Who owns the water? Should water be privatized? How much should it cost? How much responsibility do corporate and individual water users have to pay for what they extract? How about to clean up (and to what level?) what they discharge back into the nearest publicly owned water body [2]? There were no definitive answers; views expressed by the various stakeholders were in alignment with their interests. Positions ranged from potable water availability as an absolute human right to water as commodity to be privatized and "market" priced, driven exclusively by the profit motive.

What is clear is that water, its availability, its potable quality, its cost and pricing, is a singular source of contention and dispute pitting global private capital's profit search against local community needs for sustainable development. Implications for land reform are embedded in the need to ensure that small farms resulting from break-up of large land-holdings are equitably resourced with water. Failing this, the success of land reform efforts will be in jeopardy. Formerly successful and large single-owner farms cannot devolve to successful smaller farms without adequate water availability. Water distribution must be integrated into land reform efforts. This needs to done through implementation of additional water collection and storage technologies or through extension of original water distribution networks to incorporate smaller land parcels. To be successful, newer and appropriate technologies must be developed and implemented. The communities that take over the small land parcels should be empowered, both politically and technically, to control water supply and distribution.

The critical importance of local community control and education is best exemplified in the struggle between a local village community in Kerala, India, and a large multinational corporation that extracts groundwater from land owned[9] by it but that is within the village community [4]. In the late 1990's, the Plachimada village council, under pressure from the State Government and with the promise of jobs, sanctioned the location of a Coca-Cola manufacturing and bottling plant in the *panchayat*[10]. The company drilled wells and extracted groundwater at increasing rates. A few years later, community residents noticed reductions in water availability evidenced by drops in well water levels as well as reductions in water quality with consequent adverse health impacts. The *panchayat* council then refused to re-authorize the plants license, which was challenged by the corporation in court. A series of court filings, appeals and counter appeals ensued. In the most recent ruling, the Kerala High Court judged that underground water does not simply belong to the entity owning the land above the water, but belongs to the public community that is served by that watershed. The court ruled that the State must act as trustee with a duty to prevent overuse and that the State had a responsibility to see that community water needs were not adversely impacted. In fact, ruled the Court, these needs must inform water extraction rates by private corporations that extract the water for production and not simply for agricultural and domestic use [5]. This was a big victory for the community in their struggle to retain ownership and access to what had historically been their water. The larger implication of this case speaks to the importance of political empowerment, community education, and democratic governance structures in effectively maintaining local control over water resources. Kerala is governed

[9] The ownership and use of the land by Hindustan Coca-Cola beverages has been in dispute. The plant was originally set up on a 15-hectare plot in violation of the Kerala Land Utilization Act of 1967 that sought to prevent agricultural land being used for non-agricultural purposes [3].

[10] Panchayat can loosely be defined as the grassroots-level political authority comprising one or several villages/communities and government including tax and revenue is based in this governing council.

under the *panchayati raj* (rule at the level of the village community) so that village councils have authority over resource extraction and use, and must permit an outside entity access to that resource. Developing and implementing such a governance structure is critical to successful and sustainable land reform.

Water privatization as a solution to water availability and distribution problems is often proposed and implemented, seldom successfully. In Buenos Aires Azurix Corporation, the water subsidiary of Enron, managed water services for a total of 78 cities and 44 municipalities in Argentina. Soon consumers, complaining of poor water quality and erratic availability, refused to pay their bills. Complaints included interruptions in services, contaminated water and other lacks of compliance, and consumers began to lobby the government to redress the situation. The government did not do anything, but when Enron collapsed, Azurix abandoned the water service and broke its contractual obligations. When Azurix left, the union representing the workers took over operation and management of the water utility system, finding themselves burdened with a utility that had large numbers of uncollected bills. Nevertheless, after a series of negotiations, a newly formed water company called ABSA (Aguas Bonaernenses Sociedad Anonima) began operating the water utility. Currently, it is not running a deficit, the unionized workers are the operators, and a mixed State/Worker-owned workplace proposal is in full force.

This negative response to privatization has been widespread and not restricted to the less developed countries. In Newark, NJ, USA, the city council voted 7 to 2 to stop a plan to privatize the city's water utility[11]. The city was in debt, but the citizens did not see a long term solution in selling off its water utility system. In Stockton, CA, USA, a past $600 million water privatization contract was judged illegal because of inadequate environmental impact assessment.[12]

The opposition to water privatization is broad and community based, grounded in the fear of reduction and loss of local control and public rights. On the ground, private financing is always more expensive than government financing, and water companies become accountable to shareholders, not consumers. Water privatization also opens the door to bulk water exports and reduction of clean water access for the local community, especially the more economically depressed amongst them. Furthermore, water privatization may lead to job losses, as in Indianapolis, IN, USA, after their wastewater treatment facility was privatized. Opposition to privatization comes from academics and NGO's[13] as well as the UN and governments; nevertheless, huge pressures from multilateral and unilateral aid agencies promote privatization, often tying financing to restructuring economies and ownership.

These actions and community responses demonstrate that a substantive component for the maintenance and re-assertion of local community control is based in an adequately informed and empowered citizenry and underscores the critical need for education and knowledge transfer to be inseparable and implicit components of appropriate technologies when implemented as part of effective and sustainable land reform.

Appropriate Technology

Appropriate technology (AT) is difficult to define; its development and implementation have been a source of debate for some time [6]. There is general agreement, however, on what characterizes such a technology. AT is viewed as a technology that requires small amounts of capital, emphasizes the use of locally available materials, is relatively labor intensive and is small scale and affordable to individual families. AT should

[11] For more information, visit http://www.citizen.org/cmep/Water/us/municipal/newark/

[12] For more information, visit http://www.cccos.org/assets/courtruling.pdf

[13] Public Citizen is an exemplar of such an organization, especially through their Critical Mass Energy and Environment Program, http://www.citizen.org/cmep

be understandable, controllable and maintainable without high levels of education and training; able to be produced in small shops and villages; adaptable and flexible; and should include local communities in the innovation and implementation stages. Finally, AT should not have an adverse environmental impact [7].

The rationale of AT resides in its empowerment of people at local levels. Local needs can clearly be met more effectively if the community itself works to address their own needs. Tools developed should extend, not replace, human labor, and AT emphasizes controllable scales of activity. The rationale is grounded in minimization of financial, transportation, education, advertising, management and energy services and costs with the goal of engendering self-sustaining and expanding reservoirs of skills within a community. The result should be lessening economic, social and political dependency, and should lead to sustainable development focused on peoples needs and grounded in empowerment through education, technology transfer and local control.

Appropriate Technologies for Water

The applications of AT for water use are diverse and encompass water collection, storage and treatment technologies and water distribution systems; these technologies have been developed within the context of agricultural and human water use. The guiding principals are water quality and water conservation, maximization of water re-use and groundwater re-charging, and maintenance of water distribution and quality pertinent to its use.

Water Collection, Storage and Treatment

Access to clean water is a fundamental human right. Arguments about the cost of water notwithstanding, without clean water, people will die. In the less developed world, especially in rural areas, minimum access for human health has been defined as a potable water source within one kilometer of any locus. An appropriate water supply is critical but care must be taken to consider economic, social, and environmental and health factors in determining whether a particular technology choice is "appropriate".

Pacey [8,9] catalogued a broad array of low-cost water treatment technologies and made the critical point that no one technology will fit each situation; the key is matching people's needs and cultural patterns with given water supply potential. An example is shown in Figure 1 below. Water is collected as surface runoff and rainwater runoff from the dwelling roof; implementation of this will enhance water availability and choice.

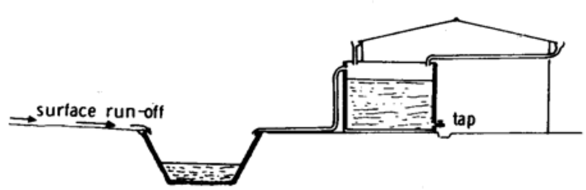

Figure 1: Rainwater catchment from roof and ground surface. Adequate precautions can prevent droppings, dust and debris from being washed off the roof into the tank; the roof tank is potential drinking water source while the excavated tank can provide wash or garden water [7, 286].

Rainwater Harvesting

Clean drinking water is essential for life but requires access to the water utility supply grid. The urban and rural poor cannot afford capital intensive, technically complex water treatment and supply systems. Community based water supply plans can be less capital intensive but often suffer from inadequate maintenance. Groundwater supplies may be unavailable or polluted with industrial and human wastes. This underscores the critical need for adequate water supplies to enable successful land reform implementation.

Rainwater harvesting is one proven technology that maximizes groundwater recharge flows, minimizes runoff, contributes significantly to water re-use and conservation, and maximizes the use of rainwater which would otherwise be lost to surface runoff and groundwater infiltration. This technology offers many advantages for water collection. AT based systems have been developed that are adapted to locally available skills, materials, and patterns of rainfall and water consumption [10].

The basic components of rainwater harvesting systems are simple and easily installed. These include catchement area (such as the roof), transportation system, screens to remove debris, water treatment system, tanks to store collected and treated water, and delivery system (either gravity based or pump driven) to convey water for use.

The catchement area size along with the rainfall patterns for the region of interest, will determine the amount of water that might be harvested using rainwater harvesting technology. This is an appropriate technology in that it is small scale, applicable at the local level with little, if any, outside resources, no requirement for sophisticated training and expensive maintenance while capital outlays required for such systems are relatively small. These systems will need to be developed and implemented along with land reform programs if these programs are to be successful and self sustaining.

Water Wells

Water wells are the most common water supply technology in the less developed world, especially in rural areas. Well drilling and excavation have been extensively studied and discussed in the AT literature; many books and booklets are available from non-governmental, governmental and multilateral development organizations [9, 11-13].

In land reform, as large land holding are broken up, it is important for success of land reform efforts to engage in the development and resourcing of additional water supplies. The large single owner farm may only have had one water supply. Digging additional wells is a mechanism that can address the need to have equitable water supply available to the smaller farms that devolve from the original large farm.

Hand Pumps

Collected or well water needs to be accessed for use and the hand pump has demonstrated itself as the most reliable low cost technology. The choice and suitability of a hand-pump for a particular location, installation, maintenance and other related topics have been described, and recommendations have been provided by the World Bank [14] and the World Health Organization [15].

Water Storage

Water storage has been accomplished using ferrocement (wire-reinforced cement mortar) tanks in diverse settings, including the Sahelian drought zone by the Dogon of Mali [16], where these tanks have been used with great acceptance by the community as it "fits well into their social and cultural visions of life". This underscores the importance of local input and control over the decision making and technological choices of communities in their development, as they improve their quality of life, and as they become engaged in equitable land redistribution efforts. In the tropics, bamboo-reinforced concrete rainwater tanks [17] have shown success, especially in rural areas, where over 5,000 such tanks have been constructed with direct loans to the villagers and with community supplied labor.

Water Treatment

Water treatment can be effected by different mechanism but, in the absence of specialized chemical and physical technologies, slow-sand filtration is an "appropriate" choice. The slow sand method can be the cheapest, simplest and most effective water treatment. They are also extremely simple to maintain and operate and can provide clean water without large technological and capital inputs. Figure 2 below illustrates their construction and the flow and treatment of water in the filter. Slow sand filtration provides water purification adequate to substantively reduce water related disease incidence. Their implementation has demonstrated dramatic increases in water quality with noticeable impact on reduction of water borne illnesses and in improving the quality of rural life. Water purification, usually the tertiary treatment step in modern water treatment facilities, yields water that has been cleaned of pathogens, disinfected and is ready for potable use. Several appropriate technologies have been developed and implemented in a variety of settings for the purification of water including chlorination pots (Figure 3) and solar distillation technologies (an example is shown in Figure 4).

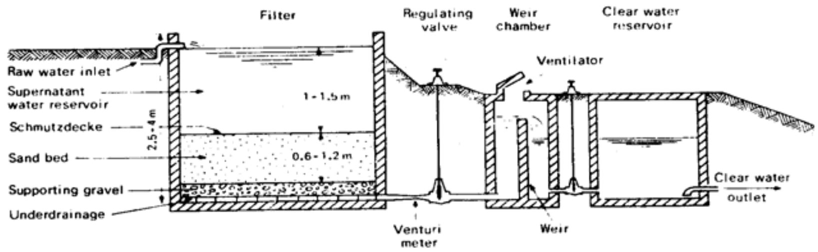

Figure 2: Diagram of a slow sand filter [18].

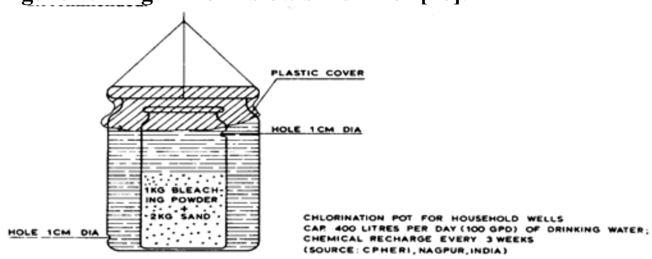

Figure 3: Chlorination Pot, design courtesy of CPHERI, Nagpur, India [7].

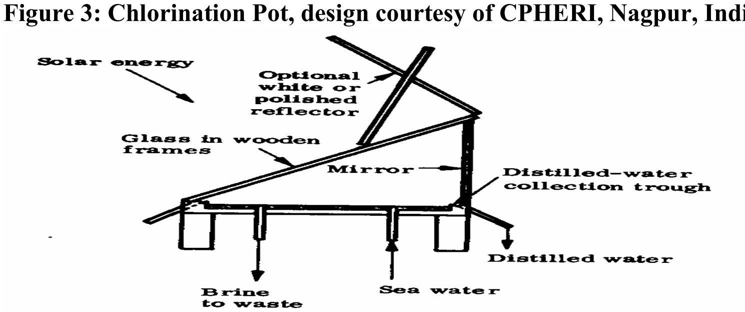

Figure 4: A Solar Still for distilled water production from sea-water (From "Solar Distillation as a Means of Meeting Small Scale Water Demands", UNIPUB, 1978; See [6])

Water Distribution: Drip Irrigation

A functioning, efficient and sustainable irrigation system is required for successful land reform. As large farms with acreage in the hundreds and possibly thousands are broken up, the success of the resulting smaller farms will hinge on availability of resources. The one critical system that needs to be maintained and (re)distributed is the irrigation supply and network. This may mean installation of new wells and water extraction sources, including groundwater bore wells, sunken wells and sourcing from any surface water bodies that may be accessible. It may require new water distribution networking to take advantage of the water sources that already exist.

Water use in irrigation necessitates development and implementation of effective technologies to maximize water use, minimize resource water extraction and maximize re-use of grey water. Surface flooding-based irrigation utilizes large quantities of water; much is lost to run-off, groundwater percolation, and evaporation, and only a fraction is actually utilized by crops. Drip irrigation, as the name implies, utilizes drips of water delivered in a targeted, direct and regulated manner thus consuming less water.

In the west, drip irrigation, initially developed in Germany (1860), consisting of subsurface clay pipes, resulted in doubling of crop output. In the 1920's, experiments with perforated pipes began and, with the development of plastics, perforated pipes of various materials were easy and cheap to manufacture, speeding up development [19]. In the 1960's, microtube networks were developed and applied in Israel speeding the greening of the Negev[14]. Other drip systems were also developed, including a subsurface drip irrigation system and the *drip tape* for vegetable crops. Drip irrigation systems were also used in tribal and rural cultures. In Meghalaya, India, tribal communities used bamboo-based drip systems for over 200 years. Water from mountain streams and springs were routed through bamboo pipes to irrigate plantations several hundred meters away.

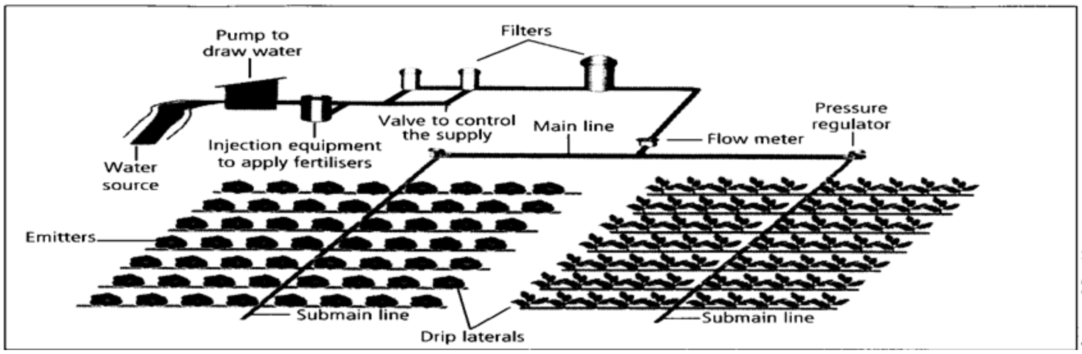

Figure 5: Components of a drip irrigation system.

Sophisticated drip irrigation networks require expensive sets of pumps, valves and piping, as shown in Figure 5. They are capital intensive, requiring small farmers to rely on financing to procure and implement. Government subsidized cost structures exist, but the bureaucracy involved results in potential for corruption and implementation delays. Capital intensive drip irrigation systems will not benefit the small farmer and careful attention must be paid to the selection and implementation of these technologies in the land reform effort.

Several methods that fit under the umbrella of AT have been developed, especially by International Developmental Enterprises (IDE). Two such design methods developed by IDE for poor farmers are shown in Figure 6; the capital requirements are low and installation and maintenance is straightforward with no requirements for advanced training or education.

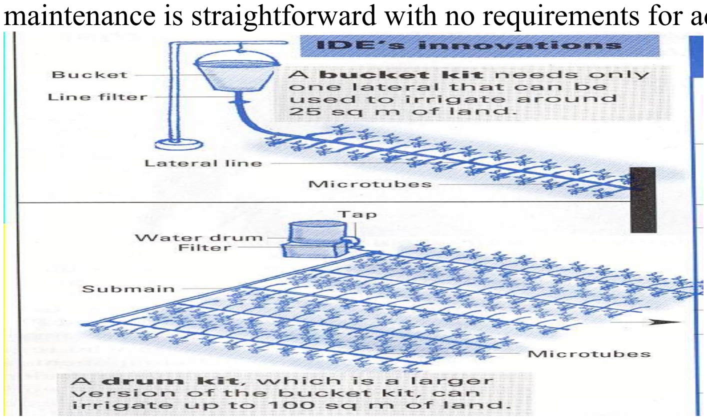

Figure 6: Low cost drip irrigation methods (IDE)

Summary and Conclusions

Appropriate technologies for water use and conservation, and to enhance the viability and sustainability of land reform programs have been presented and discussed. These

[14] To distribute water, you must first have water. Thus, Israel's access to fresh water was much increased after the 1967 six-day war, the occupation of the West Bank and access to, and control over, the River Jordan.

appropriate technologies will need to be implemented in concert with land reform programs. Failure to do so raises the possibility that the land reform effort will result in the creation of smaller land parcels that are off the water utility grid, that are inadequately resourced with water supply for domestic and agricultural use and that therefore cannot sustain themselves. This risk must be confronted and avoided through the judicious planning and rigorous application of appropriate water collection, storage, and treatment and use technologies.

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The Political factor in Irrigation Development in Zimbabwe.

Tracing technology choice changes in smallholder irrigation from the missionary era up to the Third Chimurenga.

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Key words: smallholder irrigation, technology choice, political factor

Abstract

Irrigation technology choice for smallholder farmers in Zimbabwe was never a simple linear, or orderly where choice was based on technical appropriateness for sustainable use. Instead, the process has always complex one and included the political, economic and socio-cultural factors. Evidence from the study of tec choice in the smallholder irrigation development in Zimbabwe revealed that the political factor predomin only the technology choice but also identifies the beneficiaries, crop choices and markets, plot sizes, organisation, operation and maintenance. The players in the political factor encompasses the local tra leadership, the church, the donor community and of course the government of the day. We assert that whe its due prominence, the political factor or content can help and redress some of the reasons why some sma irrigation systems fail to deliver. Research on the other hand, has traditionally marginalized or left out enti political content in the analysis of smallholder irrigation functioning and performance.

1. Introduction

The turn of the new millennium brought with it one of the most dramatic 'reforms' in the history of Zimbabwe. The resolution of the Land Question in Zimbabwe took the names such as the 'Fast track' resettlement program, 'The Third Chimurenga' (*meaning the third uprising, after the first and second uprisings for independence*) and also 'Hondo Yeminda' (*shona language standing for literal war for land*) implying hasty and defiance of logic and reason. This was inarguably the most controversial post independence national program ever implemented by the government. In many instances this program took violent courses including arrests and deaths of several white commercial farmers. This national program, 'national' because of scale and not consensus, led to the collapse of the country's image internationally and to a large extent caused the decline of the economy to an all time low. Consequently, a host of social, economic and political problems ensued. The 'fast track' resettlement program achieved overnight to place many smallholder farmers and 'new' farmers on productive land. This land was endowed with not only harnessed, free flowing and developed underground water but in many cases with a whole range of sophisticated irrigation technologies in place from farm to farm (Zawe, Svubure and Shambare, 2003). The water sector reforms of the late 1990s (WRMS, 1998) never imagined in its own right to place so many smallholder farmers in 'access to' or face to face with water for food production in the way the 'fast track' resettlement program did. A dilemma arises therefore. Overnight, the smallholder farmers found themselves face to face with some of the state of the art irrigation technologies, which under the national development discourse of the country then could not have been chosen for them. Will the farmers leave the irrigation technology to lie idle as 'inappropriate' for them? Or will they grapple with it; modify it intentionally or by default (Zawe and Svubure, forthcoming). This paper reveals how smallholder irrigation development was guided especially in terms of technology choice prior to and after the explosion of the Zimbabwe land question at the turn of the new millennium. It further highlights that irrigation technology choice in Zimbabwe was mainly based on socio-political factors rather than on the best bet choice to provide the irrigation service. However in works of irrigation performance analysis, the socio-political factor is not given its due prominence. Ultimately this paper aims to contribute to the debate on irrigation technology choice for smallholder farmers in Zimbabwe.

The paper first presents a theoretical framework, which describes the theoretical positioning of the paper. Subsequent to this it gives highlights of the political history of smallholder irrigation development in Zimbabwe from which conclusions, recommendations and issues for debate are raised.

2. Theoretical framework

Knowledge and technology recommendation or choice for smallholder farmers is a crucial area in development discourse that has to be studied in order to understand the performance of smallholder irrigation projects in Zimbabwe. The criteria for technology choice have a bearing on the performance of such technology. Our paper asserts that irrigation technology choice for smallholder farmers in Zimbabwe was never a linear, simple, logical and orderly process where choice was based on technical appropriateness for sustainable use. Instead, it has always been a complicated process taking into account factors that include the political, economic, social and cultural environment of the day. We would like to argue that the relative weighting of the political factor in technology choice was never given the prominence it deserves in the analysis of irrigation technology performance. Our paper looked at the political history of the country from the pre-independence and post-independence era and in the aftermath of the 'fast track' land redistribution program and analysed its role in smallholder irrigation development, particularly on the aspect of technology choice. As a result, the prominence of the political factor in the functioning, performance and sustainability of smallholder irrigation sub-sector is unearthed. This is a departure from most of the assessment of the performance of the smallholder irrigation systems which emphasised such factors as market availability, crop choices, farmer organisation, plot sizes, water use efficiency and operation and maintenance as being the main factors of irrigation performance. This tended to leave out some of the criteria used in irrigation technology choices. The result is that the political factor in irrigation operation and maintenance is marginalized. The political factor when given its due prominence can help and redress some of the reasons why some irrigation systems fail to deliver. Politics in development discourse has always been given a negative role (politics interferes with development).

This paper will show that the performance of smallholder irrigation in Zimbabwe had a political content (Manzungu *et al*., 1996), which had profound effects on performance and sustainability of the sub-sector. The authors assert that politics defined the development discourse of the day and with it the technologies made available to the smallholder farmers. It also defines who the players are, what resources are available, market and the support given to the technology user; this coming by design or default. Evidence for our paper was gathered by employing methodologies, which included a literature review on how smallholder irrigation technologies choice was guided in Zimbabwe prior to and following the ‘fast track’ resettlement program. The authors also rely on evidence gathered through their long involvement in irrigation development prior to and after the ‘fast track’ land redistribution program as senior government officials in the Ministry of Lands, Agriculture and Rural Development. Also ongoing research by the authors contributes to information contained in this paper. The paper recognises four phases in irrigation development in Zimbabwe. These are the phase of the missionary involvement, the pre-independence phase, the post-independence phase and the ‘fast track’ resettlement program phase.

3. The political factor in smallholder irrigation development in Zimbabwe

The significance of the smallholder irrigation sub-sector to the national economy has been reported to be low. For example, in the 1984/85 agricultural season, the gross output from smallholder irrigation was only 0.4% of the total agricultural produce (Peacock, 1995). By 1997, the area under smallholder irrigation was about 10 000ha, which constituted about 6% of the estimated total area under irrigation in the country (Roder, 1965 and Rukuni and Makadho, 1994). However there is high interest in the smallholder irrigation sub-sector that is quite disproportionate to its scale and current contribution to the national economy (Rukuni and Makadho, 1994). One of the major reasons put forward for this high interest in smallholder irrigation is that it has always had a political content as it embodied two of the most contentious issues in Zimbabwean history, land and water (Manzungu *et al*., 1996). This colonial injustice in land and water was obvious and remained unresolved 20 years after independence. This paper analyses in a four-phase way the technology choice changes in smallholder irrigation development in Zimbabwe and shows how it has been part and parcel of the political process in the country. In this way it clearly shows the predominance of the political factor in irrigation technology choice.

3.1 The missionary phase

The missionary phase is preceded by a period where, farmers on their own initiative practised irrigation (Roder, 1965). These irrigation projects were mainly based on run-off the river canals systems, which brought water to their gardens and watered the crops with containers and furrows. It was very simple technology where tree branches were used to partially block the river or stream flow in order to raise the water level making it gravitate into the dug out unlined earth canals. The canals did not follow any specified gradient and neither did they have any water control structures as they simply meandered from the river delivering water to the garden. These irrigation projects manifested themselves throughout the country and notable village based schemes were Chakohwa and Mutambara in Manicaland province. Such irrigation projects were characteristically small, manageable and sustainable because even today they are still there dotted throughout the country. The socio-political set up then was the people's local traditional leadership, which included the kraal heads; headmen and chiefs who basically determined the location of the irrigation project in their areas of jurisdiction and sanctioned its initiation. That period was also one of no exposure to other types of irrigation technologies.

From 1912 through 1927, the missionaries started joining hands with farmers to upgrade the farmer-initiated irrigation systems (Rukuni and Makadho, 1994). The missionaries provided resources to align the canals and put brick or concrete lining to minimise water loss through seepage. The canals were also put on gradient to control and manage the water and to minimise its surface erosive power. This technology development process was cohesive in that more people were mobilised by the missionaries to start and expand existing irrigation projects and in the process bringing society closer to the church. Government was not directly involved as it watched these developments from a distance (Rukuni and Makadho, 1994). Mainly surface schemes were upgraded and these included Hama-Charandura irrigation scheme at St. Josephs Mission, Bangure near Holy Cross Mission and Siyaso near St. Luke Mission all in Mvuma district, Midlands province. The Roman Catholic Church missionaries spearheaded these schemes. All the three surface schemes were on sandy soils that could have been irrigated by pump-fed sprinkler systems. The missionaries decided many factors on these schemes. Besides the technology choice, they also decided the cropping and that produce was not for sale but for consumption only. Plot sizes were very small (0.1ha) and the aim was to involve as many beneficiaries as possible and thereby increase the church following. Mr. Mhaka (pers. comm.), the chairman of Bangure irrigation scheme asserted that the pump-fed sprinkler systems were not considered because the then Land Development Officer of the area, Mr. Bruce Moffart considered that Africans could not be trusted with sprinkler irrigation systems. Electricity was accessible and in fact a 4-ha pump-fed sprinkler irrigation system operated by the missionaries themselves was located only 500m from the dam. The case of these irrigation schemes provides a glimpse of how the missionary 'politics' was involved in smallholder irrigation development in the country then. It is important then that in the analyses of the performance of such schemes that this 'political' factor must be given its due prominence. Researchers should realise that by giving the 'political' factor its due prominence, it could play an even bigger role in redressing some of the causes of scheme non-performance.

3.2 The pre-independence phase

The history of smallholder irrigation development and technology transformation in Zimbabwe has been documented elsewhere (Roder, 1965; Alvord, 1958; Rukuni and Makadho, 1994 and Zawe, 2000). During the period, 1928-1934 the colonial government through officials in the Ministry of African Affairs provided services and helped to develop the smallholder irrigation sub-sector with the farmers maintaining control over the schemes (Alvord, 1958). In 1927 Emery Alvord, an American missionary was appointed the first government agriculturalist for the instruction of natives. Alvord started Nyanyadzi irrigation scheme in 1934 as one of the first schemes constructed by the government. In the period 1935 to 1945, government through the Ministry of African Affairs took over the management of African irrigation schemes (Rukuni and Makadho, 1994). This intervention by the colonial government was a political process to rein in on the native people and not allow them to cater for themselves (Ranger, 1985). The pretext though was provision of food security as many of these schemes were in the dry and drought prone Save valley (Alvord, 1958). The smallholder farmers were now mobilised into much bigger irrigation schemes run on a full time basis by giving up rain-fed cropping and other non-irrigation activities (Roder, 1965). With the amendment of the Land Apportionment Act of 1930, people were moved to Native Reserves, the present communal areas to make way for the establishment of white large scale commercial farming areas. Surface irrigation schemes such as Nyanyadzi and Devure in Manicaland province were constructed and the displaced people from Chipinge were resettled there. Clearly the politics of the time not only determined the irrigation technology choice but also who the beneficiaries were and their number, the cropping programme, the market and marketing support structures and generally the whole management of the scheme. From 1946 to 1956, smallholder irrigation development was stepped up in order to meet the political objective of resettling the displaced native population (Roder, 1965). The new schemes were heavily subsidised by government and were mainly surface systems, as pump-fed options were considered too expensive. Only very few pump-fed irrigation schemes, which included Chibuwe in Manicaland, were constructed during this period (Rukuni and Makadho, 1994). In 1957 the Department of Native Agriculture engaged an economist to examine the profitability of smallholder irrigation schemes and it was concluded that the majority of the schemes were uneconomic (Hunt, 1958). As a result, the development of new smallholder schemes was temporarily halted up to about 1965 (Hunt, 1958). This also demonstrates the role played by the state and politics in the whole developmental process.

The period leading to independence in 1980 saw the colonial government adopting a policy of segregated development for blacks and whites by introducing a strategy of rural growth points based mostly on large estates run on commercial basis. Smallholder settler farmers acted as out growers of the estate by adopting the estate's cropping programme and selling their produce through the estate (Rukuni and Makadho, 1994). The Tribal Trust Lands Development Corporation (TILCOR) was set up to develop irrigation based growth points in the Tribal Trust Lands, the present communal areas. Examples of schemes constructed under this policy include Gowe in Sanyati communal area and Chisumbanje in the lowveld (Rukuni and Makadho, 1994). The state exercised complete control on virtually all operations in the out grower settler irrigation schemes from crop selection, inputs to repair and maintenance of the irrigation system (Reynolds, 1969). The farmers had no choice on the irrigation technology; it was simply handed over to them. The government assumed that the Estate Management Board will look after the technology and that the farmers were not expected to manage it themselves. The Agricultural Rural Development Authority (ARDA) succeeded TICOR in 1981 (Rukuni and Makadho, 1994) which pulled out of Gowe in 1990 and leading to the collapse of the smallholder irrigation system later as they could not sustain the system on their own.

3.3 The post-independence phase

The early 1980s period was marked by the rehabilitation of irrigation schemes and other infrastructures destroyed during the liberation war. The rehabilitation and reconstruction programme was funded by the United States Agency for International Development, USAID and the United Nations High Commission for Refugees, UNHCR. No new technology was introduced and the development of new schemes was insignificant.

The period 1985 to 1990 was also characterised by the politics of donor funding as each donor institution tried to propel its own development discourse the in smallholder irrigation development process. Donor funding was available from several international aid agencies including the EU, IFAD, DANIDA, KfW and FAO. For example, the FAO programme focussed on operation and maintenance by prescribing the drag hose sprinkler system technology to the farmers. The emphasis was on equipment ownership by the individual farmer plot holder hoping that he will maintain it in good working order. DANIDA's emphasis was on empowering the smallholder farmer through training and setting up of a revolving fund for operation, repair and maintenance costs. The ultimate objective was to make the farmer independent from government's assistance. Some non-governmental institutions focussing on using small amounts of water also gradually introduced the drip system. But with the proliferation of only Netafim drip system products, it appeared more of a market search game. With dwindling financial resources, government had no choice but to accept any irrigation technology for as long as it gave its people some kind of development. The Irrigation Testing Centre constructed at the Institute of Agricultural Engineering in Harare, which could have done the testing and screening was never utilised.

In 1991, Robert Mugabe's government dropped the Scientific Socialism policy in favour of the World Bank and IMF sponsored Economic Structural Adjustment Programme (ESAP). In many sectors of the economy, government subsidies were drastically reduced or removed out rightly as it struggled with the economic reforms. The government's capacity to provide finance for operation and maintenance for smallholder irrigation was severely eroded and there were a lot of experimentation with irrigation management turnover to make farmers contribute resources for operation and management (Manzungu *et al*., 1999; Zawe, 2000). The government though continued to participate in smallholder irrigation for political expediency. In the 1995 general elections for example, the minister of Lands, Agriculture and Water development, promised at the ZANU (PF) annual conference that each of the country's 56 districts would receive a dam and an irrigation project. So smallholder irrigation was a favourite campaign promise for aspiring politicians.

3.4 The 'fast track' resettlement program phase

During the year 2000, the government's proposed new constitution was rejected in a national referendum following the successful opposition from the National Constitutional Assembly, NCA (a grouping of civic organisations) and the Movement for Democratic Change, MDC (a newly formed labour-based opposition political party). The constitution was believed by the landless and the war veterans of the 1970s liberation struggle to have contained the necessary legal framework to ensure the speedy resolution of the land question (Zawe *et al*., 2003). This rejection triggered a nation-wide 'land invasion programme' by the landless masses mobilised and guided by the war veterans. On July 15, 2000, the 'moving-in moving-out fast track resettlement programme' also code-named the 'Third Chimurenga' was officially launched by the government (Land Reform Program, President Mugabe Speaks out, 2002).

This paper noted the dilemma; quandary, predicament or tight spot smallholder farmers who benefited from the whirlwind 'fast track' resettlement program found themselves in. Suddenly, they are face-to-face with high tech irrigation technologies, which included the pressurised semi-portable systems, centre pivot, microjet and drip systems with organisational complications ranging from single farm operated systems to sophisticated multiple farm consortium operated systems (Zawe *et al*., 2003).

The lawless environment that characterised the 'fast track' resettlement programme led to a widespread vandalism and looting of movable irrigation equipment. This included the pumping units and in-field equipment making the systems completely dysfunctional as only the buried pipe network remained. In 2002, sensing a huge wheat deficit and realising that most commercial farm irrigation systems where now completely unusable, the government embarked on a massive irrigation rehabilitation program called the "Winter Wheat Irrigation Rehabilitation Program, 2002" (Zawe *et al*., 2003). This was extended into 2003. The authors were heavily involved in this program as the technical members of the Provincial Wheat Taskforce Committee responsible for the approval of the application before forwarding it to the Agriculture and Rural Development Authority (ARDA) through the Department of Agricultural Engineering Head office for financing. The program was a huge failure mainly because of inadequate funding from central government, the hyper inflationary environment, corruption and the absence of clear implementation guidelines from government. The area grown to wheat in Mashonaland West Province sharply declined from about 33 000ha in 2001 (of which more than 90% was grown by the large scale commercial farmers still on farms) to about 16 000ha in 2002 (with nearly 70% grown by commercial farmers still on their farms). The area further went down to about 11 000ha in 2003 with more than 50% coming from commercial farmers that remained on their farms. These figures were obtained from various progress monitoring reports.

The programme started with no clear implementation guidelines from central government departmental headquarters, and there was no deliberate effort to explain the programme to all farmers either (Zawe *et al*., 2003). All the farming categories including the A1 smallholder beneficiaries applied and were considered. The majority of the beneficiaries from the program were A2 farmers. Some A1 farmers also benefited as a group and notable examples were Chipfundi, which is based on a semi-portable sprinkler irrigation system and Elmly Park, which is based on the centre pivot irrigation system. Both schemes were in Makonde district, Mashonaland West province and were the first smallholder farmer groups in the country to benefit under this program. The outgoing commercial farmer, Mr. John Eden was promptly paid (Z$40m) by the government for his irrigation equipment. Elmly Park A1 (smallholder) farmers became the first farmers to operate a centre pivot irrigation technology system previously regarded as a preserve for the white large scale commercial farmers leap frogging from the surface based and to a smaller extent sprinkler irrigation systems. This clearly demonstrates the predominance of the political factor in smallholder irrigation technology choice. The government also spelt the cropping program (wheat-soya rotation) and that the market for wheat was to be solely the Grain Marketing Board (GMB) since wheat was a controlled commodity. So there was no flexibility on crop choice on the part of the farmer groups. Inputs were to be obtained on loan from the GMB. The government promised assistance on operation and maintenance costs but nothing came forth when equipment breakdowns were encountered. Instead the outgoing commercial farmers still around assisted with managing the equipment and the crop, not because they wanted to, but because of political pressure.

4. Conclusion and issues for debate

Our paper has looked at glimpses in the development of the smallholder irrigation sub-sector in Zimbabwe from the missionary phase through the 'fast track' resettlement program phase at the turn of the new millennium. The highlights of this historical tracing have demonstrated the presence of the political content in smallholder irrigation development in Zimbabwe. We conclude that this political content defined the development discourse of the day and in the process decided the irrigation technology choice for the smallholder farmer. It also defined who the beneficiaries were; what resources were available, the cropping program, the market and other support to be given to the technology user. The players in this 'political content' embraces the local traditional leadership, the church, the donor community and of course the government of the day. We recommend that in the analysis of the functioning, performance and sustainability of smallholder irrigation, the political factor must be given its due prominence. It is not the cropping program, which is wrong, neither the operators nor technology failure but it is the sayings of the political content. So it must be used to play its role in redressing or finding solutions to the performance of smallholder irrigation.

This study of the political history of the country and the smallholder irrigation development also brings the question of the credibility of the concept of 'appropriate' technology to the fore. Is it the question of technology being 'appropriate' for the job at hand or is it the question of 'appropriateness' for a specific technology user group (Zawe and Svubure, forthcoming).

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TRAINING NEEDS ON ENVIRONMENTAL ISSUES FOR A1 MODEL RESETTLED FARMERS IN ZIMBABWE

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Key words: environmental issues, resettled farmers, sustainable land use

Abstract

The project set out to find the effects of the fast track A1 Model resettlements on the environment and ways of addressing them. The hypothesis is that, some negative effects on the environment emanated from this exercise. The majority of beneficiaries are former communal farmers with no training in agriculture and environmental conservation.
The major reference was the Utete Land report of 2003, containing a comprehensive picture of the resettlement process. A case study was made in Bubi district of Matebeleland North. Interviews were conducted with the Chief, the Councilor, and resettled farmers. Questionnaires were sent to the District Administrator and other council officers.
The major findings were that substantial deforestation, poaching and gold panning have taken place in areas visited by the researcher and the district authorities. Although the resettlement itself was a great success, little attention was given to environmental security. Potential land degradation is evident in some areas. The resettled farmers expressed concern about the deterioration of the environment requiring urgent attention.
The farmers need training in environmental conservation and sustainable land use. Workshops and seminars are recommended on self-help projects. Attention is required in the sphere of health particularly concerning domestic water sources and sanitation.

1.0 Introduction

Land reform is imperative in a postcolonial era. In the paper by the Henry George Institute on Liberation Theology and Land reform, it is expressed that the deadly connection between land-ownership concentration and wretched poverty is absurdly obvious on every continent [1]. Land redistribution in Zimbabwe has been for a long time, a pertinent issue that required a justifiable solution. The year 2000 saw a move to resolve this issue once and for all. One of the major aims was to decongest communal areas. To fulfill this requirement, the government put in place the A1 model Resettlement Scheme. A1 farms are small pieces of land averaging 305 hectares allocated to a household. This hectarage includes a homestead, a crop field and grazing land [2]. The decongestion has been partly achieved with 127 192 households having been allocated 4 231 080 hectares as at 31st July 2003 with a take up rate of 97% [2].

The beneficiaries of this exercise are expected to positively contribute to the agricultural output of the nation. Such contribution can only be realized if these farmers are adequately equipped in terms of inputs and management skills. Entangled with this expectation is sustainable land use and environmental preservation. After land has been made available, natural resources and the environment must be preserved by implementing proper land management policies. In El Salvador, ecosystem-based community forestry is used, where natural resources especially the forests are controlled over, and enjoyment of the benefits from the forest by the local community. Ecosystem based resource management seeks to sustain fully functioning ecosystems by adapting economic activity to natural limits rather than eroding ecosystems to support economic activity. To achieve this kind of resource management, appropriate technology must be applied. In land use, appropriate technology is that technology which is essential, affordable, of low maintenance and furthers the sustainable use and management of resources and opportunities, with due discernment of the local environment, social, economic and political settings, conditions and values [3]. In this paper, the environmental challenges going with the resettlement exercise are examined.

2.0 A1 Resettlement figures

Table 2.1 A1 Model allocation per province.(Utete report, 2000 – 2003)

Province	**Resettlement area for Model A1 in Hectares**	**Number of Households resettled**
Midlands	513 672	16 169
Masvingo	686 612	22 670
Manicaland	195 644	11 019
Matabeleland South	683 140	8 923
Matabeleland North	543 793	9 901
Mashonaland East	302 511	16 702
Mashonaland West	792 513	27 052
Mashonaland Central	513 195	14 756
TOTAL	**4 231 080**	**127 192**

Table2.2 Land ownership patterns after Fast track as at 31 July 2003

Category	Area (million hectares as at 31 July 2003)	% of total land area
A1	4.2	11
A2	2.2	6
Old Resettlement area	3.7	9
Communal	16.4	41
Large Scale Commercial	2.6	6
Small Scale Commercial	1.4	4
National Parks & Urban	6.0	15
State land	0.3	1
Other	2.8	7
Total land area	39.6	100

Source: The Utete Report / Provincial Files

3.0 Farming activities

According to government policy, the A1farmers are expected to contribute to the nation's food security. They have to use the land profitably and sustainably. Industrial or Commercial agriculture, which requires machinery would not be possible for these farmers as they do not have the resources. Industrial agriculture involves mechanization, large quantity of fossil fuels and fertilizer usually to produce large quantities of single species of crop. [4]. The thrust of A1 farmers is therefore should be in subsistence agriculture.

3.1 Types of subsistence agriculture:

3.1.1 *Shifting cultivation* - involves clearing and burning of forests to release nutrients in the forest biomass for agriculture. When the soil is depleted of nutrients, it is abandoned.

3.1.2 *Intensive Crop Cultivation* - Labor-intensive agriculture practiced on good land. Uses little machinery, inorganic fertilizers, and pesticides. Common in Japan, India, China, Central America, Southeast Asia, and parts of Africa.

3.1.3 *Nomadic Herding* - agriculture involving the herding of livestock on tropical and temperate grasslands. Common in Africa, Middle East, Northern China, Afghanistan, and Mongolia [4].

Shifting cultivation and nomadic herding are not sustainable methods of agriculture. Shifting cultivation has been practiced in communal lands in Zimbabwe since the colonial era [5]. Training in appropriate technology is paramount in these resettlement areas to avoid land degradation experienced in communal lands due to lack of management and knowledge [5].

4.0 Environmental awareness

4.1 Addressing attitude problems towards the environment.

The need to make the rural population aware of environmental protection is not a new one as evidenced by the existence of the Natural Resources Board prior to independence [5]. It is the people's attitude that needs to be addressed as well. Some people think that environmental issues are a government problem. Traditional energy sources like firewood involve cutting down of trees and the consequences thereafter are usually not addressed. Such practices are not expected to continue in the resettlement areas. Farmers should be conscientised to have intrinsic motivation towards conserving natural resources.

4.2 Knowledge base

Knowledge of sustainable land use by resettled farmers should not be assumed. People have not applied scientific principles of agriculture in communal lands. Most of these farmers may not know the organic activities that take place in the soil to maintain its fertility. The symbiotic nature of ecosystems is unknown, hence one does not care about anything that does not seem to be directly connected to his crops or his herd of cattle. This leads to indiscriminate cutting and burning of trees, poaching, gold panning leaving trenches which later develop into gullies and so on [6]. Ignorance of land carrying capacity would lead to overgrazing. The work done by Agricultural Extension officers should be enhanced by people based projects established through environmental awareness campaigns. One would expect cooperation from the farmers who now have land that truly belongs to them.

5.0 Interviews.

5.1 Interviews with local leadership (Councilor, Chief, Village Head)

5.1.1 The following ratings were given on these environmental issues from three questionnaires returned out of five issued out:

- Communal lands decongestion; insignificant.
- Farmers have satisfactorily engaged in agricultural activities.
- Negative environmental effects; significant.
- Deforestation and wild life destruction; high.
- Risk of spread of water and sanitation related diseases; high.
- Potential land degradation; low.
- Attitude change towards environmental conservation; very little.
- Gold panning; very high.
- Farmers' knowledge on conservation of natural resources; very little.

5.1.2 The following reasons were given for the negative effects on the environment:

- Deforestation:- random cutting of trees for hut structures, home and field fencing, firewood both for personal use and for sale.
- Wildlife:- hunted and snared for personal consumption and for sale.
- Land degradation:- gold panning, removal of original paddock fencing leading to uncontrolled grazing.
- Diseases:- drinking water collected from unprotected wells and dams, no toilets.

5.1.3 The following recommendations were made:

- Workshops on environmental protection should be intensified.
- Paddock fences should be maintained and carrying capacity of the land adhered to.
- Providing transport for the officers to visit all farmers, teaching and addressing pertinent issues would enhance adequate supervision by AREX.
- All stakeholders should be involved in addressing these issues especially Local authorities, AREX, Training institutions, and the farmers themselves.

5.2 Interviews with resettled farmers in Ward 1 Bubi district

5.2.1 The following were responses from 23 questionnaires returned by newly resettled farmers out of 30 questionnaires issued out:

- Farmers preferred the A1 farms because they were more fertile than the communal land, good for livestock and less congested.
- The reasons why communal lands were severely degraded include use of sledges, random tree cutting, firewood as the major source of energy, shifting cultivation, uncontrolled grazing, and crowded settlements.
- The A1 farms are likely to be degraded in the same way if no training is given to the new farmers and AREX policies are strictly enforced.
- As major activities of the new farmers, crop farming and animal farming were mentioned and some included gold panning.
- All agreed that deforestation, poaching and gold panning have accompanied the resettlements, and there is a risk of diseases due to poor water sources and absence of sanitation facilities including malaria due to open pits left by gold panners.
- As a remedy farmers suggested that the government should help them by:
  - providing funding for building latrines, drilling boreholes.
  - Providing training in new methods of farming and providing adequate farming inputs.
  - Electrifying the areas to avert use of firewood.
  - Helping the farmers in starting other income generating projects to raise money for other daily requirements like school fees, medication and so on, so that they will not turn to gold panning.
  - Discouraging the issuing of mining licences near or within resettlement areas as this diverts the attention of many farmers from agricultural activities and causes environmental risks as some of these small-scale mine owners do not have proper technology or equipment for mining.
  - Providing seminars to explain the government policy on land use and agriculture.

6.0 Observations on the ground

The Utete Land Commission report alludes to some of the environmental concerns arising from misuse of resources by resettled farmers in some cases, these include cutting down of trees, poaching and gold panning. These observations are not in variance with the observations made by this author in Matabeleland North province where he carried out a case study.

The case study was made in a cluster of A1 farms in Bubi district which include; Treahern, Deeside, Leighton, Killeger B, Braemar, Fetekil,Hulhunters, Dromoland Ellarmarna, Alfa-alfa' Helenvale, Kopjies, Freidi, Paradise, and Dollar Extension.

The following environmental concerns were observed:

- Poaching was prevalent in all farms and most animals especially the wild pig which used to be a common sight was no longer found.
- Tree- felling for fencing purposes in both crop fields and homesteads was very prevalent.
- Gold panning in the area around Lonely Mine was very high and many pits and trenches could be seen around. This is a potential danger for gully formation, trapping and drowning of animals including people, in these pits, when grass is tall or during the night. Heaps of crushed stone were seen near water sources like boreholes and wells. Another hazard observed in connected to gold panning was the unprofessional use of mercury and ammonium fertilizer in extracting gold.
- Removal of original wire fencing that used to demarcate paddocks has resulted in uncontrolled animal movement.
- Bush fires have occurred very often in the past two years, especially in Paradise farm.
- Cattle and goats have been brought in from former communal lands. At the moment there is no danger as far as the carrying capacity of the farms is concerned, how ever control will be required in future as more farmers acquire animals.
- Lack of sanitary facilities is a problem in all the farms. A few farmers have built toilets in Dromoland farm. Contamination of water sources and an advent of water borne diseases like cholera, dysentery among others is looming in all these farms.

Interviews made with some farmers indicated that a number of beneficiaries did not fully understand the government's objectives regarding this model of resettlement. Many expressed happiness that they now owned highly productive land, with abundant firewood and game. The impression was that, this was just an extension of the former communal land and nothing new was expected of them in terms of productivity and land management. Such settlers were found to spending most of their time panning for gold and very little had been done in terms of clearing land for cultivation and building huts at their homesteads.

7.0 Training needs (Recommendations)

In light of the above information, it is recommendable that training programmes be introduced in the A1 model farms countrywide. The effort of the agricultural extension officers is plausible, but a more precise programme directed towards environmental concerns is also required to address problems linked to the background of the new farmers or at least some of them. Such programmes need separate funding from that of the agricultural sector.

7.1 Areas that could be covered during training are:

- The government focus and aim of the A1 farm resettlement scheme. First and foremost, these farmers should understand why they are called resettled farmers and not simply 'resettled families'. This will make them understand that the resettlement exercise is not a mere shifting of families from old communal land to new communal land [7].
- Land as finite resource. Farmers have to understand clearly that although soil does not get finished per ser, it does lose its productivity and becomes unable to sustain life. There is a need to continually replenish soil contents so that its use is sustainable and remains so for other generations to come.
- Land has a fixed carrying capacity and by that we do not mean space available on it but its ability to adequately support all living ecosystems without itself getting obsolete. The idea is that if one does not understand how something works, there are more chances for him to misuse it. A simplified understanding of the nature of soil is necessary. Simplified in the sense that the new resettled farmers have different levels of formal education.

  Masses of mineral particles alone do not constitute a true soil. True soils are influenced, modified, and supplemented by living organisms. Plants and animals assist the development of a soil through the addition of organic matter. Fungi and bacteria reduce this organic matter to a semi-soluble chemical complex called humus. Larger soil organisms, like earthworms, beetles, and termites, mix humus into the mineral matter of the soil. Humus is the biochemical substance that makes the upper layers of the soil dark. Humus itself is colored dark brown to black. Humus is difficult to see or study in isolation because it becomes intimately mixed with mineral particles. Humus provides the soil with a number of benefits:

  - it increases the soil's ability to hold and store misture.
  - It increases the eluviation of soluble nutrients.
  - It is an important source of carbon and nitrogen required by plants
  - It improves soil structure necessary for plant growth

  Organic activity is abundant in soils. One cubic centimeter of soil may contain over 1,000,000 bacteria. A hectare of pasture land in a humid climate can contain more than a million earthworms and about 25 million insects. Insects and earthworms are very important in mixing and aerating the soil. These organisms are also responsible for producing a significant part of a soil's humus through the incomplete digestion of organic matter [8].

- The concept of ecosystems. The need for the farmers to understand that some seemingly useless organisms to us actually play a hidden role in maintaining the soil's productivity and the general interdependence of living organisms.
- Sustainable agriculture. A sustainable agricultural system involves the modification of agricultural techniques in both existing industrialized and traditional agricultural systems in order to provide for the needs of current and future generations while conserving natural resources. In order for a agricultural system to be sustainable the following requirements must be met:

  - Soil conservation must be practiced so that erosion, salinization, water logging or loss of soil fertility does not degrade the soil.

- Water resources must be managed so that they are preserved yet still meet crop needs.
- The system must be economically viable.
- The biological and ecological integrity of the system to be preserved [8]

- Proper use of agricultural chemicals such as fertilizers, pesticides and other inputs.
- General hygiene to incorporate sanitation and protection of water sources.

7.2 Methods that can be used for training

- Holding seminars at village level.
- Film shows showing land degradation and reclamation of land by closing gullies and reforestation.
- Practical demonstrations, closing gullies, filling up pits left by gold panners, tree planting and so on.
- Digging blair toilets.

7.3 Participants

- Agricultural Extension Officers
- Forestry Commission Officers
- Wildlife Conservation Officers
- Health Inspectors / Officers
- Researchers and Training Officers (Lecturers from Technical Teacher Education Department, NUST).
- Non-Governmental Organizations.

8.0 Conclusion

The resettlement exercise is not conclusive on its own unless the beneficiaries are trained on sustainable utilization of the land and all other related resources. Knowledge dissemination and management is urgently required to address the environmental challenges that come with the A1 model resettlements.

Emphasis has been made on the need to provide agricultural inputs to the new farmers, however close management on the ability and further more proper use of these inputs. It is clear from the observations made after about two to three years of resettlement, that if such training programmes are not put in place, these settlement areas will soon deteriorate to the same fate that the old communal areas found themselves in. Such a situation would be counter productive and render the land distribution exercise in these areas meaningless and disastrous.

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FOCUSING ON FOOD TECHNOLOGY FOR LAND BASED DEVELOPMMENT

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Abstract

Recently, technology in relation to higher education and development has been under scrutiny parallel to skills in science and mathematics. Debate has moved from technical skills to a more sophisticated theorization of technology. The road to technology education in secondary and post secondary is not clear. This is because technology is characterized as a diverse, concrete-product oriented activity associated with addressing human needs through the problem-solving process. This paper examines the concept of technology and the need to integrate diverse activities for its implementation. An example of food technology is given. Using data from an in-depth study of food processing gives an insight on the nature of technology, concepts for study and the set of processes involved in problem solving. Current social realities on food and its management are explored. Food technology as a problem solving activity is used to illustrate how problems of a developing society could be addressed. Solving problems in the environment through technology involves wide ranging human activities in projects that can alleviate poverty and hunger. In an attempt to solve current food problems a technology model for local needs has been designed. The model can be used as a starting point in the process of addressing different social needs and in rural development.

INTRODUCTION

The need to include technology in the curriculum at secondary, further and higher education became a topical subject after the Education Commission's Report of 1999 [1]. At present technology as a school subject like science is non-existent. This is because it has been disguised across courses under the names of engineering, technical training and applied sciences [2]. While there has been an expansion in the numbers of students studying technology, this area of study has remained scattered in different fields with no clear knowledge base.

The field of technology is diverse. Groups interested in the subject include philosophers, education scholars in technology, researchers in different technologies, practitioners in design, scientists and those involved in solving human problems in society [3] [4]. With these varied interests and the diverse nature of the subject, different people use different reference points in discussing technology. This paper looks at the definition of technology, the concept of food technology and its knowledge. It also looks at current social, problems faced in the country and the needs of rural and urban societies for education and training in food technology. A food technology model that could be introduced in education in an effort to reduce poverty and the dependence on food aid is suggested.

Definitions

Technology

Definitions of technology vary. Some definitions rely on the characteristics of diverse groups, while others emphasize design and solutions to social problems using the available resources.

The following are the most frequently used definitions of technology.

- In education technology is seen as a new subject that brings together a set of activities in the real world that are found widely scattered across a diverse spread of occupations and functions [3].
- Another education scholar says that technology is about controlling anything that is part of the environment. It is knowledge expressed in human action seen as a process and efficient means of using resources [4].
- In applied science, technology is seen as an applied science guided by employing skilled approaches derived from concrete experiences [5].
- Still in applied science technology is seen as the structured application of scientific principles and practical knowledge to physical entities and systems [6].
- From a philosophical point of view, technology is that which solves problems and seeks to make things better [7].

The above definitions indicate the diverse nature of technology. They also contain several points in common. The advocates agree that technology includes a set of activities found in a spread of occupations and functions in the real world. They believe that basically it is about the efficient application and combination of human skills, knowledge and hardware expressed in the environment through concrete experiences. Technology is also about solving problems in the environment by making products that will improve the quality of life of a society. This is what is of value to society.

A working definition for this research is that technology is a combination of knowledge and skills from different areas of study that is used to solve problems in the environment. It is also a problem solving activity where decisions on the best course of action are taken by designing solutions that work. This means activities in any technology are varied and spread over different occupations. Technology is also seen as a result of a combination of knowledge and skills contributed by scientists, designers, manufactures, business people and those involved in research and development. In addition technology is the application of human skills and knowledge for production using available resources.

Food Technology

Food Technology is a combination of knowledge and skills, scientific principles, use of equipment and management. Constituents of food technology are know- how, techniques, scientific principles, equipment use and organizational management [6]. In food technology for example, designers would be employed in designing food products and testing products and communicating their findings. At the same time scientists would look at physical, chemical and bio-chemical properties of food materials. Agriculturalists would be concerned about primary production, the quality of the food crop in order to meet human needs, while environmentalists are concerned about environmental issues. After crop production manufactures take over. They are involved in the secondary production, processing and making a variety of products from a single food.

In this research, technology is also seen as a problem solving process. In the process of problem solving, human skills, materials equipment and hardware resources are used in different activities in order to improve the quality of the product. In food technology this means varied products are available in abundance and there is no scramble for basic resources. This would contribute to an improved quality of life and a healthy society. A healthy society means that basic needs are satisfied, people live longer and there is good value for money. It also means that society has more time to pursue developmental activities.

Food Processing

Food processing is an important aspect of food technology. It is the conversion of an agricultural product to substances that have a particular textual, sensory and nutritional properties using commercially feasible methods [8].

The Structure of a food technology course means:

- Know how – on knowledge on foods, structure components.
- Skills – techniques of investigation, measurement of quantities, nutritional information, practical application to real situations.
- Scientific principles – biochemistry, micro – biology.
- Design and equipment – acquisition and use of special equipment for a wide range of foods, packaging equipment and related scientific technology, quality and safety.

- Management – production control, co-ordination of departments and processing systems of for example a food production plant.

Important aspects in Food Technology are:

- Biochemistry and microbiology: For properties and components of food, chemical and physical properties, nutritional properties, sensory properties of taste, texture appearance and odour.
- Food Processing: Processes associated with a food, possible products, reasons for using the food and methods.
- The food business: markets and market research, product development, shopping habits of consumers.
- Managing the making of food: control of production, co- ordination of manufacturing systems and quality control or Total Quality Management.
- Manufacturing Systems and Design: Design of manufacturing and production systems and methods, making products, packaging and dispatching.
- Research and Development: Product development, nutritional analysis, and product analysis.
- Information Communication Technology ICT): Responsible for nutritional labeling, development of software to communicate design ideas, CD ROMs, videos and video conferencing facilities. [8]

Food Technology in Zimbabwe

In Zimbabwe and in the region actions taken in education to adopt food technology should first of all remove boundaries between subjects and merge food science, food production and processing, and the food business and food management. This will enable the different areas to pursue technological projects that focus on the same goal. The main advantage of the merge is that different divisions would have a common target. This would promote a comprehensive understanding of food technology. Various areas of scholarship of food science, food processing, business and food management and information communication technology would have the same research target that is food technology as shown in Fig 1.1.

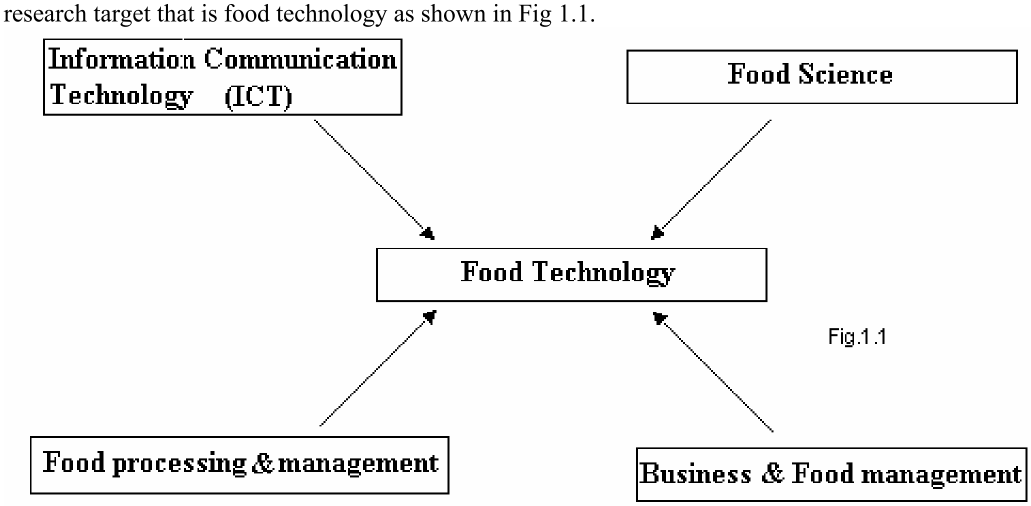

Fig.1.1

To implement food technology fully, fundamental changes will need to be made in conception, organization and execution of technology activities. These changes require modifications in the secondary and post secondary education curricula that have been dominated by a subject division and specialization. Thus, implied in the definitions is the concept that technology cuts across subjects and specialization. It also means simultaneous changes in teaching methodology so that students are involved in practically oriented research projects and food production. Secondly, this means removal of gender stereotyping that food related subjects are only for girls, by teaching food technology to both female and male students because food is everybody's problem.

Food technology should become part of education in the region for three major reasons:

1. So that current social realities on food supply can be addressed,
2. To bring together and harness cultural food processes and
3. To meet the needs of rural and urban societies through technology, education and training.

A holistic food technology program would be composed of:

- Food Science
- Food Processing
- Food Business and Management
- Product Development
- Information Communication Technology [8]

The program would cover for example:

Food Science:
- Composition, chemical, physical, nutritional and sensory properties

Food Processing:
- Primary and secondary products
- Production
- Nutrition
- Unit operations
- Processing
- Preservation

Food Business and Management:
- Markets
- Consumer habits
- Market research

Product Development
- Nutritional analysis
- Product analysis
- Scanning
- Measuring and recording variables

Information Communication Technology (ICT):
- Raw material evaluation for quality
- Food processing and control
- Software to communicate ideas
- Nutritional labeling

Suggested Model for Zimbabwe

In introducing food technology, there is need to adopt a holistic approach. This means incorporating scientific concepts from food science. Secondly, identifying the main foods that could be processed in different geographical areas or regions. Third, setting up major food technology plants with the necessary equipment for food processing. Fourth, carrying out research on foods and in the food business and management. Fifth, training product development personnel and analysts to develop various nutritious food products. Finally, setting up Information Communication Technology units at the plants for evaluation, control, and communication of ideas and findings. This model would address problems faced in Zimbabwe today.

Current Social Realities

Food consumption in Zimbabwe is culturally pluralistic and socially stratified. There are rural and urban societies. Their food needs are different. Rural communities still rely on subsistence farming for their food provisions. Maize is the staple food plus sorghum and millet in drought prone areas. Fresh vegetable and fruit are seasonal and available seasonally. Areas with irrigation have a continuous supply of fresh produce. Surplus fresh produce is transported to towns. However, some of the fresh food is wasted through rot due to over supply when there is a glut of any food. This is one problem that could be addressed through food technology.

As a staple food, maize is often used in its natural state. Usually, the staple food is preserved only for a short term using chemical methods. The maize sold to the Grain Marketing Board (GMB) is treated in the same way before processing. Storage of maize in silos is meant to preserve the grain before processing but this is only for a short time. Since the grain is not protected adequately, often it gets spoiled through environmental conditions. This is a second problem where food technology could be employed through food processing, research and manufacture.

During the drought years of 2001 to 2003, the government, United Nations and Non – Governmental Organizations (NGOs) have been involved in food distribution especially in rural areas. International food donations have often included "whole- meal" food packets that include a complete meal by including maize meal, Soya - bean flour and cooking oil to improve the nutritional value of the food packages. This has been an improvement on the local staple food and people's diet. The only problem has been on the alternative protein foods. These are not readily accepted by society due to cultural eating habits. Research and Development in food technology could assist in the processing, packaging and development of recipes of textured vegetable protein (TVP) and other protein foods. Foods with traditional flavours added to maize flour would be a nutritional advantage to consumers.

In urban areas, the population is separated according to economic status. Most members of society buy most of their food provisions. They consume mostly processed food. On the other hand, some members of society survive on a merger income and cannot afford enough food. Divisions between the two groups of society are increasing instead of diminishing due to inflation. The divisions are also an indication of differences in culture and food needs. Research on customer needs and preferences needs to be undertaken through food technology so that their different social needs can be addressed.

The economic differences between the groups means that the different groups are more likely to live on different diets. The absence of food technology and the lack of variety in foods has reinforced food stereotype by making people live on a limited range of food products. Food technology is necessary to help diversify the food industry so that they can produce a variety of food products in order to satisfy the needs of different social groups.

Food for health

Although there are minimum standards set for processing food, society continues to consume highly refined foods such as bread and white maize meal. There is no whole- wheat flour or straight run maize meal on the market. Also there is no healthy bread on the shelves. This is not a healthy situation. First, this means there is no clear policy in food processing. The absence of a clear food technology policy and set minimum standards has led to many people being engaged in food processing. Thus some indigenous millers, during the food shortage period produced sub-standard maize- meal, bread flour. Also, animal fats high in cholesterol find their way onto the shelves. Refined cereals and cereal products and foods high in animal fats are churned out for the unknowing consumer. Nutritional analysis and food labeling in food technology is a potential means of correcting this problem.

Food Management

The recent practice of buying, hoarding and reselling of food in urban areas has been symptomatic of mismanagement in the distribution of food. Society has also been plagued by queues and shortages for basic food commodities. There has been no diversification in the processing of food and its distribution. In addition, the market value of the foods has not been realistic in the past forcing some of those in the food business to opt not to sell basic foods. This has been a problem to society. A simultaneous opening of food technology manufacturing plants in different areas would alleviate the congestion by consumers in urban shops and at GMB. Secondly, total food production that involves processing, manufacturing and packaging of 'ready to cook' or 'ready to eat' foods would make more food available on the market.

Addressing needs of society through food technology

Food technology is one way of addressing the current food problems in the region and especially in Zimbabwe. This can be done through problem – solving. Problem solving is a process of addressing social needs in the environment [11] [12].

The problem in developing countries and especially in Zimbabwe is that there is a never – ending stream of food problems. Very little is done by those facing the problems because the culture of problem – solving through technology is lacking.

There are many social groups with different food needs. The main groups are rural and urban societies. The needs of rural and urban societies differ according to age, consumption habits, health and social class. Cultivating a culture of solving problems through food technology is essential. There are complex systems of society and on the other hand there are modern industrial technologies that can be used to solve these problems. The problem solving approach to food technology can be used to solve most of the food problems faced by Zimbabwe today. In this research, it is believed that the establishment of a good food technology foundation at school level, further education and university levels is a starting point. This will help to solve the numerous food problems faced by Zimbabwe and other developing countries.

Problem solving is a process. In a process there are stages to be followed systematically. These are:

- Identification of the problem or need
- Generating ideas to solve the problem
- Research and development on the problem
- Choosing the best solution to the problem
- Taking action to solve the problem
- Testing and evaluation of a product

Problem solving means social interaction with those experiencing the problem in order to find out the full extent of the problem. It also means carrying out research in society in order to express the variety of situations and not in the laboratory. It is also a way of bringing together to work the different scholarships in solving food problems. In practical terms, this means food science, planning, analyzing problems and taking decisions, testing and evaluating ideas on food be done under the umbrella of food technology.

Food technology and problem – solving means carrying out projects that are linked to industry. It also means producing a variety of tangible products that can be used to solve problems of society [10].

Being involved in food technology using the problem solving approach means participating in a variety of activities, using special equipment in measuring, processing and packaging food. It also means developing skills in different food technology areas called for by the type of project. Thirdly, it offers free enterprise to those involved in management of food businesses and in the marketing of food products.

Conclusion

Food technology would contribute to sustainable development in the country because skills from different scholarships would all be consolidated in the production of food products that can solve problems especially of rural consumers. In this way, food technology would play a major role in social development and poverty alleviation.

Market research and food product research should be pursued together by carrying out consumer research and trying out products. This calls for a departure from the traditional methods of teaching and learning in the classroom or laboratory to working on site in industries. In this way, more food products would be developed to cater for the needs of different groups. Improved food processing and preservation methods would be developed through market research. Research in the processing of local foods will be initiated. This could lead to small agro – food based industries in rural communities that could also supply urban centers with quality-processed food.

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Design of a Flood Water Powered Water Pump

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Abstract

The paper set to discuss the research to develop a machine that collects water from flooded rivers and pumps it to a reservoir so that it can be used to water crops during the interludes of dry spells that characterize the Zimbabwe rain season. This water is not necessary intended to irrigate the crop on full scale, but just to bridge the crop and sustain it during the critical weeks of the dry spells which usually stresses the crop beyond recovery even after the rains resume.
The simple machine designed relies totally on the force of the flood water to pump water from the river and send it to the reservoir, thus making it possible for the machine to be used in the rural areas where there is no electricity. The cost of the model that was built is given as well as the pictorial view of the model.

1.0 Introduction

Zimbabwe and most of the countries in Southern Africa are experiencing droughts which result from the unstable rainfall patterns (Hove, 1995). It is recorded in climatic history of Zimbabwe that some amount of rainfall was received even during the worst drought years. Hove (1995) said that prior to the 1980, the worst drought had been recorded in the 1946-47 agricultural season where rainfall had averaged 365mm. A study of rainfall patterns in Zimbabwe from as early as 1901 to 1995 show that drought years are usually preceded by normal rainfall years which have the annual average of 650mm (see Fig 1.1). A good example is the 1915 –1916 drought with below 400-mm average annual rainfall was over 800mm. If some water had been harvested from the heavily flooded rivers in that previous year the crop failure in 1916 would have been avoided as this water have been kept and used to sustain the crops during the bad year.

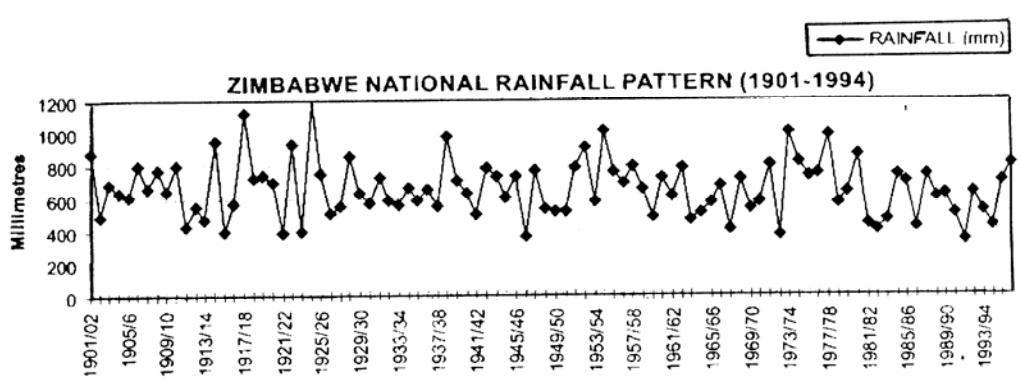


Fig 1.1: Zimbabwe .National Rainfall Pattern (1901-1994)

In Zimbabwe the rainy season has become short or in some cases it is characterized by long dry spells during the rainy season, which sometimes last up to four weeks. This has caused failure in the staple crop (maize) which cannot endure the hot dry spells when they become too long. As a result the crops dry before they mature. These dry spells usually occur in January and by the time the February rains fall the crop will be stressed beyond recovery. Trying to plant another crop in February will be a waste of time as the rain season usually ends in March, which will not give this crop enough time to mature. Information form Agritex Masvingo highlighted that the fact that the life of the crop becomes endangered when it reaches the permanent wilting point which usually occurs a few weeks or even days before the rains resume. As long as the crop is in the temporary wilting state it cannot be resuscitated even if the rains fall. A way to provide water at that crucial period when the plant is about to get into permanent wilting point and just keep them in controlled moisture-stress will enable the crop to be sustained until the next rains (Dewa, 2003).

Taking into consideration the fact that the December rains are usually very heavy and manage to flood rivers this water can be use to save the crop during dry weeks. Water can be kept using dams but this has its limitations which are:

- Dams are expensive to build
- The water in the dam still needs fuel or electricity to pump to the areas to be irrigated

Which is the reason why the farmers are hit by drought even if they live near dams.

The potential contribution of water-harvesting techniques in rain-fed areas include:

a) reduced pressure to invest in conventional water augmentation through large dams and run-of-the-river diversion schemes, among others;
b) relatively cheap technology easily available to poor farmers
c) Environmental benefits with reduced pressure on groundwater resources.

1.1 Water Harvesting

Developments in water-harvesting systems, which include low-cost, labor-saving techniques as well as construction materials for building catchment bands and distributing water, induce more adoption as they offer agricultural and ecological benefits. The advent of precision agriculture, which makes use of site-specific soil, crop and environmental data, and contour plowing and precision land leveling make water harvesting even more attractive. Conservation tillage, such as minimum till and zero till, together with precision agriculture and water harvesting, increases the effective rainfall used for crop production.

However, despite the apparent advantages of this water-harvesting technology, social and economic conditions of farmers may be constraining adoption as indicated by the abandonment of some constructed water-harvesting schemes (WFS, 1996). This suggests the need to realistically take into account expected gains in yield for certain levels of inputs, the risks involved, labor requirements and cash flow at the household level. Moreover, governments in arid and semiarid countries are still to acknowledge the value of water harvesting as part of rural development, specifically, as a central component of the water and agricultural development policy. Further research is required to understand and overcome the apparent policy and institutional constraints to scaling up these technologies, and to understand the possible hydrological limits to expanding water harvesting in upper catchments.

1.3 Sustainable Management of Groundwater

In many countries with high levels of rural poverty, groundwater development offers major opportunities for promoting food and improving livelihoods. Simple and affordable innovations in water-lifting technologies, such as the treadle pump and the motor-pump technology, have the potential to dramatically improve poor people's access to groundwater, The capital requirements to develop groundwater irrigation are generally low and its productivity is generally higher than that of surface irrigation. Farmers tend to exercise more care in using it because of the costs involved in lifting water, thus maximizing application efficiencies. It also offers farmers irrigation water "on-demand" and a relatively reliable source in times of drought (Mahoo, Mzirai and Hatibu, 1999).

There are tremendous opportunities to apply both African-grown and African-adapted low-cost technologies for lifting and applying water for agricultural use, for example: bucket or drum and drip systems; treadle pumps and small low-cost power pumps; and conservation farming. The main issues that need to be addressed are to identify what institutional arrangements, support systems and policy requirements are needed at different scales to encourage innovation and enabled option and sustainability of more productive, environmentally sustainable and profitable water-and land-management innovations. To promote innovative approaches in water in agriculture, an enabling environment is very important. The recent World Summit on Sustainable Development and the launching of NEPAD at the highest political levels offer us an opportunity to reverse the negative trends of the past, building on positive experiences in Africa and elsewhere, and finally helping Africa achieve its vision of a better life for all (Hatibu, (2003).

2.0 Flood Water Pump Design

2.1 Design Brief and specifications

The aim of the underlying project was to design a simple machine that will enable pump water from flooded rivers using the force of the floodwater as its main source of energy.

Based on the above aim the following were some of the specifications needed:

i) The water pump designed needs to pump water using the force of the flood.
ii) It needed to be able to pass this water to the reservoir without any form of fuel or artificial forms of energy.
iii) The machine would also need to have enough power to overcome the resistance meet in pushing water through pipes to a reservoir situated on high ground.
iv) In designing the machine the issues such as rusting needed to be considered.
v) The machine was designed to be able to change the turbine blades when necessary depending on the force required.
vi) The machine needed to be mounted on a very strong foundation so as to survive the possibility of being swept away by the flood.

2.2 Audit on Flood Rainfalls

To achieve the above objectives there was need to obtain a clearer picture of he flood patterns of the rivers in the case study provinces (Masvingo and Midlands). Interviews with three subsistence farmers in the Zimuto area of Masvingo and three from the Mutevaedzi area of Mberengwa (Midlands) were held. The following questions were asked;

i) Have you experienced any periods in the rain season when crops in your area have suffered from moisture stress
ii) What is the usual length in weeks of these dry periods
iii) What is the length in hours of the average flood of he Bubye or Popoteke River
iv) Have you ever experienced a drought season where the Bubye or Popoteke River did not flood?

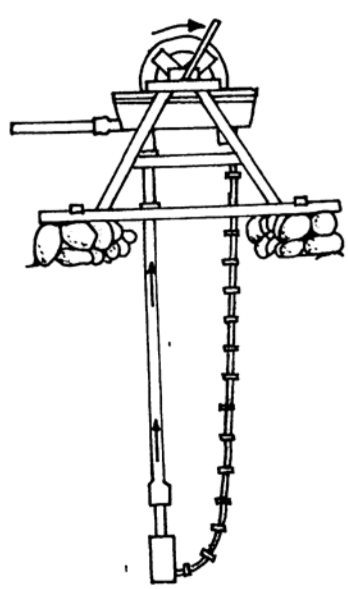
All the farmers interviewed stated strongly that the maize crop in their area always suffered from moisture-stress as a result of long dry spells in the rain season. The three farmers from Mberengwa stated that in their area the dry spells usually stretched for up to five weeks. On of the farmers further explained that the crops usually endured the stress for the first three to four weeks because of the high moisture retention rate of the loam soils in their area. He went on to explain that the crops usually got bad in the fourth and fifth weeks and if the rains fell latter than that it would be too late for the crop to recover. Responding to the first question all the three farmers from Mberengwa and Masvingo areas stated strongly that rivers got flooded more than three times in good years and that there is no year they remember where the river did not flood. Based on this information this is an indication such information of floods even down to district levels should be documented and archived for future use in designing for appropriated technology.

Responding to the question about the length of the flood, two of the three farmers from Mberengwa claimed that Bubye river takes at least six hours to get back to its normal flow when it get flooded. The other farmer claimed that the flood takes more than seven hours. All the three farmers from Masvingo stated that the Popoteke River usually gets flooded for at least five hours. Thus there was need to design an effective pump that would have the capacity to pump enough of the needed water fast enough in five hours.

2.3 Type of pump and machines available

Before the one could come up with a design there was need to know what other designs were available.

Fig 2.1: The rope (soga) pump



2.3.1 Rope pump

Arlosoroff et al. (1987) says these pumps use a series of rubber discs along a nylon cord which when it drags the rubber disc through a narrow pipe produces a pulling affect which pumps the water to the surface. The pictorial view is shown in Fig 2.1.

2.3.2 Puno-Pump

The conventional puno-pump and the direct action pump, pumps water by creating a vacuum when the pistons are pulled up causing water to be sucked into the cylinder through the inlet valve. The water moves further up through the outlet valve on the piston and as this action is repeated, the water is pumped further up until it spills through the outlet pipe. (see Fig 2.2)

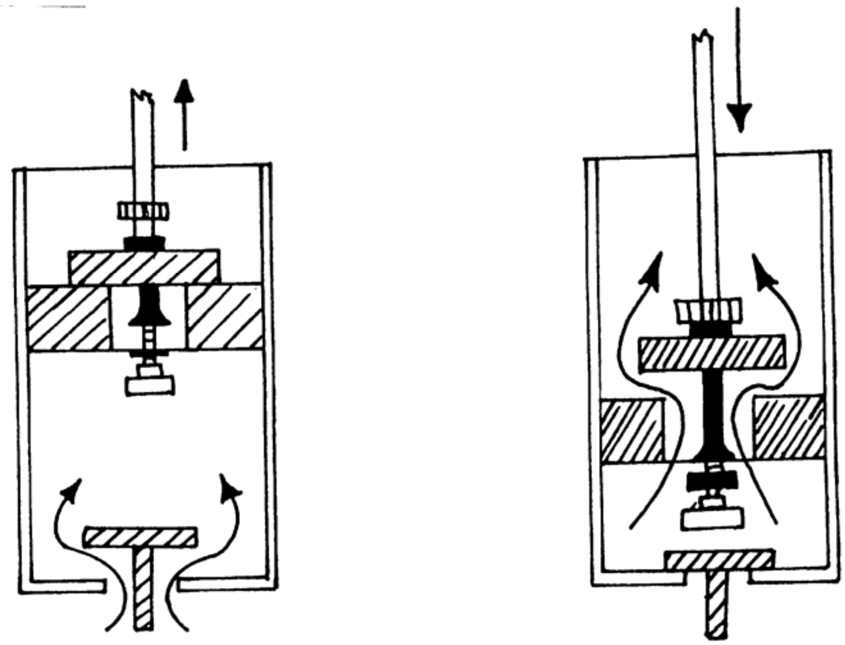


Fig 2.2: Puno-Pump

2.4 Model design

2.4.1 Materials

For the basic framework it was decided to use mild steed which strong enough to withstand the forces of abrasion that occur when the machine runs.

2.4.2 Performance

The machine basically consists of a turbine with wide blades, which will be pushed by the running water, causing the turbine to rotate. The turbine will be attached to the crankshaft, which will rotate with it thereby pedaling an arm attached to a piston in a cylinder. The upward movement of the piston would suck water into the cylinder through the inlet valve and the down ward movement would compress the water and push it out through the outlet valve.

The pump attained a speed of 52 revs per minute which means that its average speed can be rated as 120 revs per hour. The pump with an average cylinder volume of 10*l* in an average rive should be able to pump 31 200 litres per hour calculated as follows:

Volume of water per rev	= 10*l*
Number of revs/ throws per hour	= 3120
∴ Amount of Water per hour	= (Volume pumped per rev x revs per hour
	=10*l* x 3120
	= 31200*l*/hr

Assuming that an average flood takes 4 hours the volume of water pumped per flood will b 124 800*l* per flood.

This amount of water may seem insignificant but it may mean the sustaining of crop enough to survive the heat stress before the next rains.

2.4.3 Model Flood Water Pump and Costs

The pictorial view of the pump design is shown in Fig 2.3 while the bill of material and their estimated costs is shown in Table 2.1.

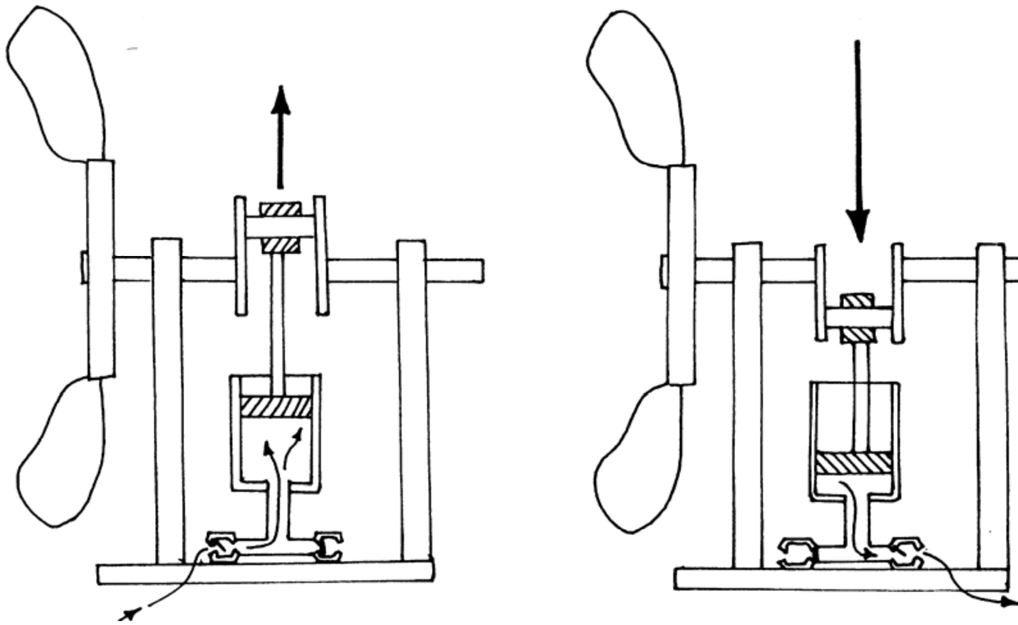


Fig 2.3: Pictorial View of Model Flood Water Pump

Table 2.1: Bill of Material and the estimated cost

No	Material	Quantities/ Units	Area of Use in project	Estimated Cost
1	Solid Mild Steel bar (50mm thickness)	1m	Supporting Bars and hub Mounting Rail	\$9 000-00
2	Valves	2	Pump unit	\$5200-00
3	Solid Mild Steel cylinder (¬60mm)	100mm length	Making the piston	\$950-00
4	Welding rods (mild steel)	5	Welding the parts together	\$2300-00
5	Red Oxide	0.5*l*	Prime coat for machine	\$2800-00
6	Alka Paint	0.5*l*	Painting the machine	\$3168-00
7	Metal Sheet	(600 x 400) mm^2	Making the blades	\$2800-00
Total Cost of Material for the Model				\$26 218-00
Estimated cost of the real pump of 1: 10 scale compared to model = \$262 180-00				

3.0 Conclusion

The paper briefly set the justification of the project by looking at the rainfall pattern in the Zimbabwe since 1901 to 1994 thus the justification of te necessity to harvest flood rain.Brieflt was discussed the importance of harvesting rain coupled up with sustainable management of groundwater. The citation of other examples of pumps considered in the design leading to the final design of the FloodWater Pump. In conclusion the cost of the model pump ready for commercialization was given. The project is worthy pursuing up to commercialization since it will help sustain the crops thus alleviate poverty in the country and in the region

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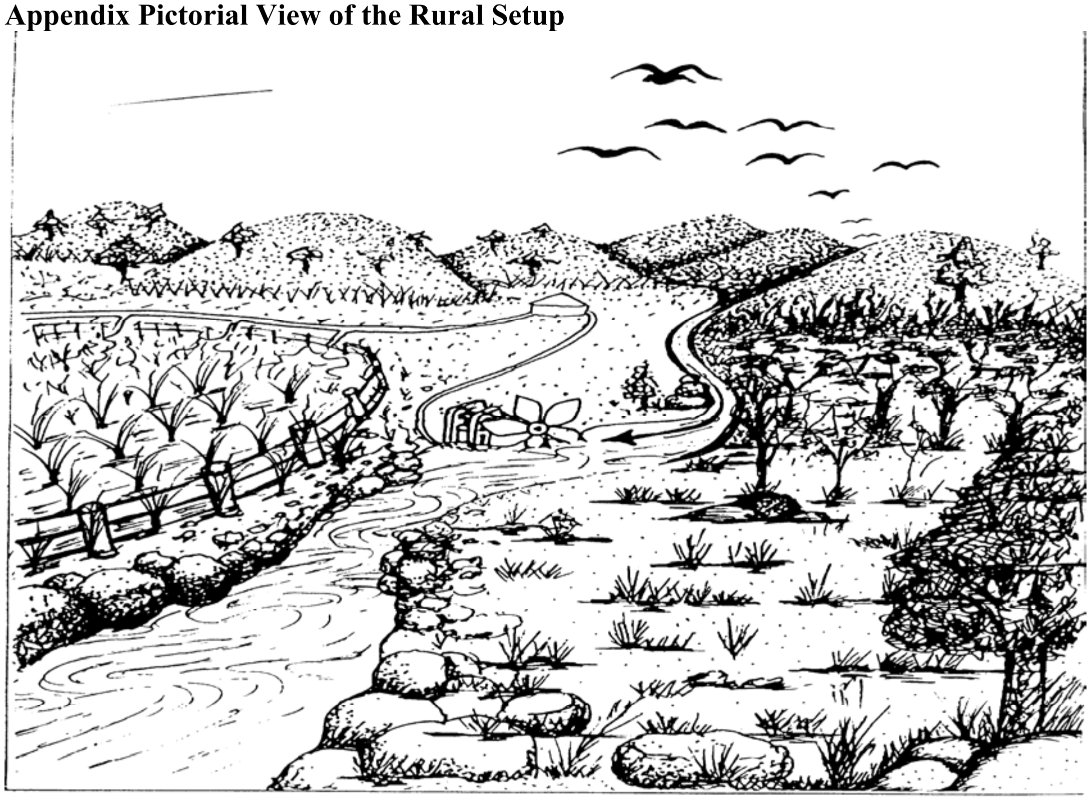
Appendix Pictorial View of the Rural Setup



An Organizational Framework for the Creation of Economically Vibrant Agricultural Cooperatives under Land Reform

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Key Words: sustainable agricultural cooperatives, land reform, appropriate technology

Abstract

Land reform is an opportunity to create new systems of local governance and sustainable agricultural communities. It must be designed to achieve these objectives. This paper presents twelve guiding principles for the establishment of economically vibrant agricultural cooperatives resulting from the redistribution of previously large, productive agricultural lands into the hands of the masses (land reform). Under a cooperative economic and democratic governance structure, leaders are held accountable to the application of these principles. Processes may then be established which, effectively and continuously, give birth to innovations and solutions which are indigenously created, situation specific, environmentally and economically sustainable, of value to all stakeholders, and enhance the quality of life of the community. Appropriate technology is recognized as a process, which systematically generates solutions by and for the benefit of the local community rather simply by the application of a specific solution to a local need. As a process, it can be designed, modeled, analyzed and refined for maximum efficiency subject to the priorities and strategic plan of the organization. Maximum value can be achieved for the community when the structure of the cooperative achieves a healthy balance of order and disorder; of accountability empowered to create, innovate, and renovate itself.

I. Appropriate Technology in the Context of Land Reform

In Zimbabwe, as in much of the colonized world, "colonial policies of expropriation gave a few thousand white farmers ownership of huge tracts of arable land. According to government figures … some 4,400 whites owned 32% of Zimbabwe's agricultural land, around 10 million hectares. Meanwhile, more than one million black families have struggled to survive on land that was allocated to Africans by the colonial regime." [1] Land reform typically represents the effort of a governing body to reclaim and redistribute large tracts of land to its indigenous people. It is an attempt to reverse a legacy of parasitism which has depleted the host nation's human and natural resources. "In the first phase of Plan Zamora [Venezuela, 2003], more than a million hectares were transferred to *campesinos* [peasants], benefiting more than 40,000 families. The government handed over 31,437 land deeds, 121 farm machines and 30 billion bolivars (US$20 million)."[2]

Land reform is a chance to start anew and establish a new paradigm for land resource management aimed at poverty reduction and self-sufficiency. "Once the legal device of private property has been removed, there is freedom to arrange everything anew – to amalgamate or to dissolve, to centralize or to decentralize, to concentrate power or to diffuse it, to create large units or small units, a unified system, a federal system, or no system at all" [3].

This paper presents an organizational framework for the creation of economically vibrant agricultural cooperatives within the context of land reform. The organizational model of the cooperative must be structured for sustainable development. Prior solutions involving large-scale mechanization implemented by the large-farm landowner must be reexamined against criteria of appropriateness.

The idea of establishing agricultural cooperatives in the land reform movement is not new. Significant precedents are noted in Cuba (1959), Thailand (1975), Philippines (1988 and 1999), and recently, Venezuela (2003). "If we really want to end world hunger, returning of agricultural land to local communities for cooperative farms will provide miraculous results. Limiting export crops is another important key. What we won't see is large profits for corporate interests, of course, but more people will have essential nourishment."[4]

It is the expectation that an effectively organized cooperative will also be a progenitor of multiple technological solutions contributing to the goal of sustainable development (ie. meeting "the needs of the present without compromising the ability of future generations to meet their own needs"). [5]. Appropriate technology is understood to be a process, which produces solutions (products, decisions, or methods) whose outcomes support the goals of sustainability. It is akin to the field of operations research, which applies mathematical and scientific methods to organizational problem solving.

Appropriate technology is inherently a local solution to a common problem applying scientific principles against sustainability criteria. It thus mandates empowerment of the local stakeholders in order to produce their own solutions. In the context of an agricultural cooperative, appropriate technology is inseparably concerned with the practical management of the cooperative. Its success is tied to the delivery of positive, understandable conclusions to decision makers when they are needed. It adopts an organizational point of view and seeks optimality for the entire cooperative and its stakeholders.

Appropriate technology, like operations research, involves a team approach of individuals highly trained in the disciplines of "mathematics, statistics and probability theory, economics, business administration, electronic computing, engineering and the physical sciences, the behavioral sciences, and the special techniques of operations research."[6] The cooperative must allocate resources to solve problems. The process involves: data collection, observation, mathematical modeling, analysis, establishment of short and long term criteria, research and validation of precedents, design and testing, implementation of an optimum solution at an appropriate scale, and solicitation of feedback for future improvement.

Twelve principles are introduced to guide the governance and administration of the agricultural cooperative. The principles strategically address some of the lethal pitfalls, which have permanently crippled today's developing nations, ensuring they remain in complete servitude to the developed, parasitic nations. They represent a blend of cooperative economic concepts and core values, which are intrinsic to some of the world's best managed organizations and technology companies.

II. An Organizational Framework for Agricultural Cooperatives

"The Ministry of Agriculture [Cuba] is able to turn food production units into self-supporting co-operatives, so it concentrates on innovation and exploration of new ideas like agro-forestry and community and municipal composting projects; and on infrastructural projects like the reforestation of the city. This organization was given world-wide recognition when they were awarded a Right Livelihood Award in 1998 by the Swedish Parliament "[7]. A report by Food First co-director Peter Rossett notes that "research shows that small farmers are more productive and more efficient, and contribute more to broad-based regional development than do the larger corporate farmers" [8].

As part of a national economic strategy, land reform policies should promote the establishment of small-scale, farming cooperatives within the newly appropriated lands. Their internal organization should be democratic and sustainable in its governance. It must be designed to consistently produce outcomes, which simultaneously benefit both the individual landowner as well as satisfy stakeholder expectations. The recent decision of Zimbabwe's government to nationalize its productive farmlands centralizes the control of land distribution and land use. It eliminates title deeds and enables the implementation of a national economic strategy. "Ultimately, all land shall be resettled as state property. It will now be the state which will enable the utilisation of the land for national prosperity," stated Land Reform Minister, John Nkomo.[9]

The following is a conceptual organizational framework for a large agricultural farm, which has been repossessed by the government under a land reform initiative. It is proposed that a series of agricultural cooperatives be established within the redistributed lands and that each unit of the cooperative be represented by a democratically elected leadership. The leaders of each unit would form a Board of Oversight for the cooperative.

As an illustration, in Zimbabwe, the average size of a repossessed farm is approximately 2,445 hectares. The land could be sub-divided equally into 12 cells of approximately 200 hectares, each of which would support a community of 50 families using a ratio of 4 hectares per family. The 12 contiguous cells may then be, jointly and legally, organized to constitute a Landowners' Cooperative (Fig. 1). Property would be classified as either common or private. Each family within a cell would own a plot of land (private) for basic housing and would also be a stakeholder in the remaining (common) land of that cell. Seventy percent of the land in the cell would be designated for agricultural use. The common land within the cell is held in trust by a Board of Trustees formed from the families. All families in that cell share a stake in the management of the common land in accordance with a set of guidelines to be developed by the Board of Trustees.

Each cell would be subdivided into residential, commercial, industrial, and agricultural zones, according to a consistent array of criteria established by the national government (Fig. 2). The Board of Oversight would be given responsibility for determining which crops are to be cultivated within a particular cell; food crops for sustenance within the cooperative and cash crops for trade. Crops considered for export may be purchased by traditional buyers or by other cooperatives in the region.

Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6
Cell 7	Cell 8	Cell 9	Cell 10	Cell 11	Cell 12

Fig. 1 – Conceptual Delineation of Cells in a Cooperative

As stewards of the land in their cell, all families are charged to organize their labor for maximum productivity of the cell. Within a cell community, other key functions, such as provisions for education, health, safety, culture, and economic development, would be performed by the families within that cell. Functions beyond the capability of a cell may be performed by entities in other cells or through a combination of cells. The assignment of families to a cell would consider the complete range of skills needed to ensure that the cell's basic needs are addressed. All cells in the cooperative are to be interdependent, collectively striving for self-sufficiency and autonomy. Ideally, their essential needs are met through the resources developed by the cooperative.

Cell #1 **Cell #2**

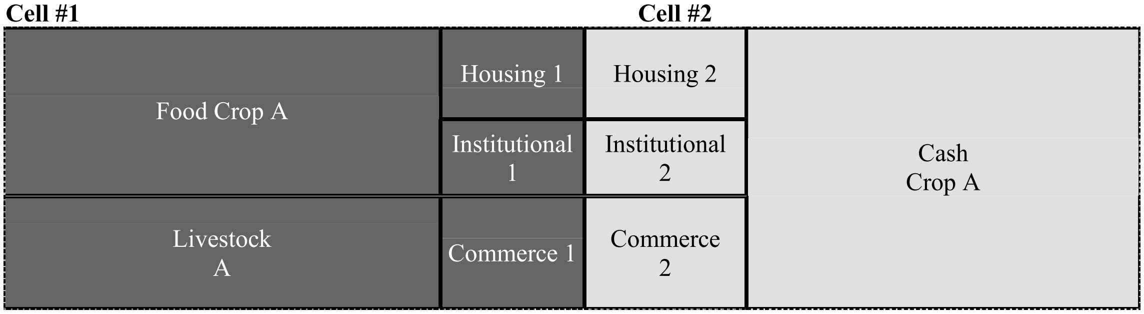

Fig. 2 - Example of Land Zoning for Two Adjacent Cells

The Board of Oversight will consist of two elected leaders from each cell. The Board is responsible for ensuring overall productivity of the resources within the cooperative. It is accountable to the local cells in the performance of their duties and is bound in their decision-making to the guiding principles presented later in this paper.

Reporting to the Board would be five functional division leaders representing the following functional areas: Community Infrastructure, Export and Import Processes, Education and Training, Community Services, and Technology.

Technology	**Community Infrastructure**	**Export and Import**	**Education and Training**	**Community Services**
Agriculture	*Road and Transport Systems*	*Community Banking*	*Trade Schools*	*Security and Emergency*
Animal Husbandry	*Energy Systems*	*Exports*	*Primary and Secondary Schools*	*Human Resources*
Education	*Water Supply*	*Imports*	*Adult Education*	*Health Systems*
Construction	*Facilities*	*Partnerships*	*Distance Learning*	*Media*
Information Systems	*Environment and Waste Treatment*			*Economic Development*
Communication	*Utility Distribution*			*Culture and Recreation*

Fig. 3 – Major divisions of the Landowner's Cooperative and their departments

Each functional division would be supported by a Quality Assurance Group. This is an interdisciplinary team responsible for identifying community needs, evaluating compliance of strategic goals/objectives, monitoring internal and external customer satisfaction levels, developing strategies for improvement in all relevant areas identified in a strategic plan, analysis of the cooperative's performance against a balanced scorecard of key measures, fact finding and data validation, reporting and recommending solutions to difficult challenges, and anticipating/predicting future trends.

Stakeholders in the successful performance of a cooperative would be: the family unit, the national government, purchasers of cash crops and other products, vendors and service providers, and other cooperatives. The Quality Assurance Group determines stakeholder satisfaction using tools such as annual surveys and interviews, focus groups, weekly roundtables, monthly village meetings, guided discussions, and weekly leadership team luncheons.

III. Guiding Principles for an Effective Organizational Structure

Many rural black Zimbabweans have expressed a profound disapproval of the manner in which the government has carried out land reform, in particular, the lack of clear criteria for the allocation of land and the lack of structured support for new settlers. "This issue of land, we are not saying people should not be given land, of course they should; but it should be done in a proper way. Some people can just go and settle at a place where there are no facilities like water, schools, clinics, sanitation...And the loss of jobs brings hunger to the farming areas, since the workers aren't buying from the small-scale farmers either."[10] A UNDP technical team considering the fast track land reform program in late 2001 noted that "the provision of roads, schools, clinics and boreholes, etc. was lagging far behind settler emplacement," and that the provision of essential public infrastructure within a reasonable timeframe "will be impossible on the Government's past track record and its current implementation capacity" [11]

Land reform must, therefore, must have a rational plan and be implemented in a "proper way". There must be a set of guiding principles which, when codified, will lead to the desired end. According to Mr. Tsvangiraia, leader of Zimbabwe's Movement for Democratic Change, a "change in land and economic distribution and utilisation in Zimbabwe must be based on a sustainable programme" [12]

In Haiti, Aristide's Lavalas movement demanded a 'cleansing flood' after decades of Duvaliarism. For land reform to be effective, it requires a cleansing of value systems imposed since the colonial era before new thought can be introduced. The 12 principles which follow serve to underpin the organizational principles of the cooperative. Together they define an ideology for governance which is pro-local, pro-worker, pro-stewardship, pro-cooperation, pro-wealth creation, pro-environment, entrepreneurial, and democratic. These principles and their corollaries by no means represent an exhaustive and comprehensive set. They are merely a beginning.

Principle One: Common Heritage - Recognize that land and natural wealth are free to everyone. Stewardship, rather than ownership, is our primary responsibility as citizens of the earth. The International Forum on Globalization has identified three categories of common heritage. The first category includes the water, land, air, forests, and fisheries on which everyone's life depends. The second encompasses the culture and knowledge that are collective creations of our species. Third, are those public services that governments perform on behalf of all people to address such basic needs as public health, education, public safety, and social security, among others [13]. Efforts to monopolize an essential common resource are consistently detrimental to society.

"As one analyses the primary monopolies of land, technology, money, and communications, it becomes apparent that residual-feudal exclusive title to a gift of nature creates unnecessary social costs. Instead of society paying non-producing monopolists, nature's bounty should be distributed to all a nation's citizens through the land tax structure, patent structure, or financial structure of private ownership within a modern commons" [14].

Principle Two: Subsidiarity - Whatever decisions and activities can be undertaken locally should be or should favor "the local whenever a choice exists" [15]. Subsidiarity recognizes the inherent democratic right to self-determination of people, communities, and nations as long as its exercise does not infringe on the similar rights of others. "In other words, legitimate authority flows upward from the populace through the expression of their democratic will" [16]. Subsidiarity teaches us that loyalty can grow only from the smaller units to the larger (and higher) ones, not the other way round – and loyalty is an essential element in the health of any organization. … The center will gain in authority and effectiveness if the freedom and responsibility of the lower formations are carefully preserved, with the result that the organization as a whole will be "happier and more prosperous" [17]. In the context of an agricultural cooperative, the principle of subsidiarity empowers the cell leadership to the handle those issues most affected by them.

Principle Three: Disorder within Order - Large organizations require order and accountability structures to function efficiently. In contrast, entrepreneurial organizations, being small, need a great deal of freedom and creativity and are characterized by a semblance of disorder. Both can co-exist within a cooperative if the *Principle Two* is enforced. "The large organization will consist of many semi-autonomous units. …Each of them will have a large amount of freedom, to give the greatest possible chance of creativity and entrepreneurship"[18]. Simultaneously, it must be recognized that it is "difficult for top management to carry through their creative ideas without impairing the freedom and responsibility of the lower formations." This dynamic of competing priorities must be embraced in the governance of the cooperative but monitored for imbalance.

Principle Four: Cooperation - Each unit within the cooperative must work together, support each other, understand the value of each other, defend each other, and celebrate with each other. The establishment of trust between workers and leaders is essential to productivity gains. The human body best illustrates this principle. "For the human body is not one member but many. ... Members of the body which seem to be feebler are necessary … but God hath tempered the body together, having given more abundant honor to that part which lacked, that there should be no schism in the body, but that the members should have the same care one for another. And, whether one member suffers, all the members suffer with it; or one member be honored, all the members rejoice with it" [19]. People will generally act in accordance with their personal motives. However, non-competitive systems of reward and recognition may be implemented which promote cooperation while respecting the self-directed motives of the individual.

Principle Five: Vindication – A subsidiary unit needs to be defended against reproach or accusation by its governing body. The principle of *Vindication* describes this responsibility of central authority towards lower formations [20]. This aspect of organizational governance recognizes the need for protection of the subsidiary unit (cell or functional division) against forces which seek to disrupt its effectiveness or to destroy it. Protection may be legal, informational, equipping, or a form of policing, as may be appropriate.

Principle Six: Visionary Leadership – The leadership of the cooperative and cells must set directions and reinforce a customer focus, clear and visible values, and high expectations. The directions, values, and expectations should balance the needs of all stakeholders. As servant-leaders, they are responsible to all stakeholders for the ethics, vision, actions, and performance of the cooperative. They are responsible to the cooperative's governance body for their actions and performance. They should serve as role models through their ethical behavior and their personal involvement in planning, communications, coaching, development of future leaders, review of organizational performance, and staff recognition. [21]

Principle Seven: Customer-Driven Excellence – The cooperative's customers are both internal and external. Interdependence of units within an organization establishes the customer relationship. The product one cell supplies or the function performed for another cell must be performed at maximum value to that "customer". Each internal customer must, therefore, document the standards of excellence required and communicate the degree of compliance achieved. Similarly, the expectation of maximum value must be defined and documented by each external customer to the organization. Systems must be instituted to "listen to the customer", thereby receiving feedback for process improvement and correction of shortcomings. Such behavior leads to customer acquisition, satisfaction, preference, referral, retention and loyalty, and business expansion. [22]

Principle Eight: Future Focus - Sustainable organizations seek to understand the short and long term factors that affect their internal operations and threats to survival, externally. Pursuit of sustainable growth requires a strong future orientation and a willingness to make long-term commitments to key stakeholders—customers, employees, suppliers and partners, stakeholders, the public, and the community. A strategic planning process is essential if the organization is to anticipate change, in all its facets. The planning process must develop a clear vision and identify key success factors for each unit of the organization to become a high performing component of the system. Strategic objectives must link goals to stakeholder requirements and assessments of organizational strengths and weaknesses. A focus on the future includes: developing employees and suppliers, setting measurable targets for each measure of performance based upon relevant data, creating opportunities for innovation, and anticipating technological developments [23].

Principle Nine: Worker Integrity - The United Nations Universal Declaration of Human Rights established certain core rights for individuals such as "a standard of living adequate for … health and well-being, …including food, clothing, housing and medical care, and necessary social services, and the right to security in the event of unemployment" [24]. A program for worker development and fulfillment within and outside of the work place must, therefore, be a central part of organization building. Similarly, the rights and integrity of all workers must be eminently maintained. Essential to worker integrity is the design of meaningful work processes. "If the nature of work is properly appreciated and applied, it will stand in the same relation to the higher faculties as food is to the physical body. It nourishes and enlivens the higher man and urges him to produce the best he is capable of" [25]. Meaningful work must, therefore, be a necessary criterion in the division of labor within the cooperative.

Principle Ten: Continuous Improvement - For an organization to be robust and long-lasting, it must develop a culture to always improve performance. Achieving the highest levels of performance requires a well-executed approach to organizational and personal learning. Organizational learning includes both continuous improvement of existing approaches and adaptation to change, leading to new goals and/or approaches. It must be embedded in the culture of the cooperative. It must be a regular part of daily work. It should be practiced at personal, work unit, and organizational levels. Learning results in problem solving at its source. Learning is focused on building and sharing knowledge throughout the cooperative. It is driven by opportunities to effect significant, meaningful change [26]. Systems of continuous improvement generate new technologies through processes which are indigenously created, situation specific, economically and environmentally sustainable, and which produce value and/or quality of life enhancement for the populace.

Principle Eleven: Fact-Based Governance - Organizations must depend on the measurement and analysis of performance for their success. Such measurements should derive from real business needs and strategy, and they should provide critical data and information about key processes, outputs, and results. Many types of data and information are needed for performance management. Data should be segmented to facilitate analysis, extracting larger meaning from data and information to support evaluation, decision making, and improvement. Analysis entails using data to determine trends, projections, and cause and effect that might not otherwise be evident. Analysis supports a variety of purposes, such as planning, reviewing overall performance, improving operations, change management, and comparing performance with competitors' or with "best practices" benchmarks.[27]

Principle Twelve: Avoid Debt - A debtor is slave to the lender. Organizations which are intended to be long-lasting, sustainable, and healthy must deliberately avoid the debt trap. Once the most promising organization submits to the peonage of debt, in anticipation of future development or growth, it loses its freedom to excel on its own terms. "Macro-level policy prescriptions by the International Monetary Fund, the World Bank, regional development banks and the World Trade Organisation have caused tremendous difficulties and have imposed on them a model of development that suits the interests of developed countries and trans-national corporations."[28]

"Wealth that is skimmed off by the elite of developing countries and deposited in foreign banks is a large factor in the developing world's debt burden" [29]. "A debtor who repeatedly borrows more than the surplus his labor or business enterprise produces will fall further and further behind in his obligations until, sooner or later, the inexorable pressures of compound interest defeat him" [30].

Land reform initiatives, which link loans to land redistribution, sow seeds of dysfunction and ultimately seals the destiny of the landowner. Regions cannot develop a healthy economy without broad-based local buying power. "It is, after all, consumer purchasing power – adequate wages, adequate commodity prices, and profits form efficient industry and efficient traders – that determines who ends up with the world's wealth" [31]. Adam Smith comments, "If labor owned the capital it produced, then labor would employ—rather than be employed by—capital. Once subtly monopolized by exclusive title, capital's use can be denied to labor at any time, and it will be denied if no profit is made" [32].

Within the context of land reform initiatives, the establishment of a network of small farming cooperatives whose structure is democratic in governance, and is aimed at achieving a healthy balance of self-sufficiency, interdependence and symbiosis is an effective prescription for sustainable economic development. Processes may then be incorporated which, effectively and continuously, give birth to technological innovations and solutions to problems which are indigenously generated, situation specific, environmentally and economically sustainable, of value to all relevant stakeholders, and which enhance the long-term quality of life of the community.

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DEVELOPING AN ONTOLOGY FOR APPROPRIATE TECHNOLOGY PROJECTS IN DEVELOPING COUNTRIES

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ABSTRACT

Appropriate Technology-the technology, which is suited to the environment or context in which they will be used-, has now been recognized as an essential element in all development work in developing countries. ***Appropriate Technology is not simply some identifiable technical device, rather it is an approach to community development consisting of a body of knowledge, techniques and underlying philosophy. There is the need to identify, capture and represent this knowledge in a machine–readable form to enable sharing of information among Researchers, Appropriate Technologists and Software Agents.***

This paper traces the development of a comprehensive Ontology for appropriate technology projects, which can function as a unifying knowledge base or framework for the appropriate technology concepts, techniques, terminologies and theories and serve as the basis for communication between people with different viewpoints and terminologies arising from their different contexts or background, and also help achieve inter operability among systems. A taxonomy of concepts in appropriate technology projects is developed using Repertory Grid and Protocol Analysis to elicit the knowledge from Appropriate Technology textbooks and Reference Manuals. The elicited knowledge is then to be validated through interviews with experts and finally the ontology is coded using the Delphi development environment.

INTRODUCTION:

Socio-Economic conditions in developing countries and its attendant problems have underscored the need to articulate an effective approach to development projects to ensure that benefits from such projects are within the reach of the people regardless of where they live. The technological orientation of this development paradigm is what is referred to as Appropriate Technology.

Appropriate Technology-the technology, which is suited to the environment or context in which they will be used-, has now been recognized as an essential element in all development work in developing countries. Since the ideas of appropriate technology were introduced, the appropriate technology movement has gained a vast number of adherents, including some governments and a good deal of aid agencies. Some of these adherents have incorporated appropriate technology into their development programmes and projects have been initiated under this paradigm some of which can be categorized into, but not limited to, Agriculture Technology, Food Processing, water Supply, Architecture, Alternative Energy Systems, transportation, Construction, Sanitation, Irrigation Projects, Small Scale Industry, Technology in Mining, Technology and Health, Forestry And Wildlife, Computing and Textile Technology.

The growth in interest in appropriate technology so far has not been matched by the successful implementation of projects, where success is defined in terms of the proportion of investment resources incorporating appropriate technology [1]. If appropriate technology is to become a reality for the majority, rather than a minority cause, it is important to explore why this is so. Doing so points to the direction the appropriate technology movement will need to go, over the next decade. Appropriate technology projects like many enterprises depend on knowledge to make decisions affecting their operations, which is currently unavailable. Appropriate Technology cannot be seen simply as some identifiable technical device, rather it is an approach to community development consisting of a body of knowledge, techniques and underlying philosophy [2]. The failure of most of these projects lies in the non-availability of a knowledge base that seeks to integrate information on these projects that could be shared among researchers and the proponents of this technology. It is therefore the need to identify, capture and represent this knowledge in a machine–readable form to enable sharing and reuse of information among Researchers, Appropriate Technologists and Software Agents and also enable communities make informed choices regarding these projects.

The form in which this knowledge will be represented is very important. This is because there could be varying viewpoints and assumptions regarding what is essentially the same subject. Each may use different jargon or may have differing, overlapping and/or mismatched concepts, structures and methods. One way, to allow knowledge sharing and reuse, is to lower or eliminate conceptual and terminological barriers bringing all parties to a shared understanding. Such an understanding can function as a unifying framework for the differing viewpoints and serve as the basis for communication between people with different viewpoints arising from their different contexts, and also help achieve inter operability among systems [3].

Unfortunately, the information resources currently available [4] are normally available as a collection of heterogeneous databases distributed on a private Intranet or on the Internet. These Information resources usually implement conceptual models, which are characterized by tacit and meta-level knowledge about the concepts they model. They are not semantically rich enough to enable information sharing and reuse by applications from different domains. A comprehensive ontology has been proposed as specifications on an abstract level above conceptual models and [5] has been considered as an adequate methodology to support a variety of knowledge management activities including Knowledge Elicitation, Representation, Storage, Retrieval, Sharing and Dissemination. These ontologies are designed to enrich the semantic contents of data models and to capture the assumptions and intended meanings of the concepts and statements in a particular domain [4].

What is an ontology?

There are various definitions of ontology, and those in Philosophy and Computer Science vary. In philosophy, Ontology is a discipline that deals with the nature and organization of reality. It tries to give a systematic account of Existence or answer questions like what are the features common to all beings and this is what is called General ontology [6]. However researchers in computer science or artificial intelligence use it to designate the building blocks out of which models of the world are made. A body of formally represented knowledge is based on conceptualization. Conceptualization consists of a set of objects, concepts and other entities about which knowledge is being expressed and of relationships that hold among them. Every knowledge model is committed to some conceptualization, implicitly or explicitly [7]. An explicit specification of this conceptualization is called *ontology* [8]. However, there must be agreement on the conceptualization that is specified otherwise the ability to reuse the ontology will be almost impossible [9]. Therefore, An ontology can be seen as a framework that represents the semantics of data about the domain in a machine processable way. It identifies specific classes of objects and relations that exist in the domain and provide potential terms for describing knowledge about the domain.

The identified objects or concepts are related to each other. These relations are used to order the concepts in a hierarchical or associative structure. The most commonly used is the hierarchical structure in which case the concept hierarchy represents an "is-a " relation that is sub-, super-concept tree structure or hierarchy. Several variations of an ontology [7] can be constructed for a particular domain depending on a particular application and each specific ontology greatly depends on the intended universe of discourse and desired inference.

The domain knowledge [9] can be modularized by partitioning it in pieces so that the concepts are centered on base categories or viewpoints. For instance, the knowledge in the domain of appropriate technology can be partitioned into sub-domains such as health, renewable energy, and agriculture. All sub-domains can be combined in the general domain ontology of appropriate technology. This ontology could then define a taxonomy of all concepts with health, agriculture, renewable energy etc. on top of it. It is also possible to write a domain ontology that can be shared across large groups of applications. Again, the key factor is modularity. Consequently, if several agents were to be able to communicate with each other about this world or domain, the ontology must provide one or more standard vocabularies, defining the terms (concepts) and relations that are used to describe the domain or subject area. The agents also need to agree, and commit to this basic or standard vocabulary and what it means in a way that is consistent with respect to the theory specified by the ontology. This agreement is called ontological commitment [9].

The inter-concept relationships, hierarchical or associative, direct or indirect must be represented through formal models or procedures so that agents can see, share and communicate with others. An explicit ontology [3] may take a number of forms, but need to include at a minimum a vocabulary of terms (lexicon), and some specification of their meaning. The degree of formality by which a vocabulary is created and meaning is specified varies considerably. An ontology can be expressed loosely in Natural language (Highly informal), expressed in a restricted form of Natural language, greatly increasing clarity by reducing ambiguities (Semi informal), expressed in an artificial formally defined language (Semi formal) or meticulously defined terms with formal semantics, theorems and proofs of such properties as soundness and completeness (Rigorously formal). Also many different formalisms can be used to express the same ontological structures. Some of the formal languages used to express ontological structures are frames [10], Semantic Networks [11], Predicate Calculus and Conceptual Graphs [12].

The Structure of an ontology

Ontologies typically contain modeling primitives such as concepts or classes, relations, functions, axioms and instances which are needed to structure knowledge and describe the domain. [13] [14].

Concepts: represents a set or class of entities or things within a domain. A concept can be anything about which something is said. It can be something abstract or concrete, existing or nonexistent and, therefore, could also be the description of a task, function, action, strategy, reasoning process, etc. Concepts in the ontology are organized in taxonomies through which inheritance mechanisms can be applied. A taxonomy is a structured overview of classes, subclasses and instances. [15].

Relations: are logical associations between two or more things. It describes the interactions between concepts or a concept's properties. Relations fall into two broad kinds; Taxonomies that organize concepts into sub-, super-concept tree structures and Associative relationships that relate concepts across tree structures. Relation, like concepts, can be organized into taxonomies. [16]

Functions: are special kinds of relations where the input arguments (domain) have exactly one output argument (range) [17]. This output can be a simple data item or a complex data structure composed of a number of concepts and relations.

Axioms: are used to constrain values for classes or instances. It is a formal statement or principle accepted without proof as, that which can be used as the basis for (reasoning and inference) logically deducing other statements. Axioms are formed through, logical relations between concepts, like: negation, conjunction and disjunction [15].

Instances: are individual objects of a certain class (concept). An instance can be seen as specific member of a certain concept that has been defined in the ontology. Strictly speaking ontology should not contain any instances because it is suppose to be a conceptualisation. However deciding whether something is a concept or an instance is difficult and often depends on the application

Concepts as building blocks of the ontology are used to define and explain things in the domain while relations order the concepts in a network that is quite often a hierarchical structure. Ontologies generally [17] appear as a taxonomic tree of conceptualizations, and range in abstraction from very general and domain-independent terms at the top levels to increasingly domain-specific further down in the hierarchy. Constructing ontologies is an ongoing research enterprise therefore there is no general agreement on the organization of a top-level ontology. Different ontologies propose different subtypes of even very general concepts. This is because, as a rule, different sets of subcategories will result from different criteria for categorization.

In principle, the number of classification criteria and distinct subtypes is unlimited, because the number of possible dimensions along which to develop subcategories cannot be exhaustively specified. However, the classification criteria and the distinct subtypes chosen depend on the type of an ontology that is being constructed. Some researchers have proposed different kinds of ontologies taking several criteria into account such as the formality of the language, the level of dependence on a particular task or point of view, the amount and type of structure of the conceptualization and the subject of the conceptualization. Those found in literature include Application ontology, Domain ontology, Generic ontology and Representation ontology. Ontologies can be constructed from smaller modules that are ontologies themselves. Different types of these smaller ontologies can be distinguished [9]: domain ontologies, domain viewpoint ontologies, abstract ontologies and method ontologies. Many of these ontologies can be reused across different domains and applications.

Benefits of Constructing an Ontology

The use of ontology –based models has a lot of benefits to offer to the appropriate technology community.

Some of the benefits include: [15] [18] [19] [20].

- Enabling easy communication between people, between people and computer systems, or between independent computer systems
- Enabling precise knowledge bases to be created from the ontology to address specific problems
- The ability to exploit implicit context contained in the data, information or knowledge
- Enabling reuse of domain knowledge
- Enabling translation between different modeling methods, paradigms, languages and software tools.
- Providing a complete and unambiguous documentation of data, information and knowledge models
- **Making domain assumptions explicit**
- **The ontology can be used as a basis for specification and development of some software, allowing knowledge reuse.**

Applications Where an Ontology Has Been Constructed.

Although ontology development is an emerging technology whose construction is an ongoing research effort, a number of successful [9] constructions have been reported in key areas. The Enterprise Ontology [21], a collection of terms and definitions relevant to business enterprises has been constructed. Knowledge in the medical domain about diagnosis, therapy planning and patient monitoring has been formalized in the GAMES-II project [22] [23]. Many ontologies have been developed for engineering and technical applications. For example, The YMIR ontology [24] is a domain independent, sharable ontology for the formal representation of engineering design knowledge, based on systems theory. An ontology used for the development of a consultation system for financial investment can be found in [25]. The Penman Upper Model [26] is a general model about natural language that can be used for the generation and processing of different languages (Italian, German and English).

An Ontology For Appropriate Technology Projects

Based on the background information presented, this project proposes the development of a comprehensive Ontology for appropriate technology projects, which can function as a unifying knowledge base or framework for the appropriate technology concepts, techniques, terminologies and theories and serve as the basis for communication between people with different viewpoints and terminologies arising from their different contexts or background, and also help achieve inter operability among systems. The initial work was the development of a taxonomy of concepts in appropriate technology projects in developing countries**.** The domain knowledge was partitioned into sub domains of health, renewable energy, agriculture, biomas, housing, construction, transport, mining and education. All sub domains were then combined in the general domain ontology of appropriate technology. The advantage of modularization into viewpoints is that a viewpoint has less ontological commitments and is therefore more reusable than the entire domain ontology.

This model will serve as a meta-knowledge base from which precise knowledge bases can be developed to address particular problems. It can be extended or incorporated into other models with ease. Repertory

Grid and Protocol Analysis are used to elicit the knowledge from Appropriate Technology textbooks and Reference Manuals. The elicited knowledge in then validated through interviews with experts. Finally the ontology is coded using Delphi.

Conclusion

Ontology is not an end in itself but a means to an end. It serves as a Meta Knowledge base from which more precise knowledge bases could be developed to address particular problems. It will also function as a unifying knowledge base or framework for the appropriate technology concepts, techniques, terminologies and theories and serve as the basis for communication between people with different viewpoints and terminologies arising from their different contexts or background, and also help achieve inter operability among systems**.** Currently there is nothing of this sort available therefore the premise for the need for an ontology for appropriate technology projects is the need to make knowledge available to that community and its applications and also allow knowledge sharing and reuse.

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UTILIZATION OF EMERGING COMPUTING TECHNOLOGIES

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Abstract

Since the times of the software crisis the worlds of computer science and information technology have been striving to obtain a silver bullet solution to the software crisis. The initial efforts resulted in the birth of an engineering discipline called software engineering. The battle then focused on issues such as; data driven versus process driven designs, information engineering versus structured development, and relational database design versus object database design. The present age is characterized by a massive growth in the number of software development technologies such as object oriented technology, Agile methodologies, component-based development model, unified modeling, and other innumerable technologies for the management of the software engineering process. It is inevitable for business, research, academia, and all stakeholders to be innovative in the use and management of these emerging technologies in order to remain viable, competitive and relevant. This paper presents a technique that can be used by stakeholders in this information age to efficiently utilize emerging technologies. The technique is based on the effective use of existing technologies and adoption of emerging technologies through the application of the principles of lean thinking. The technique discussed here can benefit business, educational institutions, research centers, training centers, policy makers and any other interested individuals and organizations.

INTRODUCTION

The continued growth in the development of computing became noticeable from the time of the Second World War where 'information' emerged as a fundamental concept that has led to the centrality of appropriate computing technology in everything that affects human life [6]. Talk of corporations, learning institutions, family life, industrial processes, utilization of natural resources (such as land, minerals and water), or environmental management, and all have computing technology at the heart of their operations. With the emergence of the Internet, which has become a key part of most businesses, all computing technology has to be Internet friendly. This whole scenario means that computing technology will remain vital to the development of human life. What complicates things though is that the problems of human life continue to grow. As the standards of living improve in some parts of the world, they deteriorate in others. As some nations get richer, others get poorer. As medical technology gets better, incurable diseases emerge. This means that technology continues to grow due to growing needs. The use of data to operate business, the use of information to make management decisions, and the use of knowledge to improve business performance, teaches the human being innovation which leads to wisdom. But the fundamental problem still remains, that of effectively utilizing the technologies that continue to emerge.

The restructuring of organizational problems is defined by organizational learning [7]. In approaching the use of technology, there exist two types of organizations; one that sticks to its legacy systems because they get the work done and because the organization has invested lots of money into the technology, and the second organization which is a learning and innovative one that considers the use of state of the art technology as a measure of success. There are advantages and disadvantages on both sides. Wisdom probably lies in striking the balance between these two types of organizations.

The rest of this paper starts by looking at the background of software development technologies in section two which basically lays out the historical overview of the developments in computing technology and defines the problem being addressed. The third section is the main section of the paper it proposes the technique that can be used to better utilize emerging technologies. Section four gives the conclusion and the way forward.

Background of the Management of Computing Technologies

Throughout the history of software development there has always been new and promising software engineering technologies but what has always been found to be true (almost like a law) is the fact that software system development projects are prone to failure. It is usually the nontrivial and complex systems that are delivered late, over-budget and do not meet the real needs of the intended customer. A lot has been said about the real cause of these failures. Researchers and software development practitioners have often come up with innovative techniques to circumvent these problems. Some improvement has been seen as reported in the CHAOS report 1994 [1]. We are not going to quantify the reasons why projects fail. Kotonya and Sommerville [2] claim that the failures are not due to incompetent staff or poor engineering, but due to problems with the requirements of the system. What we find is that whatever variables contribute to the failure of software development projects, under utilization of existing software engineering technology (or computing technology in general) and failure to think in other terms (lack of innovation) are definite stumbling blocks to the success of any emerging computing technologies. It is not the intention of this paper to give a detailed history of software development technologies, interested readers can look at these references [1, 2, 3, 4, and 5].

This under-utilization of existing technologies and lack of innovation points to a failure in the transmission and generation of knowledge.

This paper does not intend to lead the readers into the fray on the semantics of knowledge management. There exist a number of different schools of thought about what knowledge management is and what it is not. This paper assumes that knowledge management is an umbrella term for a variety of organizational activities, none of which are concerned with the management of knowledge per se, but rather the management of information which is the management of work practices, in the expectation that changes in such areas as communication practice will enable information sharing [8]. Wilson [8] gives a more balanced view of the use of the term 'knowledge management'.

The problem that this paper addresses is how organizations can effectively manage emerging technologies. It suggests applying lessons from knowledge management to the management of technology. The proposed technique considers the following variables as key to the effective utilization of these technologies:

- Philosophy of the organization.
- Organization's culture.
- Organization's communication policy.

In the next section we show how these variables can be controlled to better manage technology.

Management Technique for Emerging Technologies

This section describes a modern Agile thinking tool for the management of change in an organization. Specifically this tool can be applied to the problem of when and how to bring new technologies into the organisation.

Philosophy of the Organization

The philosophy of an organization determines its vision and drives the entire organization vehicle towards certain goals. It is important that the philosophy includes clear principles about technology in general and change in particular. In their book 'Lean Software Development' [9], Poppendeick and Poppendeick describe an Agile methodology called Lean Software Development Methodology which is a management philosophy with a focus towards software project management. They emphasize that there can be no true agility in an organization if the executives have a wrong attitude towards change. There is therefore a need to change how organizations work from the top down. Lean Development is targeted at changing the way CEOs consider change with regards to management of projects. Lean Development is based on lean thinking whose origins are found in lean production started by Toyota Automotive manufacturing company [9].

The relevance of lean thinking to this argument is that of accepting change, in fact not just accepting change but making change part of the organization's philosophy. Most organizations that remain stuck with their legacy systems do so at the peril of their competitiveness. The indolence to change seen in such organizations is due to a straightjacket management system that assumes employees to be mechanical objects that thoughtlessly follow the organization's methodologies of work. This obviously kills innovation and leads to an inflexible culture that does not accept change easily.

Organisations need to accept that, when it comes to technology, they should expect and even seek change. For this attitude to result in innovation permeating to all levels of the organisation, it needs to be embedded in the thinking of management.

Culture of the Organization

Gerstner [10] talking about culture in an organization says that culture is not just one aspect of the organization game but it is the game. He argues that in the end an organization is nothing more than a collective capacity of its people to create value. If the philosophy of the organization is right as far as technology and change are concerned then the culture that will emerge from the organization will create business value.

Business culture is the way people in an organization carryout their daily endeavors, how they relate to each other, and what motivates them to do what they do. This may not necessarily be what is written down in corporate documents as that organization's culture, rather what has emerged to be a way business is done in the organization.

We are not in any way claiming that change of culture is easy; it is not. The technique is to realize that there is no business school that will teach you how to change the attitudes and behavior of your employees [10]. By saying that change must begin from the top we are not saying that the CEO can institute change by as Gerstner [10] puts it, giving a couple of speeches or writing a new credo for the company and declaring that the new culture has taken hold. It cannot be mandated or engineered.

Lean thinking means that the CEO has to understand and believe in change and then create condition for transformation. Management can provide incentives, define the marketplace realities and goals, and then through trust, invite the workforce to change the culture [10]. By promoting a culture where employees welcome change and seek out opportunities to use technology innovatively, a company will be better equipped to make the best use of technology.

Organization's Communication

The way information flows within an organization is another important factor that determines how effective the business system can be managed. The organization must have an open internal communication system for the flow of information right from the CEO to the most junior employee.

Whatever mail system is used, employees must be confident that when they get mail from whichever part of the organization it has not been intercepted by anyone for whatever purpose. Management must also be able to send mail to the employees without it being intercepted for whatever reason.

There should be more than one media of communication. It kills the spirit of unity and belonging for employees to first hear news about their company from the media, therefore the organization must have sound policies for informing its employees about the news before it goes public.

Importantly, in the context of this discussion, a system must be set up to facilitate exchange of information about technology news. This should go beyond simple bulletins and technology emails to seminars or even conferences, lectures, exhibitions or any other means that the organization finds suitable for informing all employees including management about technology. The problem with one-way information – directed from those that 'know about technology' to those that don't, is that it is often of little interest to those who do not consider themselves technologists. The challenge is to make technology everyone's business and to engage people in the organisation in talking about technology in relation to their own business problems.

An effective technique, implemented by one of the authors, is to ask more junior staff to research new technologies and present their findings to others in the company. Junior staff tend to have the time to do this research and learn valuable research and presentation skills in the process. Such presentations were followed by a brainstorming session where all present were invited to suggest ways for the company to use the technology under discussion. This process not only increased the awareness of technology but had the interesting effect of improving the overall knowledge of the business as people from different business areas discussed problems that they needed solved.

Effective communication about technology can ensure that technology is used to its fullest and encourage all in the company to get involved in the process of innovation – to generate new ways of using technology.

Conclusion

The purpose of this paper was to introduce a tool or technique that organizations can implement in order to harness emerging technologies for their competitive advantage. In order to harness technology effectively, companies need to manage change and this will ensure that they stay competitive. The proposed technique is based on principles and methodologies that have been successfully applied. It can therefore work in your organization.

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Tying It All Together
Virtual Center for Appropriate Technology Projects

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Abstract
There are few centralized resources that identify appropriate technology projects, or provide feedback on what works and what does not work. Also, there are few resource centers that allow the exchange of information and experiences necessary to hasten the development and adaptation of appropriate technology.

To physically locate such a resource center has built in drawbacks such as the costs of running it, the maintenance, and the limited number of people and locations that can be serviced by the center. Another drawback is the burden each center has to create a storehouse of information. A virtual center effectively eliminates most barriers to information and maximizes the sphere of influence by being accessible globally. The purpose of this paper is to stimulate ideas for the development of a Virtual Appropriate Technology Center by describing some benefits, desirable attributes, and management approach. Basically, the proposed Virtual Appropriate Technology Center is a web-based database or website driven by a database of information.

INTRODUCTION

The Need for a Virtual Appropriate Technology (AT) Center

The Virtual AT Center is needed to support development of indigenous capabilities to improve the quality of life often in remote locations. The Virtual AT Center would be a virtual warehouse of information that could be a venue for the exchange of ideas, feedback and problem solving. It would be a self-service center, which could be queried for assistance. The Center could provide newsletters, publish articles, and provide hyperlinks to similar websites to share AT interests and events. It could provide a forum for comments/questions and share experiences/lessons learned, funding information, collaborative opportunities and other information.

The Center is needed to assist in the selection, generation and dissemination of technologies appropriate to community objectives. Access to information about tried and true technologies reduces the implementation time and increases the success rate of projects. The appropriate technology movement has had very limited success even at times when the technology lived up to expectations. Cultural preferences and customs, the economics of the cost of production and operations, and convenience are factors that can make or break technology infusion. These factors must always be included in the equation for successful technical adaptation.

Underdeveloped countries are better off following project models that have proven to be successful under similar circumstances. An unproven or new technology is always more difficult to introduce than a technology that has been successful elsewhere. The development and infusion of a technology can be a very slow process. In a Virtual AT Center, success stories with pictures can be posted and shared. It is critical to know what works and what does not work and why. A vehicle is needed to identify AT projects that have been successful; to catalog contact information on technical consultants; to identify sources of equipment, publications, and sources of funding. A chat room for networking purposes and the exchange of ideas, online training and feedback mechanisms to pose and answer questions can be built into the design of the center. A center virtual or physical or a combination of the two can be used to reduce the time and cost of broadening the range of skills and information available. A virtual center has the advantage of being cheaper to initiate than a physical center with the largest portion of the expense is a one time expense which is related to the design and setup of the website. The virtual center can be run and maintained at a fraction of the cost of a physical center.

The objectives of the Virtual AT Center are:

(i) To improve the success rate of the infusion of appropriate technology and broadening the understanding of what is appropriate technology. At the same time, accelerate the expansion of AT
(ii) To initiate, promote and conduct research on technology policies, technology assessment, technology transfer, technology development and technology dissemination
(iii) To develop virtual training programs related to AT
(iv) To establish collaborative linkages between institutions engaged in similar objectives
(v) To disseminate information for the effective use of AT on a national and international basis and
(vi) To provide advisory services, on matters related to technology and development.

Many appropriate technology projects have been attempted and failed or experienced limited success not because the technology did not work, rather because project leaders were unaware of the pitfalls and mistakes faced by others during the infusion of the technology. The technology worked, but the people failed to adopt it and accept it culturally. Sometimes a great deal of time and substantial resources are expended unnecessarily by re-inventing the wheel because of the project leaders' limited knowledge about what has already worked successfully some where else. Easy access to innovative ideas, successful models of technology infusion and opportunities to share lessons learned minimize missteps. One of the weaknesses of underdeveloped countries is the organization of production and distribution of new technology. Also, the infrastructure to support the maintenance of the technology is often missing. The communities that need the technology are often isolated and have not developed basic infrastructure to service and maintain equipment associated with the technology. The successful infusion of new technologies is as much a socioeconomic and political problem as a technical one and a broad range of skills are needed to successfully infuse technology into communities. Rarely does a project team have locally all the skills needed, and access to sources to fill in the gaps is often difficult to find.

The Virtual AT Center works well for appropriate technology since it is a centralized source of information that supports projects that are often decentralized. It is important that the technology is understood and operated by its users (i.e., does not require outside operators), uses fuel and other resources that are either local or easily obtained, and involves machinery that can be maintained and repaired by its users. Often, but not necessarily, it is labor-intensive and involves simple machinery."

Having access to a database of information that is constantly growing allows practitioners the flexibility to keep abreast of change. This is important since "The definition of 'Appropriate Technology' changes with each situation. It's not appropriate to install solar modules in a place with very little sun, a wind generator in a place with little or no wind. What's appropriate in a large urban location is very different from what's appropriate in a remote, isolated environment. One quality that remains the same, however, is taking care of things. In each situation the essence of AT remains appreciating, helping, and caring. Planned obsolescence, throw-away products, poor quality all go against intelligent decision-making and the true spirit of appropriate technology."

Organizing the Virtual Appropriate Technology Center

Just like all centers this one will need to be designed and managed. The primary difference is that the designer (s) can be anywhere and the equipment, which in this case is a computer server in which data is stored. can be located and maintained 1000 of miles away from the designer and managers through digital access once the system has been established The information to include on the web and the organization of it can easily be developed by a committee who later turns over their guidance to the designated designers and administrator who follow the guidance. To be effective, the committee should consist of more than computer experts, and include people with significant AT experience, economists, potential users, sociologists and psychologists who know what would be useful to them.

The web administrator will set all the paths and permissions for the Center. The end result is that an endless number of people can access the information stored, and interact with one another without ever meeting one another. Wireless connections to the internet allow access in remote locations where there is no electricity.

It will be necessary to develop templates or to design the format for data entry to assure that the information tables are designed to effectively relate with each other. This means the architect or designer (s) of the site will anticipate the kind of information that is useful and setup tables, headings, rows and columns in which data is entered. The templates assure uniformity and consistency. There is already a tremendous amount of information on the internet regarding AT, even information on creative ways or “appropriate technology” that countries like Ghana have developed to work around limited computer network conductivity. Ghana has developed ways to cheaply and quickly expand internet accessibility.

The guidance committee will be challenged to decide what information to include and to organize it in a user friendly way. Just surveying what is available is a monumental task that will take considerable effort. The committee may decide not to populate the website directly with all the information determined to be useful, but rather structure the website with cues and mechanisms that facilitate first hand searches to locate the information or other sites. This can be done with hyperlinks to other sites or by listing references to articles and books, or project contact information. Thus, the amount of information that can be shared on a given size server is significantly increased. Rather than second guess the needs of all users, it would probably be wiser to collect some information that would be of common interests to most and then solicit feedback about what is considered useful and missing.

Information is power and control of information is greater power. Policies and controls will need to be instituted to maintain the quality of data posted and to protect the database from hackers. Intrusion detection and cyber security measures will definitely be needed and integrated into the website design. The good news is that the technology and know how to do this already exists.

The systems manager or administrator will control who can enter data through a log-in process which consists of a user name and password. Criteria will be established to determine who receives access and permission to provide input. The Virtual AT Center can be programmed to translate information automatically into multiple languages.

The type of content and services provided by the Virtual AT Center can be modified based on the needs of the users. The user feedback can be easily obtained.

Attributes of the Virtual AT Center

The proposed Virtual Appropriate Technology Center is basically, a database driven website in which information is organized in a series of tables that relate to each other. A relational database software such as Access can be utilized to allow users to easily research information , as well as, contribute information.

It is a low cost way of information sharing to accelerate progress in the global understanding of what is appropriate technology. The Center can be built by simply acquiring the use of a server by paying a fee of a few thousand dollars a year to a company which provides database management or by purchasing a server for an equivalent amount of dollars and managing the design and content of the website directly.

When the Virtual AT Center is first rolled out it will contain a body of information and photos that are stored in a database system. Comments and questions generated by website users will spark additional data. In the long term, planning for the site, a newsletter is foreseen that will keep the website fresh and interesting.

Rather than re-incur the cost of the original setup, provisions for users to directly make additions, as well as, the website administrator is be provided.. Of course, criteria will be set to determine who will be granted such permission. Access controls and cyber security techniques to detect hackers or intruders who might tamper with the database are a must.

Since the body of useful information is constantly growing and new projects are continuously being created and reported on, there will be a need to provide for ongoing updates. The pre-planned structure of the website will dictate the type of content and the format of information that can be added.

There are a couple of ways to populate the site with content. The site can be designed with a Content Management System (CMS) which allows approved users to either enter information themselves through a simple sign in procedure and positing the information directly or by e-mailing content to the administrator who enters it on the website. To enter data directly will not require sophisticated computer skills. Entries can be typed in and converted as needed either automatically or by the system administrator.

The structure of the website can permit information to be posted by a large number of approved people. It can be structured to be interactive such that users can pose questions and others provide answers. Articles, and publications can be posted to share project ideas, results, and problem solution can be virtually exchanged.

Structuring the virtual center in this way allows appropriate technology practitioners to conduct independent projects virtually anywhere in the world and at the time conveniently draw upon the experiences and advice from other practitioners around the world. It maximizes the conditions for success. It allows the novice and the seasoned expert to interact freely with minimal cost. This type of interaction is critical since technology is only appropriate if its users are able to continue to adapt and innovate whatever the future brings.

Appropriate Technology (AT) is an "Applied science that is suitable for the level of economic development of a particular group of people. It reflects an approach to technological development, characterized by creative and sound engineering that recognizes the social, environmental, political, economic, as well as, technical aspects of a proposed technological solution to a problem facing a society. Generally appropriate technologies are smaller scale technologies, that are ecologically and socially benign, affordable, and often powered by renewable energy. However, AT is not restricted to small scale. The field is an interdisciplinary one drawing from the physical and social sciences as well as Engineering, Architecture, and Technology. Areas of interest include energy conversion systems, waste and water management, community and shelter design, technology assessment, small-scale production systems and technology transfer.

Another strong attribute is that management of the Virtual AT Center can be shifted from location to location transparent to users and without relocating the server. Ideally, a university that has a strong interest in AT would be a good candidate to control and implement the Center because of the availability of student assistance and often strong research interest.

Next Steps

If the idea of the Virtual AT Center is embraced, then the next steps should take place at this conference .to make it a reality. Those who would like it to become a reality should form a working committee to start the concrete planning. At a minimum, a working group leader should be selected and the roles and responsibilities of the working committee should be defined and assigned before the conference ends.

Following the conference a project plan for the center should be developed and work begun to execute the plan.

Conclusion

Success in appropriate technology requires a strong background in a wide variety of technological areas. Individuals need to be committed to making the world a better one through the development of improved technological systems. The Virtual Center will help build the models of success and serve as a resource to further define what is appropriate technology.

Concerns about environmental and social degradation are strong motivating factors to develop appropriate technology projects. Individuals should be able to solve a wide variety of problems technical and non-technical and work independently as well as with groups. Knowledge and skills in many technological areas; including drafting and design, wood and metal working, computers, architecture, construction, graphic arts as well as renewable energy technologies, energy efficient solar building design and construction, waste management, research methods and contemporary technological are required to solve problems facing society. The knowledge range is so broad that collaborative and group efforts are necessary to be truly successful. The Virtual Appropriate Technology Center could bring worldwide experiences in appropriate technology to the fingertips of people located in the most remote locations. It is practical and doable within a modest budget. Let the work begin.

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