

Design for Sustainable Mobility – the appropriation of open-source technology in industrially developing contexts

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The central theme of this paper is the interrogation of factors relating the successful appropriation of open-source technology in an industrially developing context using a LeNS-inspired sustainable mobility project set in Cape Town, South Africa. *Design for Sustainability* (DfS) in general, and *Product-Service-Systems* (PSS) models in particular have both local and global components that interact in a complimentary manner to ensure efficacy. The sustainable mobility project discussed herein acts as a catalyst for DfS diffusion in settings far removed from their industrial place of origin. Naturally, peculiar challenges and unique opportunities arise that potentially impact on the successful adoption and mainstreaming of similar strategies in the pivotal informal economies within the contexts of appropriation.

Further, this paper explores the potential for incorporating home-grown ethos (such as the community-orientated and participatory practice of *ubuntu*) to inform more robust and resilient social responses to pressing issues around sustainability. Linked to this place-specific notion is the potential for dissemination of DfS elsewhere in Africa as a vital contribution to the worldwide transition towards a more sustainable society. Finally, this paper articulates a vision on the future role of LeNS-Africa with respect to benefits accruing to active membership in the said network in various design programmes to effectively address sustainability issues in design.

Keywords: *Appropriation, Industrially Developing Economies, LeNS-Africa, Open-Source, Sustainable Mobility, Technology Transfer, Ubuntu, Universal Design.*

Introduction

This paper argues that the appropriation of technology in an open-source modality would have a far more effective ability to yield sustainable solutions than the patently prescriptive traditional top-down approach that is employed in technology transfer between industrially developed and developing contexts.

Technology transfer implies that flows in given socio-technical systems result in the enhancement of quality of life in the receiving context. Notwithstanding, popular notions of technology transfer often fail to adequately recognise and engage with locally available expertise and resources. Subsequently, the needs of intended beneficiaries are often left unmet, despite the massive publicity (often focusing on the negatory images of poverty, instability and disease in Africa) that accompanies such efforts. Innovation is a constant reality on the continent without the need to romanticise the poverty and suffering of Africa's denizens. If a more collegial attitude is embraced, Africa does have the capacity for co-creating innovative and context-responsive solutions through an appropriate use of technology transfer.

Technology Transfer

Technology Transfer (TT) within the context of this paper refers to the movement of a technological concept or device from the context where it was created, to a context where it is intended to be implemented. In the case of the sustainable mobility project discussed herein, the transfer happens from an

industrially developed country in Europe to an industrially developing country in Africa.

Successful TT even within the bounds of a country as diverse as South Africa is difficult to achieve. Problems have been encountered as recently as 2005 (Du Plessis, 2005) and 2009 (Njobe, 2009) in two local examples of technology transfer where appropriate approaches to the projects were not employed, thus necessitating the creation of *ad hoc* and *ex post facto* guidelines to more adequately inform the process. During the 2005 ICSID InterDesign Workshop on *Sustainable Rural Transport* a number of cautionary concerns were raised by Du Plessis (2005) with reference to technology transfer:

- Failure due to the culturally '*incorrect*' way a product is introduced to the community;
- Failure of designers to take specific culturally orientated designs into account;
- Failure to include and consult the community in the product design and development process;
- Introducing products that by nature are foreign to the (rural) community; and
- Ignoring the specific socio-economical circumstances and needs of the community.

This event was geared towards a more rural context, however, the highlighted points still have relevance to a much wider scope of applications, including the sustainable mobility project discussed herein.

The second example is the *Amadrum Project*, which was established to combat a massive outbreak of cholera in one of the provinces in South Africa. This was effected by creating and distributing a home water treatment plant comprising a plastic drum with separate compartments for flocculation, sedimentation, filtration and disinfection. It was designed as an interim measure, providing clean, safe drinking water until a potable water supply system could be installed (Njobe, 2009). Unfortunately, despite the best of intentions, the project failed due to the use of the drums not being adequately considered within the user context, along with poor forward planning. Subsequently, the following insights were gained from the project's failure and would have resulted in greater success had they been observed:

- Include local stakeholders;
- Assess whether local infrastructure is ready to absorb a new technology;
- Create awareness of your technology and prepare the community to receive it;
- Train people to use and maintain it; and
- Monitor and evaluate your progress to identify any changes that may be needed.

Njobe (2009) more importantly includes the need to engage local innovating talent for solutions to local problems, rather than hiring outside experts who are often unversed in local geopolitical realities. He specifically discusses the use of the 'FabLab' model, as promoted by the M.I.T, to foster innovative talent to generate solutions (*ibid*). There are, however, different ways in which to conduct or undertake technology transfer, as listed hierarchically below:

- 1 - The transfer of a device or a technology, without modification, for implementation in the developing context;
- 2 - The transfer of skills from an industrialised country in the form of a consulting designer;
- 3 - Collaborative work on a design between an industrialised and an industrially developing context;
- 4 - Appropriation of technology from an industrialised context by an industrially developing context;
- 5 - Complete autonomous local design of a product from scratch based on the idea from an industrialised context; and
- 6 - The transfer of knowledge in the form of education and training – educating local people to become designers (Papanek, 1985).

Open-source

The term 'open-source' (OS) has its origin in the field of software development and is attributed to the *Open-Source Initiative*, which was established by affiliates of the *Free Software Movement* who were more concerned with practical issues surrounding free software development, as well as the need to make it more appealing to the business world. Although both of these movements describe almost the same category of software, their value systems differ fundamentally.

Free Software according to its founder Richard Stallman is a social movement (Stallman, n.d.a), which is uncompromising in its promotion of the ethical practise of collaborative free software development and maintaining user freedom as the underlying tenet, where the societal benefit from having access to open source software is valued above individual commercial gain (Bornfreund, 2004). It is based on the *Copyleft* ethos, which uses a *copyright* license and distribution terms, in a contrary manner, to guarantee freedom for users to use, modify, and redistribute the work and continue to make it (and any derivatives in which it forms whole or part) freely-available to others under the terms of the parent license (*ibid*). OS on the other hand is a development methodology with over 50 different licenses, which are focused on both Copyleft and non-Copyleft licenses. It provides a form of accountability, as well demonstrating integrity to users (Stallman, n.d.b).

Creative Commons is an organisation that was established in 2001, to meet the growing needs of individuals who wanted to protect their original content from exploitation by the unscrupulous. They provide **free** licenses and other legal tools to mark creative work with the freedom the creator wants it to carry, so others can share, remix, use commercially, or any combination thereof (Creative Commons, n.d.). They also offer a number of different licenses, free of charge, each allowing the originator of a media item or device to decide how much power to grant a user, in terms of commercial or non-commercial distribution, and whether modification is permitted or not.

Solar-cookers as open-source technology

The use of solar energy to prepare food is a functional appropriation of an abundant energy source. The solar cooker makes a good case study for the appropriation of open-source technology (see Figure 1). According to *The Solar Cooking Wiki*, the first documented solar cooker was created in 1767 by a French-Swiss scientist, Horace de Saussure (Knudson, 2004). His solar heat trap design was the forerunner of today's basic box type cooker. This box cooker has spawned two other types, the curved concentrator (parabolic) and the panel cooker. These three types collectively have evolved further into over 204 variations to meet the constraints of available resources and varying environments around the world where the said cookers are used.

A significant percentage of the innovation which has taken place with respect to solar cooker technology was effected by independent users, or via participatory design sessions between users and non-governmental organisations (NGOs). This has all been compiled on the solar cooking *Wiki*. The scope of this project is evident by the translation of sections of the website into 51 different languages – by its very nature a *Wiki* implies that the resource is for open-source distribution (http://solarcooking.wikia.com/wiki/The_Solar_Cooking_Archive_Wiki).

Figure 1: The solar cooker – Earthbound

Photo: Tom Sponheim - http://solarcooking.wikia.com/wiki/File:Earthbound_EB-42T.jpg



Open-Source within Technology Transfer

The majority of open-source licenses serve to protect the freedom of the users to use, alter and distribute the available device, however, when this is considered within the practise of what is ostensibly philanthropic technology transfer to an industrially developing context it becomes clear that in reality it is the users, and not the originators who decide which licensing restrictions are placed on the OS device. This is what could be termed as appropriate licensing. If this factor is ignored, the oversight could negatively impact on the device or technology being successfully adopted for use, manufacture and distribution, and potentially creating and maintaining a local market and industry that supports the technology.

Additionally, merely stating that a project is open-source does not protect its use and distribution from exploitation by the unscrupulous. This often keeps the receiving context ignorant of the true dynamics at play in such a project. Further, this outcome potentially jeopardises future technology transfer initiatives. An open, transparent and convivial relationship would forestall such a likelihood thus increasing the probability of end-user adoption and by extension is a more sustainable proposition from a community perspective (Manzini, 2007). Such a relationship could foster social equity and cohesion (Vezzoli & Ceschin, 2008). For example, although the Copyleft license protects the highest ideal of freedom and collaboration, if one considers such a license applied to the development and dissemination of the *Kenyan Ceramic Jiko* (Figure 2) it quickly becomes apparent what effect prescribing an open-source license would have on a technology or device. In this particular case it would have stunted the success of the device in reaching as many people as it did, because no individual or organisation would have been prepared to manufacture the stoves for free distribution, as the license would stipulate.

Figure 2: The Kenyan Ceramic Jiko
Photo: Mugendi M'Rithaa



The Kenyan Ceramic Jiko

Jiko means 'stove' in KiSwahili – one of the most widely spoken languages in Central, Eastern, and Southern Africa. The Kenyan Ceramic Jiko is the result of close to three decades of product development in the quest for as a low-emission, high-efficiency (char)coal burning cook-stove. The widespread use of firewood and less efficient cook-stoves led to irreversible destruction of trees and related ecosystems in many parts of the country. Subsequently, a push led initially by foreign engineers led to the adaptation of a ceramic lined stove design from Thailand to suit local realities. The success of the *jiko* resulted in profitable collaboration between government departments, aid organisations and local rural women's groups resulting in the development of the *Maendeleo jiko* that is fabricated in the ubiquitous informal sector known locally as '*jua kali*' (literally meaning '[in the] hot sun' in KiSwahili). Such a model differed from that taken in China – here the government opted to give local energy offices responsibility for handling technical training and setting of manufacturing standards (Kammen, 1995). No direct subsidies were offered, and people exercised their prerogative over procurement of the stoves. In India on the other hand, the government offered a 50% subsidy on the cost of some eight million stoves distributed. Unfortunately, only half of this number of stoves was taken up for use – the government had failed to take cognisance of the regional differences in cooking habits (*ibid*). The lesson here is that all key elements of the socio-technical system of the receiving context should be interrogated and addressed adequately to ensure ownership (Vezzoli *et al.*, 2009).

Table 1: Appropriate technology: a comparison

	zero-emissions + expensive + slow	emissions + inexpensive + fast
low-tech – local parts	Solar Cooker	Ceramic Jiko (cook stove)
hi-tech – imported parts	MULO sustainable vehicle	Minibus / Tuk-Tuk (three-wheeled taxi)

Appropriation

The word appropriation comes from the Latin word *appropriare* which simply means 'make one's own' (Oxford Dictionary of English, 2003). Notwithstanding, when the act of appropriation is considered within an industrially developed context the term implicitly connotes a negative and/or illicit action. Appropriation in a commercial context is generally viewed as an illegal or subversive activity, as it infringes upon patents and copyrights and threatens the public image and commercial success of a company. There are no specific methodological guidelines for appropriation. It is an open and infinitely flexible process ungovernable and unrestricted and is practised with little concern for any prescriptions from allied socio-technical systems. Fundamentally, it is a negotiation about power and control over the configuration of the technology, its uses, and the distribution of its benefits (Bar *et al.*, 2007).

Figure 3: Appropriated Watering Can – *Vuvuzela*

Photo: Author Unknown - <http://lifeissavage.com/dont-have-a-vuvuzela-make-a-plan-pic/>



Appropriation is typically opportunistic in nature. It exploits the most useful qualities of a device or technology, regardless of planning or principle and puts it to a new use immediately – this is appropriation practised in its most fundamental manner. The image (in Figure 3) shows a soccer fan appropriating a watering can by turning it into a *vuvuzela* (a popular variety of plastic trumpet used in South Africa). However, within the context of sustainable mobility, appropriation will be considered as a form of adaptation as conceptualised by Eglash (2004).

Eglash (*ibid*) proposes three analytic categories by which to consider an example as to how strong a case is for its classification as appropriation. The weakest case, *reinterpretation*, is defined by a change in semantic association with little or no change in use or structure, such as graffiti. The next stronger case, *adaptation*, is defined by a change in both semantic association and use and can further be described as the "discovery" of a "latent" function (*ibid*) – this is the case in Figure 3. The strongest case for appropriated technology is *reinvention*, in which semantics, use and structure are all changed. That is, if *adaptation* can be said to require the discovery of a latent function, *reinvention* can be defined as the creation of new unintended functions through structural change (*ibid*). Under optimal conditions, reinvention is possible.

M-Pesa: an interesting example of appropriation

M-Pesa™ ('M' is for mobile and 'Pesa' is KiSwahili for money) was originally conceived as a service to enable borrowers to repay their loans to a microfinance institution in Kenya, by streamlining the process through the use of the borrower's cell-phones and the network of local pre-paid airtime agents (see Figure 4). After two months into the pilot project the option of buying pre-paid airtime was introduced. Apart from the standard loan repayments, the users began to adaptively appropriate the whole service and to use it in all sorts of new ways to accomplish previously challenging or impossible tasks, as well as innovating new unanticipated functions for the service (Hughes & Lonie, 2007).

Figure 4: Advertisement for M-Pesa™

Photo : <http://www.guardian.co.uk/technology/blog+business/banking>

Indigenous knowledge is an important contributing factor to successful acts of appropriation, in this example awareness of local conditions and the manner in which the technology could be adapted to suite the unique needs of the end-users. Appropriation enables this indigenous knowledge to become apparent in the uses people create to deal with their environment, and can serve as invaluable information for future development products. The manner in which people or a community appropriate technology can be a means to understand the capability of a community or of a person to innovate. Consequently, appropriation can be used as a means to ascertain what sort of adaptations need to be made to a specific version of a design in order to make it more appropriate to a given context and community. In other words people appropriate technologies to make them appropriate to their needs. Appropriate technology can be viewed in this context as a catalyst or means to creating sustainable solutions – it is a personal process of adaptation of a device to meet the end-user's functional and/or aesthetic needs.

Sustainable Mobility

Within the ambit of this paper, sustainable mobility refers specifically to a public transport service, whether privately owned or managed by government. If it is considered public transport then the emphasis changes from being focused on the technology, as in the case of personal mobility, to that of the service, which commuters can make use of to get from point 'A' to point 'B'. The reason for this is that transporting large numbers of people using a single vehicle is a great deal more economical and less polluting than if every commuter has their own vehicle. As a means to create a benchmark for the concept of sustainable mobility in Cape Town within the Western Cape Province, three zero-emission variants have been used as examples.

Table 2: A comparison of locally available options

Vehicles	Emissions	Fabrication	Parts	Repair	Power Source
cart horses – Cape Town	zero	local	local available	simple	animal drawn
rickshaw – Durban	zero	local	local available	simple	human pulled
PediCabs – Cape Town	zero	Bogotá, Colombia	import	expensive	human pedal
MULO – Cape Town	zero	local	combination of local & import	expensive electrical components	human pedal & solar electric

Cart horse and driver

Cart Horses have been operating in Cape Town even before the introduction of the internal combustion engine and could be seen as setting a benchmark for sustainable mobility in the most practical sense of the term. Even after the

introduction of a major technological advancement in mobility (such as the internal combustion engine) the use of cart horses persisted. It is the original zero-emissions vehicle; save for the occasional obnoxious effluent left although in the streets was an organic by-product. There are at present around 230 cart horses actively working in and around Cape Town primarily in the gathering and transportation of scrap metal. They are also used as personal transport by the owners. These carts can often travel for up to 100kilometres per day at a walk or a trot pace – larger horses have the capacity to pull a payload of about one tonne. It costs around ZAR600 – 1000 per month to maintain a cart horse, a portion of which is subsidised by the *Cart Horse Protection Association*. Instructively, the cart horses operate in the same region of greater Cape Town that the MULO is destined to ply.

Rickshaw Pullers

The rickshaws provide another example of sustainable mobility, but from the perspective of human power. The rickshaws operating on the Durban beachfront in KwaZulu-Natal Province (of South Africa) have a rich history of more than 100 years of operation and adaptation. Their introduction to the city, by Sir Marshall Campbell in 1892 from the east, is an early example of technology transfer of a zero-emissions vehicle for the purpose of public transport. By 1902 there were 2170 rickshaws in operation both in the city centre and the docks, owned by local operators. The rickshaw pullers were required, by legislation, to wear a basic uniform consisting of an unbleached calico suit and trimmed with a single band of red braid in order to identify and regulate them (Ezакwantu, n.d.). However, after a short period the pullers began to appropriate their bland and formal uniforms, themselves, by adding decorative elements, which included adding extra braids and wearing bangles of plaited reeds with seeds which rattled upon their white painted lower legs. Two horns were also added to the pullers brow, which was intended to show the man to be as strong as an ox (*ibid*).

By 1918 the horse drawn carriage and the motor vehicle had presented fierce competition to the rickshaw pullers and by the 1930's the streets in Durban were over-crowded by more than 9000 motor vehicles and 10000 horse drawn carts, as well as a number of buses and trams, however the rickshaw pullers still managed to remain popular as they could offer short journeys in and around the city centre. By 1940 in an attempt to boost dwindling popularity the puller's adapted their attire further with more elaborate and outrageous decoration, including beaded vests, skirts, aprons, belts, sheep skin anklets and other accessories, virtually covering their entire bodies. The headdresses become enormous, incorporating two to four painted ox horns each (*ibid*), which had now started to become popular with tourists on the beachfront. There were now only 900 rickshaws in operation. The rickshaw puller's clientele started to change and they adapted to meet the demands of this new niche market, as the demand for rickshaws as a taxi service ended. From the 1950's up until the present day, the rickshaw puller's unique appropriated style has remained the same. Contemporary rickshaw pullers are self-sufficient, operating and owning the vehicles themselves. Currently there are only 25 in operation serving the tourist market along the beachfront. It costs around ZAR10000 to purchase a new rickshaw, with the wheels costing around 40% of this figure due to their unconventionally large size. The strength of the rickshaw (and accompanying) is its ability to allow pertinent cultural expressions as a form of identity and marketing strategy.

Figure 5: Durban rickshaw puller

Photo: <http://hubpages.com/hub/South-Africa-KwaZulu-Natal-Holidays>

Pedicab

The PediCabs operated by a Cape Town based company called CycleCabs have slowly become accepted by the public as a form of inner city transport. The PediCabs started operating in January 2009, first as a pilot project for a period of 6 months after which the business model began to prove successful and they proved to be economically sustainable. The PediCabs provide another example of technology transfer, which is akin to the rickshaw in Durban, in that they were also seen to be operating successfully in a foreign context, in this case the South American city of Bogotá in Colombia. 11 PediCabs were originally imported by CycleCabs to use in the Cape Town central business district (CBD). However after a relatively short time problems were identified with the wheel hubs and had to be replaced at great expense from Bogotá. The PediCabs experience reveals the downside of technology transfer when local socio-technical capacity is overlooked. Frequent breakdowns on account of the inferior quality of the components, as well as availability problems have continued to plague the operation of the vehicles. This illustrates the importance of accurately considering the appropriateness of a technology for a context, even when it is from a similar industrially developing context where some reasonable degree of compatibility is envisaged.

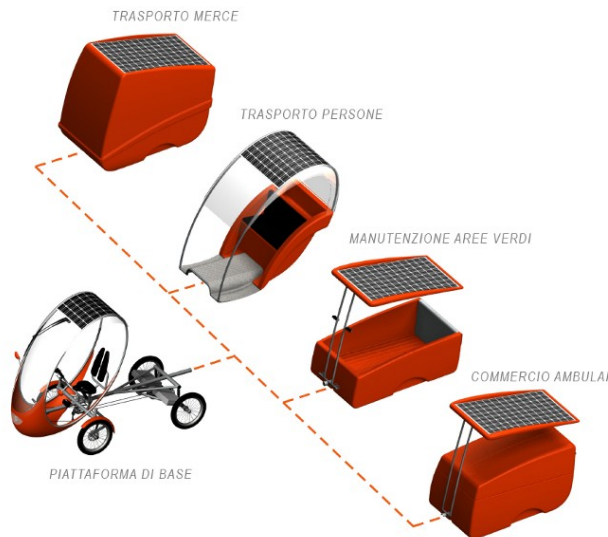
One thing which is consistent across these 3 examples is economic sustainability and the ability of the drivers/operators to adapt their function or service to meet the needs of a changing operating environment. The relevance of this to the issue of sustainable mobility is that allied socio-technical systems must of necessity allow for appropriation to accurately meet the mobility requirements of the receiving community.

Sustainable Mobility Project (MULO)

The project is currently in the phase of technology transfer. The manner in which this is being undertaken is through collaborative work on the redesign of the open-source sustainable mobility platform, MULO, between a team at the Cape Peninsula University of Technology (CPUT) in Cape Town, South Africa and the Politecnico di Milano (Polimi) in Milano, Italy. A co-design approach of the vehicle's platform and the rear section is running concurrently. The focus on the rear payload area follows Universal Design principles that would result in an accessible platform for the elderly as well as people with disabilities who could be using wheelchairs for independent ambulation. This paper reports on the research and development implications on the transfer of technology using a working case study surrounding the adaptation of a hybrid vehicle (primarily relying on human pedal power, with solar energy fuelling the back-up system), called the MULO System (see Figure 6). The project is a pivotal one with regards to inter-university transfer of technology and is instructive in the assessment of perceived challenges encountered in the transfer technology from an industrially developed context to a developing one. The perspective adopted is that of the receiving context, namely Cape Town and interrogated through the main concepts of appropriate technology, appropriation and sustainability in order to highlight the challenges that this example of international technology transfer entails.

Figure 6: The MULO sustainable mobility system

Source: Fabrizio Ceschin - 2006



This collaboration focuses on the MULO System, a modular platform of a zero-emission solar powered hybrid vehicle, which was designed, prototyped for Italian conditions and infrastructure and tested in a 591kilometre run across the sunny Italian countryside by Fabrizio Ceschin for his Masters thesis at Polimi. The vehicle then formed part of a paper on '*Designing Sustainable System Innovation Transition for Low-Industrialised Contexts*' (Vezzoli & Ceschin, 2008). This paper explored the possibilities of co-ordinating a group of stakeholders, using a model of system innovation, who could work together in an open-source modality (*ibid*) to develop and implement the original MULO System in one of three low-industrialised contexts, namely Burkina Faso, Zambia and Nigeria. The goal of the project was the diffusion of a sustainable and long-lasting mobility system in low-income/industrially developing African contexts, based on local resources (*ibid*). '*System Design for Sustainable Mobility in Zambia*' was collaboration between Polimi and the Technology Development and Advisory Unit (TDAU) at the University of Zambia (Bazzi, 2008). The project was also part of the Third Phase of the redesign of the MULO platform for the transport of produce from farms to the market place in rural Zambia – the has yet to be implemented (*ibid*). The design specifications for all the MULO variants in the different African countries did not leave much room for local aesthetic and cultural reinterpretation allowing such cues to be embedded in the overall appearance of the vehicles. There was however allowance for the use of locally available materials and processes.

The Cape Town phase of MULO Pilot Project was formally initiated in September of 2009 and was the Fourth Phase and implementation of '*KANGA: A Sustainable System Design for the Transportation of Learners with Disabilities in Cape Town-South Africa*' (Gumus, 2009). This project was initially destined to be undertaken in partnership with the University of Lagos in Nigeria, but due to difficulties in establishing a contact with the university, the project was diverted to Cape Town, South Africa by a serendipitous meeting between professors from both Politecnico di Milano and CPUT. Three further stakeholders, above and beyond Polimi and CPUT, were identified by Gumus (2009) to take part in the project. Two *Disability Workshops* (DW) and a social welfare organisation in Bridgetown will be hosting the pilot project – this fourth phase of the project will be conducted with the vehicle's intended use being to serve the transportation needs of the elderly and disabled wheelchair users within the Bridgetown community.

Overview of the Fourth Phase

After some investigation and discussion with the stakeholders it appeared that there was a lack of consensus as to how the project would be conducted, and the specific roles of key actors, as well as the sources, quantities and flows of anticipated funding. The task of redesigning the vehicle was split between a Polimi team, who were responsible for the platform, and the CPUT postgraduate student (one of the co-authors) who would redesign the rear payload section and create the overall aesthetic look, as well as manage the socio-technical aspects of the project in Cape Town.

Both Disability Workshops had a similar purpose, in assisting and serving their constituency of people with disabilities. DW 1 is a non-profit organisation that is geared towards creating sheltered employment for people with disabilities and preparing them for the open labour market and is totally reliant on external donor funding. DW 2 is an independent business enterprise that was established around providing services and assistive technology and equipment, which they produce themselves, principally for the disabled community.

The agenda of DW 1 was related to meeting the expectations of their funders, whereas DW 2 was primarily concerned with sustainable economics and considering the long-term viability of the vehicle as a source of revenue. Whereas DW 1 had assumed responsibility for the funding of the project at its inception, ideological differences between the two stakeholders and logistical delays in getting the fabrication of the vehicle led to DW 1 withdrawing unconditionally from the project. A timely injection of funding support from Polimi helped ameliorate this daunting reality, along with a significant financial contribution from DW 2 in the form of fabrication facilities and production.

The lessons learnt from this experience follow:

- The need to mediate between the two Disability Workshop stakeholders;
- The need to formulate a comprehensive product-service system to manage the operation of the vehicle;
- The need to align priorities of the originators (e.g. aesthetic integrity and publicity potential) with those of the receiving context (e.g. financial viability and practicality);
- The need to negotiate issues of freedom, control and responsibility within the design process; and
- The need to establish a clear schedule of mutually acceptable obligations for the smooth running of the project.

Post-Pilot Project Sustainability

In the long run, post-pilot project sustainability can only be secured if there is 'buy in' from the community that opts to make use of the anticipated transport services. Currently the service will make use of a core group of volunteers from the local community to operate the vehicle. Additionally, if the vehicle is donated to the community then there would be no financial burden on the recipient community in servicing a debt towards repayment – the said vehicle would then offer a free public transport service to vulnerable or 'special needs' members of the community who are typically economically underprivileged.

The carrying capacity of the MULO vehicle is 3 people at a time – in the case of the Bridgetown pilot area there are around 40 elderly people who need transport to the community centre for their weekly social gathering. Ideally, there should be a number of these vehicles in operation to effectively service the needs of the community (including numerous people with disabilities). Due to the high cost of such vehicles, it is incumbent on the product-service system to identify a sustainable business model that would guarantee the viability of the project. A number of other beneficiaries (such as school children) have been identified and would stand to benefit from an expanded MULO system. It is thus imperative that a sustainable mobility project such as the MULO system be

conducted in the appropriate manner to bolster the aspirations of the receiving community without threatening the survival of complementary modes of transport (such as the commuter taxis that ply the longer routes). The project's dependence on expensive imported components would also have to be addressed to ensure technological sustainability of the planned product-service system.

Conclusions

The potential role of LeNS-Africa in the promotion of DfS-related projects and initiatives is significant and serves as a replicable model for the transfer and exchange of technology and related didactic tools. The members of LeNS-Africa have acknowledged the intrinsic value of such exchanges and seek to explore similar ventures in the near future. Further, the copy-left ethos espoused by LeNS allows for easy adoption, adaptation and diffusion of pertinent best-practices of relevance to the African context.

The MULO project arguably represents a 'hi-tech' variant of technology transfer (when viewed against the appropriate technology domain) and by extension introduces certain complexities of a socio-technical nature in an otherwise straightforward venture. Future projects of this nature would benefit greatly from the lessons learnt in this pivotal multi-dimensional project. These include financial, geopolitical, stakeholder and technological considerations. The need to harness renewable sources of energy to drive transportation can not be over-emphasised. Notwithstanding, unique socio-technical challenges need to be addressed so as to facilitate more equitable and sustainable exchanges.

Consequently, through a peer-to-peer *learning-by-sharing* exchange that is allied to the continental ethos of *ubuntu* (promoting human-focussed and community-building dynamic), LeNS-Africa members stand to gain valuable insight into the dynamics of technology transfer and related socio-technical concerns. The said lessons also enrich research competence and inform more context-responsive models for multi-stakeholder engagement.

Finally, the MULO example should be viewed within the wider framework of DfS projects and initiatives that could potentially bolster and catalyse Africa's quest to leapfrog into a more sustainable future, and subsequently avoid many of the debilitating setbacks of unsustainable production and consumption patterns elsewhere (particularly in more industrially developed contexts). It is within this framework that active membership within the LeNS-Africa network represents the greatest value.

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