

A Bicycle-Wheel Handcart: Applications, Development, Testing, and Dissemination in Sub-Saharan Africa.

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ABSTRACT: Handcarts using bicycle wheels are well suited to SSA conditions. They enable an average person to transport loads <100 kg with little effort as the weight of the load is balanced over the wheels. Effort is used to propel, rather than lift the load. These carts are adapted to many uses in both rural and urban areas. The widespread dissemination of this technology is economically feasible and should be actively undertaken by both governmental and non-governmental organizations.

Applications

All families require an adequate supply of water for drinking, cooking, and hygiene. In sub-Saharan Africa (SSA) most domestic water must be carried from source to homestead on the heads of women. The dearth of water for hygienic purposes has been identified as a major cause of morbidity and mortality in SSA. All farm inputs and outputs must be transported in some way. In SSA this usually means carried on the heads of smallholder farmers, most often by women and children. It is obvious that this places serious constraints on crop production. Lack of transport effectively precludes many smallholder farmers from marketing their agricultural surplus, as they have no way to get it to market. This dearth of affordable transport technology exists throughout SSA.

In Malawi (where the bicycle-wheel handcart this paper describes was developed) the ratio of people to motor vehicles is around 350:1. I have been unable to locate statistics on the number of bicycles in use, but my impression is perhaps one cycle per six households. The bicycle is ill-suited to the carriage of bulk goods, although it is often pressed into service for such use. The most common bulk-goods wheeled transport vehicle in Malawi is the wheelbarrow, which is unsuitable for carrying heavy loads over long distances. The wheelbarrow operator must carry almost half the combined weight of the load and the wheelbarrow. In addition he must balance the load laterally. The ox cart, and the far less common donkey cart are both prohibitively expensive. An ox cart cost some K 23,000 / \$433 in July 2000, whereas a handcart cost only K2,300 / \$43. In addition the ox cart is useless without the attendant pair of oxen, which would add an additional K 16,000 / \$301 to the cost, for a total of K39,000 / \$735.

Most smallholder transport activity involves short trips in and around the village. The handcart is in many cases better suited to these short trips than either the ox cart or donkey cart. The return on investment in a handcart is far more favorable for most smallholder farmers than for an ox cart, as the handcart will have a far higher utilization factor. For loads within its capacity, which are the vast majority of loads required to be moved by smallholder farmers, a handcart is handier to use than an oxcart. It requires no set-up time (locating, feeding, watering and harnessing draft animals) and is as fast or faster than an ox cart for loads within its capacity.

Both rural and urban dwellers engaged in small trading or vending require some form of

transport. The handcart is well suited to these activities, and its body can be easily modified to suit specific applications. Urban transporters in Malawi have been relying on wheelbarrows, but would be far better suited by handcarts, in terms of volumetric capacity, weight capacity, and ease of carrying long planks.

The HIV-AIDS epidemic in SSA has sickened and killed young adults, making it difficult for the very young and very old to cope with the need to carry water and firewood, let alone farm input and output. The availability of an affordable handcart would do much to alleviate the suffering and family disruption associated with this scourge.

In summary, it appears as if this is the first handcart design to be introduced to SSA that meets the criteria of adequate carrying capacity, ease of use, affordability, ease of manufacture using locally available labor and materials, and readily available spare parts. Its widespread introduction would confer enormous economic, labor-saving, and health benefits.

Development

In 1989 the utility of the handcart (garden cart as they are called here in the USA) for applications in Malawi and elsewhere in sub-Saharan Africa (SSA), dawned upon me as I helped a friend clear some land in the Catskill Mountain region of New York State. His garden cart was used by the two of us to move earth, rocks, brush and firewood over the dirt tracks of his property. It was apparent that the basic mechanical elements of his garden cart, (two lightweight steel spoked wheels on ball bearing hubs, fitted with wide pneumatic tires, and with both wheels mounted on a common 3/4" / 20mm diameter steel axle,) could readily be adapted to a wide variety of body types, made of wood planks, as opposed to the plywood box that his factory made cart possessed. I took several photographs of these garden carts and their mechanical components with me to Malawi that summer. The smallholder farmers I showed them to readily appreciated the potential utility of the carts in the photographs, and were keen to purchase one if it were available. Unfortunately, this type of wheel-axle set was and remains unavailable in SSA.

In 1992 I visited Malawi and brought with me a set of two 26" / 66cm diameter wheels and their 3/4" / 20mm thick steel axle. At Livingstonia, I engaged Mr. Duncan Mysalie, a master carpenter, to build a cart using these mechanical components. He made it small enough to fit (with its wheels removed) into the boot of my automobile. I drove this sample cart around and demonstrated it to farmers, NGO's, government ministries, importers and distributors. My intent was to convince these entities to import and distribute the wheel-axle sets so that they could be sold to those interested in building handcarts either for their own use or for sale to others. I failed in this endeavor.

In 1997 I corresponded with the Malawi Ministry of Agriculture, and offered to put up a small sum to test the public's interest in, and the potential utility of, the wheel-axle handcarts. And in 1998 I was invited by Mr. Aleke Banda, then Minister of Agriculture, to visit Malawi and carry out my demonstration. I spent a month at Malawi's Natural Resources College and the Chitedze Agricultural Research Station, building two carts (24" / 61cm and 26" / 66cm wheel diameters), testing them in collaboration with Mr. Wells Kumwenda, the Ministry's senior

agricultural engineer. I also visited government ministries, NGO's and commercial interests as I had done in 1992. Although Mr. Kumwenda's report on the usefulness of these handcarts was favorable, once again there was no follow-through and no one took up the challenge of importing and distributing the wheel-axle sets into Malawi.

In the summer of 2000 I again decided to try to convince the development authorities in Malawi to import these wheel-axle kits, and I carried seven sets of them of various sizes with me to be built up into trial models for evaluation. I still thought that the wheel-axle technology was the best and probably the only way to economically build a workable handcart. Happily, I was mistaken.

In 1992 I had seen several handcarts built of welded steel and employing ordinary 28" / 71cm bicycle wheels in use at a commercial rose farm on the outskirts of Lilongwe. The Dutch horticulturist in charge of the operation stated that although these handcarts were prone to breakage, they saved so much labor that they more than paid for their construction and maintenance costs. They employed horizontal forks of steel rod welded to steel strip and angle section frames. They were employed to carry cans of water containing cut rose stems around greenhouses and refrigerated storage areas. At the time, I was still fixated on the wheel-axle design of cart, and did not fully appreciate the design of these steel handcarts employing bicycle wheels. I had also seen somewhat similar horizontal steel-forked bicycle wheels incorporated into the structure of locally made invalid carts fabricated in the workshops of Malawi Against Polio.

A conceptual breakthrough was made several months after my return from Malawi, when on September 5, 1998 I came across and purchased a book, Rustic Retreats: a Build-it-Yourself Guide, by David & Jeannie Stiles. (Storey Books, Pownal VT, 1998) On pages 7-9 the authors sketched out and described a "Handcart" built mainly from common 2"x4" (4cm x 9cm) framing lumber and plywood, and employing two 26" / 66cm bicycle wheels, each carried in a horizontal wooden fork. Unfortunately, from the details of the sketches, it appeared as if the cart as described stood little chance of holding together under moderate use, let alone under far more severe Malawian conditions. Furthermore the use of plywood for the floor was impracticable for reasons of cost, availability and durability. About a year later, I contacted the authors via their publisher, and queried the senior author about the cart's constructional details. I specifically asked if they had actually built the cart as described. I was assured that they had. I asked for photographs of their cart, but unfortunately they were not forthcoming.

The Stiles' plan gave me the idea that the steel horizontal frames I had long been familiar with on the MAP invalid carts, and on the rose farm handcarts could readily be translated into wood. On board the aircraft on my way to Malawi in late June of 2000, with seven wheel-axle sets in my baggage in the plane's hold, I decided to make my first priority the designing and building of a wood-framed bicycle-wheel handcart.

On arriving in Malawi my research assistant, Mr. Chika Mughogho and I purchased two sets of bicycle wheel rear hubs, rear rims, spokes, tubes and tires. I had brought with me a variety of wood screws, threaded rod, nuts, washers and perforated steel strip. At Livingstonia, our base of operations, we negotiated with local sawyers and purchased planks of local hardwood. Although dry to the touch, it was green on the inside. However as I was pressed for

time, we had these unseasoned planks run through the planer at the Livingstonia Technical College to the desired 3/4" / 2cm thickness. I then began to design and build the prototype employing a local carpenter, Mr. Trynos Chirwa, and his assistant, Mr. Alfred Tembo. We completed the prototype cart on July 10th, with the actual design and construction taking about five working days. We calculated the cost of the prototype, including labor at K2300. There were some 53 Malawi Kwacha to the US Dollar at that time (53K : \$1).

Testing

We briefly tested the prototype handcart with six individuals, three men and three women. Each pushed the cart (which weighed some 48kg) with a load of 100 kg (two 50kg bags of cement) along a measured 1 km course on an undulating dirt road. This 100kg load produced no discernable deflection of the cart structure. The average time taken was eleven minutes to cover the one kilometer distance. One man, Christopher Munthali, our general assistant, was commissioned to push the loaded cart continuously for one hour. He covered a distance of 4.75km in that time. He was not very tired at the end of his exertions, as he had lifted no weight, but merely propelled the load, which was balanced over the axles of the two wheels.

We have not tested the bicycle-wheel cart rigorously or for a long period of time. However it is of a very simple design, employs well-tested bicycle wheels, and screwed and bolted lap joint construction. It is very conservatively dimensioned, and the several fasteners and joints are lightly loaded. The handcart seems likely to have a life expectancy of many years if treated with reasonable care and not overloaded. However, in the event of damage, its wooden frame and body are easy to repair, and spares for the wheels are available throughout SSA.

Dissemination

After the prototype was built and tested it was thought advisable to construct a number of carts for further testing, evaluation and assessment of their market potential. Accordingly, I approached Mr. Joseph Longwe, Principal of the Livingstonia Technical College, and asked if his Production Workshop could build an initial run of ten handcarts. He assented and I agreed to furnish the assembled wheels, money for the wood, and all the necessary fasteners. The LTC was to provide the labor. The proceeds of the sales of the ten carts would provide capital for the Production Workshop to build and sell another batch of carts. I learned that 125th anniversary of the Livingstonia Mission was to be celebrated on July 29th in Mzuzu, the Northern Region's capital. The President of Malawi, Moderator of the Presbyterian Church of Scotland and numerous visiting dignitaries were due to attend. The LTC was to display its achievements at the celebration. I suggested to Mr. Longwe that our handcarts would be appropriate to include in the exhibit, and he agreed. We worked overtime in order to finish building six carts in time to be taken to Mzuzu.

I had earlier met a village carpenter, Mr. William Nyasulu, at Lura Trading Centre, situated some twenty miles south of Livingstonia, on a dirt road no longer served by public transportation. He seemed to be doing high class work. We accordingly showed him photos of the prototype cart and suggested he might find it profitable to build them himself. I offered to

provide transport money so he could travel to LTC and measure and sketch our prototype cart, and receive some instruction on the constructional details. I also offered him a free set of wheels and fasteners. He visited us a few days later, and made his drawings and measurements under the tutelage of Mr. McLonely Kaundama, LTC's Production Foreman. He returned home with his wheels, and we later learned that he took only four days to build his cart; which we later transported to Mzuzu Stadium to be a part of the LTC exhibit. It was important to be able to demonstrate that an ordinary carpenter, working in a remote rural area, could construct a handcart.

I prepared sets of photographs showing the cart being used to carry a variety of loads: water, bricks, shop merchandise, grass for thatching, maize for grinding and as an ambulance to carry a sick person to hospital. I also commissioned a technical drawing of the cart by Mr. Osward Mhango of LTC, and had copies made for distribution at the Mzuzu celebrations. I employed a small video camcorder having a built-in screen to demonstrate videotapes of the cart in use to interested parties. It was succeeded in conveying the utility of the cart to viewers.

I arranged interviews with both the Malawi News Agency (MANA) and *The Nation* newspaper, as well as with Malawi Broadcasting Corporation (MBC) radio. These interviews were printed in *The Nation* and broadcast on MBC. Additionally Television Malawi (T.M.) broadcast my meeting with President Baikal Maalox at the LTC exhibit at Mzuzu Stadium on July 29th.

I followed up on this publicity by meeting with several development-oriented agencies located in and around Lilongwe at the end of my stay in Malawi in early August. These included agricultural engineering and production experts at Chitedze Agricultural Research Station, representatives of The World Bank, and the Ministry of Local Government's "Malawi Rural Travel and Transport Programme" (MRTTP). The MRTTP is funded in part by World Bank and has counterpart programs elsewhere in SSA. I also met with the Danish Embassy Secretary, who had earlier visited LTC to arrange for a grant designed to assist in technical extension education. The Danish International Development Agency (DANIDA) advisor was very eager to disseminate the handcart technology, and incorporate it into their vocational education program.

The CARE Country Representative was eager to purchase twenty of the handcarts for use in a project employing groups of women to repair roads. Senior representatives of the National Smallholder Farmers' Association of Malawi were enthusiastic that their membership would readily adopt the handcarts, as they were affordably priced.

Since arriving back in New York, I've met with a representative of the Malawi Mission to the United Nations, and have scheduled meetings with several other UN Missions.

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