EVALUATION OF HANDCART FOR USE BY SMALLHOLDER IRRIGATION FARMING FAMILIES IN DOWA, LILONGWE AND KASUNGU DISTRICTS OF MALAWI

REPORT

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1. ABSTRACT

A simple two-wheeled wooden handcart operated by a single person in a walking position was fabricated and tested by the Agricultural Engineering Department of Bunda College, a constituent college of the University of Malawi. The cart version had been introduced by Dr Arnold Wendroff, and previously tested in many urban and rural areas of Livingstonia, Mzuzu, Mwandama Village (Zomba), Chitedze Research Station (Lilongwe) and Blantyre for domestic and small scale businesses deliveries. Previously the cart had not been tested under irrigated field conditions. Six carts were fabricated and tested under irrigation systems in Dowa, Lilongwe and Kasungu Districts of Malawi during the 2006/2007 seasons. Results demonstrated that the handcart technology surpasses any other types of transport technologies in terms of affordability; carrying capacity; versatility for use under rural (as well as urban) settings; simplicity in make, use and repair; cost effectiveness and social conformity. It is a must for solving the precarious farm input and produce transportation load and labour problems Malawian farming community faces. The cart can also be used by a physically challenged individual who cannot use a wheelbarrow while elderly, children and sick people reported that prolonged use of wheel barrow, bicycle and head or shoulder carrying of loads, resulted in chronic neck, shoulder, and back pains. The cart can make a weak person move loads in isolation independently without increased health risks

2. INTRODUCTION

There is a big potential for irrigation in Malawi which can impact positively on food security. Potential land for irrigation is 400,000 ha while only 62,000 ha are currently under irrigation, of which only 14,000 ha are owned by small-holder farmers. Smallholder farmer irrigated areas are scattered across the country and are mainly for the production of food crops. One of the major constraints to irrigation development in Malawi is lack of technical and scientific knowledge coupled with poor agricultural practices of extracting water and transporting it from source to field, and inputs and farm produce from and to homesteads respectively. The problem is even more compounded for female headed households and the sick, the elderly, children, the sick and HIV-AIDS affected families.

While motorized transport system is out of the financial reach of the majority of rural population head/shoulder loads pose laborious and limited carrying capacities for the masses. Bicycles can move fast but they have limited carrying capacity and need balancing under load. A handcart is viewed as an intermediary means of transporting goods in the villages for the underprivileged community
A small 5 horse power (3.7 kw) centrifugal motorized pump will normally deliver 3.0 l/s operating at suction lift of 5.0 m. However, use of motorized pumping systems on the other hand is economically prohibitive for the majority of farmers especially when using them individually (Singa, 1994). This is due to high energy (petrol or diesel) and maintenance costs. The costs tend to be reduced when used by a group of farmers but operational timeliness and maintenance logistics can be difficult. Where motorized pumps are used, transportation of the pumps and pipes, and farm inputs and produce is still a difficult task for the farmers.

Singa (1994) reported that in terms of water abstraction and delivery the use of **water cans** (usually on land holding of less than 0.4 hectares) is associated with high labour demand for a family. A farmer carries a bucket or water can full of water upslope to the field and down slope when it is empty until the whole field is irrigated. Most smallholders depend on family labour. Labour is an important factor that determines the extent of irrigated agricultural production.

Treadle pump irrigation is more feasible than hand-can irrigation. FAO (2000) reported that it is possible to lift water by suction up to 10m using a **treadle pump** but practically 7m is the sensible limit because of the friction losses in the suction pipe and the effort required to create an operational pump vacuum under these conditions. Treadle pumps and pipes are usually carried on shoulders or heads. Parts of the fields with lift heads and distances unreachable by the treadle pump pumps, have to be irrigated using head loaded bucket water. In addition to water can irrigation farm inputs and produce have to be carried on head or shoulders? Few farmers own bicycles, but even for them, balancing the bicycles loaded with heavy irrigation machinery, water, inputs and produce on muddy or sandy paths connecting the fields and homes is a great challenge.

In Malawi, less than 20% of the farmers own, and can afford to use, animal (ox and donkey) drawn carts. Apart from the costs associated with these animals night security, feeding and health requirements have to be met by the farmers. Handcart technology once improved upon and disseminated would be very handy to assist farmers in these respects. But these have to be transported to the homesteads after a day's use.

River diversion is usually practiced on lands where rivers flow down on differential gradient. This has tended to minimize water pumping requirements but such favorable sites are limited. In terms of water delivery, however, field areas higher than where gravity canal can reach still need water transporting mechanisms such as water can, treadle pump or ox-carts. Without these technologies river diversion alone can pose a hardship, hence some of the potential areas are not irrigated. Similarly, ttransportation of inputs and produce on shoulder or head poses a difficult task for the farmers.

Of late that sprinkler irrigation and drip irrigation systems are increasingly being introduced in Malawi as a result of water and land scarcity in some parts of the Central and Southern Regions (Kadyampakeni, 2004). **Drip System** consists of water storage drum placed on the uppermost part of the field to let water gravitate down the laterals and irrigate using the emitters. Water has to be brought up to the reservoirs using buckets or treadle pumps. The operation of filling the drums is labour demanding especially when head load water filling is practiced. Treadle pump operation can also be labour demanding.

Use of each of the foregoing irrigation systems is based on a farmer's technical and socio-economic ability as to how much of crops such as maize, beans, sugar cane, tomatoes, leafy vegetables can be grown.

3. OBJECTIVES

The main purpose of the study was to evaluate locally made 3 pairs of wooden hand carts under irrigated agricultural production systems with respect to technical, financial, social and environmental aspects in Lilongwe, Kasungu and Dowa Districts of Malawi. The participatory study was conducted in order to compile and analyse the data, results of which can be used by the resource-poor farmers, Government, NGO's and projects to ensure adoption of the cart version for ease of transportation of irrigation equipment and farm inputs and produce.

Specifically the objectives for the study under treadle pump, river diversion and drip irrigation systems were:

a) To construct a manually operated wheeled cart.
b) To determine the loading capacity of irrigation equipment, and farm input and outputs
c) To determine ease of cart traction and operation in comparison to bicycle, wheel barrow and head loading.
d) To evaluate the cart based on land terrain and soil conditions.

4. METHODOLOGY

4.1 Cart Make

The carts (sample shown on cover page) were made of rectangular wooden body mounted on two wheels. Each wheel is mounted on the external side of the wooden body of the cart. Wooden cart handles were bolted on the rear part of the cart. Two wheel versions were tested, viz: common bicycle wheel size and the new China made larger size wheel.

4.2 Study areas and Practices

The study was conducted in

i. Lilongwe (Ukwe and Ngwangwa sites): Predominately treadle pump irrigation sites except for only 1 river diversion and one drip kit farming families - three sites were used. Land terrain is mainly flat, less than 35% slope.
ii. Dowa (Mvera Areas, i.e., Kakhwesi, Kukhola and Chimbalanga): Predominately River Diversion with only three drip kits and three treadle pump technologies implemented at each of the three sites. Land terrain is sloppy, more than 20% slope.

iii. Kasungu (Kasungu/Chipala Area, i.e., Mkuyu, Chilinda and Mkhota sites): Predominately treadle pump, three drip kits system at each site and no river diversion. Gentle slope on the upper field area and flat (less than 5% slope) close to river banks.

4.3 Operations and field parameters

Ordinary carpenters in the rural areas were selected to make the carts. Each carpenter was able to make a bicycle wheel size Africart and a new Chinese larger wheel size version.

Operations involved: Training and pre-testing of the questionnaire, Soil sampling and analysis, Survey (topography, water resources, input and produce delivery distances). There was also introduction of the cart to the communities in terms of make and use, fabrication and maintenance.

Farmers already employing an irrigation technology were selected for cart evaluation. The project involved 9 farmers at each site using the 2 cart versions on rotational basis. This translated to a total of 36 households for the entire assessment. The sites selected had never used the handcarts before.

The study focused on use of the cart for transportation of filled and empty water buckets for water-can and drip irrigation systems. The management techniques were assessed in terms of costs, labor demand and ease of technical operation. The assessment was developed and implemented in collaboration with smallholder farmers, agricultural field staff, and non-governmental organization field officers to ensure true reflection of practices employed by the smallholder farmers in the selected sites.

Soil samples were taken to determine soil texture, and structure as they affect cart traction in transportation of water, inputs and farm produce upon harvests. In addition, the gender issues were also considered. Observations were made on whether all categories of gender take part in transportation practice or not.

Methodology for data collection was based on interviews, observations and measurements/testing and sampling. The collected data focused on technical, economical and social aspects for the cart technology.

5. RESULTS AND DISCUSSION

5.1 DOWA (MVERA AREA)

5.1.1 Altitude and climate

On average Mvera is at an average altitude of 819m above sea level with dry seasonal climate of moist cold temperature of 18 to 20 ^{o}C associated with high wind speed in Winter (May to July) to very hot (26 to 30 ^{o}C) and calm in hot dry months (September to November). The area has an average humidity of 33% and wind speed of 3.17 km/hr. Basing on the climatic conditions, what affected the use of the cart more was the hilly and undulating ground terrain than temperature and humidity.

5.1.2 Sources of irrigation water and areal characteristics

The sources of irrigation water are rivers which depend on springs from several kilometers upland. These rivers are Rowi, Tsikiti, and Rufe supplying water to Kakhwesi, Kukhola, and Chimbalanga irrigation areas respectively.

The fields are at an average of 1 km from homesteads at down slope of about 25% – a situation that demands means of transport for water and agricultural inputs and outputs. Soils are generally sandy loam except in river beds where silt clays are dominant hence not a problem for cart traction.

5.1.3 Crop Production

A variety of crops are grown in Mvera area as shown in Table 1 below.

Table 1: Crop production in Mvera

Site	Major crops grown	Average land holding (ha)
Kakhwesi	Paprika Maize Tomatoes Beans	0.07 0.35 0.28 0.06
Kukhola	Maize Tomatoes Cabbage	0.22 0.08 0.14
Chimbalanga	Maize Paprika tomatoes	0.05 0.03 0.01

For all the three sites, maize is the crop that is grown in large proportions. Apart from being a suitable crop for the area the crop is also vastly grown for food security as it is the staple food crop in the district. The crop needs substantial amounts of basal and top dressing fertilizers. These have to be transported to the fields on the hilly terrain. The crop also gives bulky harvests which have to be transported to the homesteads.

5.1.4 Socio-economic aspects of the irrigation community

Table 2 below shows the literacy levels and land tenure system at the 3 sites in Dowa.

Table 2: Social aspects of the three sites in Mvera Area

Site	Women (%)	% illiteracy of farmers	% of land rented
Kakhwesi	30	50	40
Kukhola	10	25	80
Chimbalanga	20	17	10 No land conflicts

In Kakhwesi and Kukhola, over 50% of the land under irrigation is rented by the users. In Chimbalanga area, 90% of the land is owned under customary inheritance and only 10% rented or borrowed. This indicates the reason why in Kakhwesi and Kukhola, there are more cases of land conflicts. It was more difficult for the farmers to jointly own the cart at Kakhwesi and Kukhola than at Chimbalanga.

In terms of women participation, a greater percentage of women is in Kakhwesi area. This has contributed to the high activeness of the individuals at the site. Under matrilineal marriage system women are more secure in land ownership and more secured to invest in a piece of land. This is also the reason why the adoption rate of irrigation technologies is high in this area. The same was observed for individual ownership intention for the cart.

Average returns, in case of maize, were found to be **K40,000.00 per hectare** at average selling price of **K12 per cob** of green maize **(1US$ = K140)**. Farmers could easily pay for the cost of the handcart with this type of business, even more so if the carts are owned by the irrigation clubs.

The treadle pumps under evaluation were Balaji and Money maker types. Their estimated costs were K15,000 and K12,000 respectively. Spares for the pumps are not locally available hence farmers just improvise. In case of drip irrigation system under evaluation was the $100m^2$ drum kit system with drippers. The estimated cost of the equipment was K5,000

There was willingness expressed to own some carts by the irrigation club members. However, the club farmers in the area did not have reasonable knowledge in proper cart loading and repair. They need to be provided with adequate information on maintenance (cost and availability of spare parts).

It was shown that in quest to achieve sustainable food security and income among smallholder rural house holds in Mvera, handcart transportation of water, farm input and produce should be promoted to enable farmers save labour and make delivery for same possible and timely. While use of drum drip kit irrigation system is less costly in terms of initial investment and operating labour, filling of the drums with water is labour challenging unless the fields are close to the water source or ease of transporting water buckets to fill the drums is devised.

5.2 LILONGWE (Mngwangwa and Ukwe Areas)

5.2.1 Area and climate

The zone lies in Lilongwe North–West, about 15 km from town. Topographically it occupies flat dambos. The most predominant soil textural class in Mngwangwa is sandy loam (64%). The remaining textures are sandy clay (27%) and loam (9%). Therefore, the soils in Mngwangwa generally provide cart traction problems only in the dry season. Soils are usually neither too sandy nor too sticky to pose traction problem with the handcart.

During the irrigation months temperatures range from 25 to 29^oC with low relative humidity, picking up just before the rains, late November. Unlike Dowa Areas, the high temperatures and humidity in Mngwangwa and Ukwe Areas of Lilongwe does render the farmers discomfort during performance of their field chores, including transportation of farm inputs and produce by head or shoulder. The handcart was useful in this respect.

5.2.2 Crop production

A variety of crops are produced at Jambo while Matchakaza and Malembo mainly concentrate on irrigation of maize and beans respectively (Table 3).

Table 3: Major crops grown and cropping land sizes per farming family

Site	Major crops	Area crop (ha.)
Jambo	**Maize** **Beans** **Tomato** **Cabbage**	**0.24** **0.28** **0.04** **0.03**
Matchakaza	**Maize**	**0.04**
Malembo river diversion(Mutu-wanjobvu club)	**Maize.** **Beans.**	**0.18** **0.18**

From Table 3 above, the highest area cumulative area of 0.42 ha was occupied by maize representing 45 % of the total farmer's area under treadle pump irrigation, followed by beans 0.460 hectares representing 44% ,while tomato, cabbage and pumpkin occupy 0.041, .0.033 and 0.046 hectares respectively. These are all mainly bulky and heavy crops, hence the need for transportation of the produce, in addition to inputs is paramount.

The Japanese International Cooperation Agency (JICA) has taken several initiatives to develop irrigation in Mngwangwa by training field officers and giving them equipment for implementing the irrigation technologies in which they were trained. Some of the irrigation technologies that the field officers have been trained in are river diversion for which equipment like wheel burrows, shovels, polythene plastic papers working suits and bicycles have been given to farming club members. However, transportation of irrigation equipment, farm inputs and produce by bicycles has posed limitations in the amount of produce they can deliver to the markets while as for wheelbarrows, in addition the limited carrying capacities, they have also proved to be laborious by the operators, more so for women. Expansion of the irrigable areas has been difficult to achieve.

5.2.3 Irrigation water sources

Water sources for all the sites are streams except at Mphetsankhule where dam water is used (Table 4). The sources provide adequate water over the whole dry season. The dam uses are multipurpose (irrigation, fishing and domestic purposes). Cultivation activities dominate the occupations of the community. The cart played a role in transporting water for irrigation and domestic use as well as

inputs and produce to and from the fields respectively. The fishermen also found the cart handy in carrying the fishing gear and subsequent caught fish.

At Mphetsankhule, where river diversion is practiced, each farming family person (A to G in Figure 4 below) is allocated time in a week to irrigate his/her plot in the field. This ensures that each farmer has equal time and adequate amount of water to irrigate his/her field. Use of the cart was found helpful in this respect. The average slopes of the 3 sites were 1.5% for Jambo and 2% for Matchakadzi and Malembo. The topography was generally uniform and therefore less carting difficulties and risks were experienced.

The sites that use treadle pumps abstract water from shallow streams and irrigate areas up to 0.6 hectares at a distance of 30m from the source. Areas further than that distance had to be irrigated using water transported by the cart.

Table 4: Economical and Technical aspects of cart

Site	Cart fabrication cost (K)	Maintenance	Availability of spare parts	Means of storing the cart
Jambo	11,500	Needs experts to maintain.	Not readily available, some improvised	Under shed
Matchakadza	11,200	Done by farmers themselves	Locally available.	Left on the open
Malembo	12,000	Done by themselves	Improvised and some local bought.	Under shed

At Jambo and Malembo, just as for Dowa and Lilongwe sites, due to the clubs having farm sheds, farmers keep their irrigation equipment band hand carts under shed after use.

5.2.4 Ergonomics of the cart transport mode

There was slight difference in the push energy requirements for each wheel size cart with the bicycle size wheels requiring more energy to operate than the larger size Chinese wheel cart. This was due to higher wheel-soil contact area with the latter, especially in muddy and sandy routes. This was more so

under load of more than 150kg. Generally women found the carts more difficult to operate under such circumstances due higher labour demand.

Ergonomic it was found that the wheel barrow needed more power to be operated (Table 5). Women could provide 100 to 135 Nm for head loads (only 25 kg weight), 110 to 160 Nm with a wheel barrow (50 kg load) 90 to 100 Nm using a bicycle (50 kg) and 90 to 100Nm for handcart (100 kg). The results show substantial energy saving for the handcart on a unit load delivered.

Table 5: Ergonomic data for mode of transport

Model of transport	**Average Energy output (Nm)**	**Unit energy (Nm per kg load)**
Head load	100 – 135	4.68
Wheel barrow	110 – 160	2.70
Bicycle	90 – 100	2.00
Handcart	100 - 110	1.05

5.2.5 Technical aspects and transportability of the drip system

Irrigation time differences in water conveyance from one site to another were likely caused by differences in the distances from the water sources to the field. Farmers were conveying water to the drums by hand bucket. This was found to be tedious and time consuming. Pumping of water using treadle pumps reduced the work but by the end of irrigation period the farmers were exhausted. Use of handcart to transport a drum of water for the purpose reduced the time requirement to one-fifth, a dramatic gain in time for the same water conveyance distance and water delivery head heads.

Farmers that use drip irrigation system on a small area of 100 m^2 found that based on economies of scale they could not financially break-even, no matter what crop they grew. Larger kits of 500 m^2 should hence be tried. This would make it even more difficult to fill the relatively 1000 litre reservoirs with water by head load buckets. Water transportation in drums by the cart would be more feasible.

5.2.6 Social aspects of farmers at Ukwe and Mngwangwa Areas

At Ukwe there was an average of 60% of the farmers who could read and write. The high levels of literacy places the farmers in a better position to follow instructions on use and maintenance of the handcart. In terms of **Land tenure system** at most sites the mode of acquisition of the land is through inheritance and there are no land tenure conflicts. Adoption of the handcart technology should be easier in this area than in the other areas where literacy level is low and rented land is used.

Gender wise, drip is the most labour-wise convenient technology for both men and women. Women are more comfortable using drip than treadle pump, especially where some rural culture forbids women

from wearing trousers but “chitenje” (piece of cloth). Operation of the pumps while wearing “chitenje” makes women feel uneasy. It is even more difficult to operate tall pump versions such as Advaith and Balaji (Figure 2). The low height of Money maker pump type makes it easier to treadle.

Weak members of the community, such as the sick, the young and the elderly found utilization of Drip Irrigation Technology less tiresome and convenient compared to Treadle pump and hand –can irrigation technology. Once the drum-kits are filled with water and irrigation commenced farmers could leave the field. They would only come back after several hours to refill the drums. The problem, however, was associated with filling the drums. The farmers could use water cans (very few 5% treadle pumps) to fill them. The task is laborious and time consuming. Use of the handcarts to transport partially filled drum or so many tins of water at a time became very handy (Figure 3).

5.2.7 Impact on the environment and crops

Drip irrigation should be used along side water delivery mechanisms of treadle pump or handcart to maximize its potential in crop production otherwise if used alone it poses problems of water supply into the reservoir (drums). The total technological cost has to be spread over 2 year payback duration for the investment to be profitable. It is the benefits in labour and water savings that make the drip technology favorable.

5.2.8 Treadle pump and transportation of the system components

Transportation of treadle pumps to and from the fields was generally by hand or bicycle. Riding the bicycle was hard in the sandy soils hence farmers had to push it balanced with the load. The fact that most irrigation fields were properly leveled made pushing of the loaded bicycle possible. However operation of the cart carrying irrigation equipment was handy (Table 2)

Generally carrying of treadle pump and pipes by hand was associated with high labor demand, and was prohibitive for some individuals. People of poor health found it even more difficult to operate it and carry it home thereafter. The cart provided an easy means of transportation in this respect (Figure 3).

Figure 2: Ease of transporting irrigation equipment

Figure 3: Drum transported water for hand-can or drip irrigation

The cart was less labour demanding than a wheelbarrow yet could carry more. Environmentally it was not forming wheel track depressions on the ground which would be hazardous to the soil (Table 6).

Table 6: Transport technology impact on operators and environment

Treadle pump equipment transportation	**Labour demand**.	**Impact on the environment**
Hand	Laborious (Heavy)	Slight soil erosion but signs of path hard pan
Bicycle	Easier, More push effort, needs balance	Slight erosion, Less hard pan
Handcart	Easy, less effort, self balance	Slight erosion, Least hard pan

5.2.10 Technical and economic aspects of the cart

In terms of loading capacity farmers tended to overload the carts, up to 300 kg loads were observed. This was despite the introductory warning against the practice. Availability of spare parts was not an issue with the bicycle size wheel components, though not durability. Farmers could easily repair the carts in the village.

Financially, many farmers who could not afford to pay for an oxcart and oxen could easily pay for the handcart from their 0.4 hectare crop proceeds. Costs of maintenance of the cart was found to low, since only handles and wheel components, such as spokes, needed replacement. The Chinese tyres were difficult to find, so were the associated parts. While the larger wheels could take more weight, they were not durable – could easily wear-out and split along the sown middle line. Low costs associated with the handcart were attributed to the fact that most materials were locally sourced and rural carpenters could easily be trained to make a cart.

Generally, the problems faced by the community using the carts were broken spokes and/or wooden handles and punctured tyres. A carpenter at Mitundu trading Centre used specially made tyres (without middle seam) sourced from the Blantyre Commercial City, about 400 km away. A Visit made to Mitundu Trading Centre revealed that some rural carpenters had been making some large size wheel handcarts. The problem had been worn-out tyres due to overloading of the carts. Lack of tyre supplies in the nearby Lilongwe City made the carts to remain idle for months. The tyres were initially sourced

from Blantyre and were no longer available. A follow-up is being made to uncover the source of the problem.

5.3 KASUNGU-CHIPALA

5.3.1 Climate and soils

The weather parameters at Kasungu- Chipala during the cool dry part of the year (end of July) are given in Table 7 below. The values collected on-spot using a Kestrel 4000 pocket weather tracker only represent the type of weather that prevailed at that time and year.

It could be noted that high temperatures are not typical of many places in Malawi at that time of the year. This suggests that the place experiences higher temperatures than those of Lilongwe and Dowa (Mvera) areas. This is supported by high heat indices. The area is of low altitude, being a river valley. It corresponds, therefore, that crop water requirements are expected to be higher than at the other 4 areas studied. The high temperatures and relative humidity, during the later part of the dry season, therefore, pose a challenge in operating most of the manual transport technologies.

Table 7: Weather conditions at Kasungu-Chipala (daily average values during the dry season)

Club	**Mkuyu**	**Mkhota**	**Chilinda**
Temperature (°C)	27.1	24.3	25.6
Humidity (%)	37	42.6	36.1
Heat Index (°C)	26.5	23.2	25.4
Barometric Pressure (hPa)	13.14	13.14	13.15
Altitude (m)	920	920	915
Dens. Altitude (m)	1560	1500	1522

The soils were mainly sandy loam on the upper areas and sandy clay loam on the lower areas near the river. On these types of soil the hand cart wheels would neither stick nor sink into the soil.

5.3.2 Irrigation practices, land area and use of handcart

The irrigation clubs operate along the banks of Dwangwa River in Kasungu District.
The actual irrigated areas are less as compared to the present physical boundaries of the potential fields (irrigable area in terms of slope and soils). This is because some areas topographically potential for irrigation are prohibitively far removed from water sources hence making it impossible for water pumping using treadle pumps (Table 8). Farmers were, therefore, using the cart to ferry water cans to the farthest points of the fields.

Table 8: Potential and actual irrigated areas

Club	Present physical boundary (ha)	Potential irrigable area (ha)	Actual irrigated area (ha)
Mkuyu	17	10	10
Chilinda	6	4	2
Mkhota	11	6	5

All the clubs have future plans of expanding their cultivated areas. The main limiting factors to their growth are lack of financial resources, managerial skills and energy saving technology for water lifting and delivery. The river supplies adequate water for irrigation except late in the dry season. It is very deep with suction depth of 4 to 7m making it difficult for farmers to operate the pumps and deliver the water to the furthest parts of the fields. Employment of the handcart was very beneficial in this respect.

5.3.3 Crop Production

The main crops grown in the area (on an average land holding of 0.1 ha per farmer) are shown in Table 9 below.

Table 9: Major Crops Grown and Land-Holding Size

Club	Major crops grown
Mkuyu	Maize, beans, paprika, tomatoes, cabbages and leafy vegetables.
Chilinda	Maize and paprika
Mkhota	Maize, beans, tomatoes, cabbages, onions and leafy vegetables.

The farmers employed treadle pump for water pumping, plastic pipe and canal for water conveyance and basin structures for water application. The pump and associated pipes were being transported by the handcart within and out of the fields. The cart body durability was estimated to be 10 years but the hub, spokes, tyre and handles would need frequent repairing. Locally, the farmers could easily repair the carts themselves.

5.3.4 Ergonomics of cart

Women expressed that they had to apply more effort to operate the cart than men. Men and women continuously operated the cart on hill terrain on 100kg load for one hour for comparison purposes.

Table 10: Ergonomics of the carting activity

Comparison		Energy expended (Nm)
Gender (sex) operating Africart (bicycle wheel)	Male	90
	Female	105
Model of cart	Africart wheel	104
	China wheel	96

Generally, China wheel cart could be operated easier and for a longer duration than the bicycle wheel one given the same load and ground terrain.

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5.3.5 Social Aspects of the treadle pump irrigation and cart use

All irrigation clubs have both women and men as members (Figure 10). Members are strictly encouraged to join the club as couples. This is aimed at discouraging extra-marital affairs among the farmers, thus reduce the spread of HIV/AIDS. In terms of literacy, over 80% of the farmers can read and write. The land tenure system is customary and the chief is the custodian. Conflicts were not noted during the study. Ownership of the carts would either be at club level or individual family level. The cart's estimated cost was K12, 000.

6. GENERAL FINDINGS ON THE CART PERFORMANCE

The following general results have come out of the Bunda college evaluation of the two cart wheel versions with farmers in Lilongwe, Dowa and Kasungu Districts of Central Malawi.

6.1 General findings, problems and tentative solutions

Eighty-five percent of those operators who wanted to use the cart for carrying patients, in addition to agricultural purposes, reported that the **deck** was too small for the need. Leaving the back of the cart open could solve the problem although if farmers are not well advised this practice would lead to cart overloading temptation. In terms of durability results showed weaknesses with handles, spokes and tyres. This is in line with several reports by Wendroff (2007). Much of the problem is associated with overloading – it is like loading a pick-up to the capacity of a lorry! Users need to be sensitized. All farmers reported that the handles were properly located, and did not cause difficulties to operate the cart.

Users stated that the handcarts currently available are not adaptable enough to permit many activities that bicycle users take for granted such as speedy operation of household chores, and participating in health activities (chassis too short to carry a patient lying down). The small village paths render problems to operate the two (side-by-side) wheel cart compared to a bicycle.

This however is pronounced by load capacity, poor terrain and long distance. Slopes higher than 30 % are prohibitive, so is the load beyond 150 kg. The small bicycle wheels make traction difficult on sandy or sticky soils. The larger China tyres are not relatively durable either although they tend to more reliable and take heavier load.

However, it is **not possible to design** a cart to overcoming all the aforementioned aspects without making it inappropriate in cost and technicality for the majority of the rural community.

The carts were tested for static **stability** for forward, rearward, and sideways tipping. Static stability was measured when the cart was positioned on a platform. The platform was tilted up or down slope, and tipping was achieved when the front or rear wheels of the prone carts lifted off the platform. The same procedure was repeated with 50-kg weights. Victimized parts were the handles and spokes. About twenty percent of the times the 2 or more spokes would break. This was more pronounced in bicycle wheel carts (24%), less with the larger Sino-wheel carts (13%). In case of handles breaking was observed at 9% of the test times.

In case of need to include **brakes,** 80% of the operators indicated that brakes were not necessary as they would increase the purchase cost and interfere with cart movement when faulty. Seventy percent of all respondents indicated that the **length** and the **height** of the cart were just right for their needs.

Seventy five percent reported that pneumatic **tyres** were strong except when they are internally made of two parts sewn together, a situation which leads to separation. Unfortunately the Sino tyres are weakly sown by cotton thread, rendering them very weak at the joints where cotton thread is used to join the two parts of the wheel. Care also needs to be taken so that the mounting of the axle on the base of the cart is not weak – the China wheels only come with round steel shaft without bolt provision features. Drilling should be carefully carried-out to avoid weakening the axle.

6.2 Favourable technical cart features

The properly packed cart has the load centered on the wheels hence does not tip front or back to cause leverage problems. The cart has the back stand support that elevates the body horizontally. This also provides positions to aid in rest for the operator.

The rural manufacture set-up provided the community with the sense of ease of cart fabrication, use and ownership. Persons with diminished stamina and muscle strength due to age and illness were able to operate the cart much better than the wheel barrow and the bicycle. The carts have not interfered with social set up of the rural irrigation community. Generally the communities have received the technology with enthusiasm.

The evaluation found that generally the cart has suitable overall length and height for average size Malawian, it posses ease of pushing or pulling for mobility and has proper weight distribution. Ninety percent reported that the body was long and wide enough.

6.3 Some Suggested Improvements

The cart must be made of hard wood or seasoned soft wood with an all- around edges for durability and user safety respectively. The cart body support must be well bolted together. The cart should be painted.

The wooden handles could easily break under heavy load and timber fatigue. Due to this problem the cart handles can be made of iron pipes for durability but this would raise the cost by about 8%.

7. CONCLUDING REMARKS

In the quest to achieve sustainable food security and income among small holder farmers introduction of the Africart is in the right direction in assisting the farmers to overcome the rural transport huddles.

7.1 River diversion

Introduction of treadle pumps to irrigate additional land area remaining idle above the main river diversion canal has helped to enlarge the irrigated area but pumping efforts limit the water delivery heads and distances. Use of the cart to transport the water should supplement river diversion.
From the study, it has also been shown that under small scale irrigation, it is possible to use canal water for irrigation using both gravity flows on lower fields of the canal and transport water to irrigate the upper fields of the canal.

7.2Treadle pump irrigation

This technology is being feasibily practiced at Ukwe, Mngwangwa and Kasungu –Chipala where farmers use treadle pumps to lift water from the rivers or wells to the upper fields canals. In Dowa at the three sites (Kakhwesi, Kukhola and Chimbalanga) where they have treadle pumps the farmers have been advised to be lifting water to the areas above the water diverting canal to irrigate the remaining potential upper land area. Handcart water delivery can assist substantially under such a situation.

7.3. Drip irrigation

The labour saving aspect of the drum kit drip irrigation system, was acknowledged as it could take 4 hours for water to get conveyed from a filled 200 litre drum. This indicates that small holder farmers can easily supplement river diversion or treadle irrigation systems with drip irrigation. However, filling of the drum reservoirs would easily be achieved through use of handcarts to deliver cans of water. Now that Malawi is installing larger Drip systems (500 m2) more water will be required to fill the 1000litre reservoirs, hence the need for technology such as handcarts.

In addition to water delivery, inputs such as pesticides, fertilizers and hybrid seeds associated with irrigation farming need use of technologies to safely deliver them to the field. In turn the increased yields as a result use of the modern farming practices pose additional challenge to the farmers in transporting the produce to their homesteads and markets. A handcart has shown to be very handy in these aspects technically, financial and socially.

7.4. Extension and farmer training

The areas need intensification on extension assistance and participatory rural appraisal (P.R.A) and demonstrations to improve handcart ownership and usability. In order to achieve the benefits of the handcart, the local manufacturing capacity should be strengthened. More local carpenters need to be trained. The handcart technology should be brought into mainstream of the agricultural, Community and Rural Transport mainstreams of activities and budget at District Assembly and Agricultural Development Division (Project and Extension Planning) levels.

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