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# Tools or Toys?

## Designing Appropriate Technology for Developing Rural Communities

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"The world's cleverest designers [...] cater to the globe's richest 10 percent, creating items like wine labels, couture or Maseratis" – an effort that is clearly perverse when compared to the billions of people that are waiting for a $2 pair of eyeglasses, a $10 solar lantern or a $100 house. [14] Providing the poor with technology that truly benefits them is no easy task, and several aspects are crucial to success of any such attempt. Simultaneously fulfilling these objectives can doubtlessly be considered an art worthy of the world's brightest minds.

Although the potential for improvement is enormous, multiple innovations have already brought relief to people in a daily fight for survival. Among those aiming for improved water access in rural communities, this paper highlights three technologies that would each be able to tell their own success stories. While discussing the most important criteria for their effectiveness and critically assessing their overall impact, the emphasis is to trace each characteristics back to its birthplace – which might be early on in the design process. In order to ultimately ensure that the community will truly benefit from the technology, people therefore need to be at the center of every decision throughout the process.

Thus, it is my primary goal to extract a list of important factors to be taken into account even in the first design cycle, although their influence is only visible once the technology is made available to the greater public. My secondary goal is to illuminate the role of the lead designer in this process, raising the question whether these 'world's cleverest designers' should be invited to this territory, or whether the 21$^{st}$ century should be "left to the rural community to apply their own skills and solve their own problems without interference and any more advice from the 'experts'," as the Indian social activist Roy suggests [19].

## Section 1. Defining Appropriate Technology

Design for the poor must not be poor design – that can easily be argued for by stating the various criteria that play into the success of any new device. But neither can design for the poor be a mere copy of western technology, often dependant on large supply chains and highly specialized labor.

Based on this conclusion, the last 40 years have seen the rise of the 'Appropriate Technology' ('AT') movement, a term that generally means "technology that is small, easy to understand and maintain, cheap, dependent on local resources, and fitted to local needs. It makes heavy use of renewable resources [...] and makes minimal demands on capital and on nonrenewable environmental and energy resources." [16] However, it has to be mentioned that there has been a "constant, sometimes pedantic, argument within the AT movement" concerning the exact criteria of its appropriateness [6]. The above list is thus meant to give a general overview of suggested criteria without being exhaustive. When it comes to a practical application, it is certainly critical to consider *participatory research* in order to avoid "separating the researcher from the researched and [to] promote the forging of a partnership between researchers and the people under study." [22] In this democratic dialogue, it is up to the community to define what criteria they wish to apply for the suitability of a future technology, while the researcher offers his knowledge and experiences "as additional information upon which to critically reflect." [22]

This paper will base its impact assessment on the three criteria suggested by the People-Centered Development Forum [1], which are

- **Justice.** Meeting the physical needs of all people, at the level required for physical and mental good health, is given first priority and progress beyond this point is "measured by indicators of social, intellectual, and spiritual advancement that reflect the quality of life, not the quantity of consumption."
- **Inclusiveness.** Every person is granted the right to participate in the decisions that shape their lives and given "the opportunity to be a recognized and respected contributor to family, community and society." The rights and needs of local communities are given precedence over those claimed by corporations or the state.
- **Sustainability.** In a constant and conscious effort, human consumption and population is balanced with the regenerative capacities of the environmental, economic and social eco-system.

Special attention will also be given to the idea of 'non-violence', stating that a technology should be "entirely controllable" and give rise to "no unintended social or environmental impacts." [6]

If the poor communities represent the ultimate authority when it comes to the appropriateness of a technology, then it makes sense to recommend a list of design criteria only if those people can be expected to take rational decisions. The functional value of this analysis is therefore based on the premise that "rural people may be poor and illiterate, but they are not irrational. In fact, the poorer they are, the more their survival depends upon their rationality, i.e., upon a proper evaluation of costs and benefits." [17] However, their attitude to returns and risks may differ from the western conception in that "they invariably take the 'worst case scenario' more seriously than the 'best case scenario' because the former can lead to total ruin whereas the latter only means marginal improvement." [17] Nevertheless, their choices are highly rational, and understanding their thought process that have caused one technology to stumble thus may provide valuable insight applicable to future design attempts in a similar setting.

**Section 2. Case Study of the LifeStraw®**

**Fig. 1:** The LifeStraw in action

Entitled one of the "ten things that will change the way we live" by Forbes Magazine [3], and being listed among "the most amazing intervention of the year 2005" by Time Magazine [23], the LifeStraw has earned international accolade for its innovative approach to achieving the Millennium Development Goal of "reducing by half the proportion of people without sustainable access to safe drinking water". It has also earned multiple awards such as the 2008 Saatchi & Saatchi Award for World Changing Ideas or the Well-Tech 2006, an innovation technology award [13]. One look at the overwhelmingly enthusiastic press reviews makes it clear: The LifeStraw is the poster child of the western media.

Technologically seen, its design is certainly innovative as it manages to purify 700 liters of water through a sophisticated combination of different filters, iodine impregnated beads and active carbon of only 25 cm length and 29 mm width (roughly 10 x

1.1 in). As a portable personal device it provides safe drinking water for one person over the course of one year, for approximately 3 US Dollars, without the need of electricity or any spare parts.

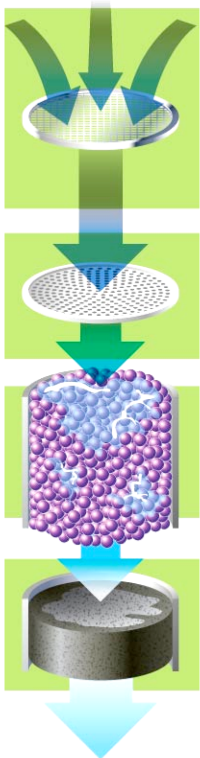

**Fig. 2:** Layout

It is applied much like a regular straw where the water is sucked from the source directly into the mouth. This has the great advantage of eliminating recontamination issues that pose significant problems with many other point-of-use filtering systems due to the containers in which the water is stored after purification. [12] Extensive research has been done to ensure the technical effectiveness of the device, showing that the final version removes 99.9999% of waterborne bacteria and 99% of waterborne viruses, [13] although it does not remove any heavy metals such as Arsenic. If used beyond the recommended time span, the filter quality is slowly reduced but the device doesn't release any toxins or bacteria into the water.

However, in spite of LifeStraw's fame in the western world, and the technical ingenuity underlying its design, it is vital to raise the question whether the developing communities share the enthusiasm about this new technology. Two independent acceptance studies were conducted in rural Ghana [2] and peri-urban Bangladesh [7], both revealing unexpected side-effects.

In Ghana, the per-liter price of the LifeStraw (0.0055 USD) is comparable to other available safe water sources, more expensive than the free but easily contaminated natural water sources, open wells and rainwater, more costly than the good-quality borehole water (0.0003 USD), but considerably cheaper than the 'Pure Water' sachets on the market (0.1316 USD). It's main advantage in this setting lies definitely in its portable nature, as both boreholes and 'Pure Water' sachets are only available in villages or cities, and the rainfall heavily varies throughout the year. Unfortunately, the study does not mention what price the participating villagers paid for their LifeStraw, if any. In a setting where the communities seem to be aware of waterborne diseases and the importance of safe drinking water, but are generally not familiar with any kind of household water treatment, the LifeStraw was readily received, raised curiosity and users repeatedly said that "everybody wanted one", not least because of its modern and expensive look [2]. Throughout the report, it is repeatedly mentioned that the users developed a strong sense of ownership, seeing it as a tool for personal use and usually not willing to share out of fear of sicknesses or out of worry that the other person might treat it less carefully.

This new point of view is in complete contrast with the local traditions in water supply, where the water is fetched (usually by women) for the entire household, considered a common good such that even the drinking cups are shared among family members and friends. At this point, LifeStraw becomes more than just a technical tool with a robust functionality, but shows a social impact that cannot be neglected. Day and Croxton conclude that "most of the Appropriate Technology movement made the mistake of overemphasizing the technical side of the appropriateness equation without fully understanding the social and economic constraints on the use of technology," [6] and this seems to be the case for LifeStraw here. The problem that western scientists and media seemed to disregard in their enthusiasm was immediately obvious to the local participants, who "often talked about the affordability problem; they would say that LifeStraw is a good product, but that it would only make sense if everybody would have one, not if only the rich people in the village would be able to buy it." [2]

By granting access to safe drinking water only to those able to invest in the acquisition of a LifeStraw and thereby decreasing their exposure to waterborne diseases, social inequities will be reinforced, contradicting the non-violence principle introduced earlier. As water supply shifts from being a household concern to an individualistic issue, this unintended side-effect becomes even more severe since "resource allocation within households is often biased against girls and women," [4] so that a family's poverty now may weigh more heavily on the female shoulders.

A second observation concerned the taste of the filtered water, another important criteria of success. Indeed, although most villagers knew that the borehole had been their safest water source available and despite its competitive price of roughly 6% of LifeStraw's per-liter cost, Bottema observed that "the communities that had boreholes were often not using them. They gave me two reasons for not using the borehole: people say that the water from the borehole doesn't taste well, and another problem is also that they have to pay for this water." [2] It is immediately clear that if in spite of its price, LifeStraw wants to be successful in such circumstances, it needs to offer a quality that the villagers perceive as greatly superior to borehole water. Unfortunately, as the LifeStraw left the laboratory, there was still a slight iodine taste to the filtered water. In the study however, several people saw the iodine taste as a proof for the device working properly, saying that they "appreciate what the chemical does." [2] Some caution has to be applied when evaluating how many people were truly bothered by the taste since the participants felt very responsible for "giving good feedback" and felt honored to be the first users. [2] Nevertheless, it can be retained that a certain visibility of the process may be quite welcome in a community that is still evaluating the necessity of a certain device, although the western trend is to hide all implementation details behind a fashionable wrapping.

The second acceptance study was conducted in Panpara, a village located 45 minutes outside of Dhaka, the capital of Bangladesh. [7] Three different point-of-use water treatment systems were compared, namely Safe Water Systems, Solar Water Disinfection and the LifeStraw[1]. 58 household were assigned randomly two of the above technologies for 10 days each. At the end, each family completed a survey comparing their two filter methods on a number of criteria. Although Safe Water Systems requires the user to fill a large safe storage container with water, to add sodium hypochlorite solution and wait 30 minutes before consuming the treated water, 80% among the ten households in that comparison group concluded that it was easier to use than the highly portable LifeStraw. This might be due to the fact that LifeStraw requires some effort to suck the water through the filters. Ten other households compared LifeStraw to the Solar Water Disinfection, which consists in collecting the water in transparent plastic bottles, placing them in the sunlight (e.g., on a metal rooftop) for at least 6 hours and allowing the water to cool before consumption. No household in this group was in favor of the LifeStraw as far as simplicity was concerned.

Before being assigned either technology, the household leader attended a workshop with information both on the usage as well as the functioning of the method. At the end of the study, their perceived safety of the tested device was evaluated, and the only technology that received the answer "not sure" was the LifeStraw (16.7%). Both other technologies convinced the villagers the water was either "probably" safe or "definitely" yes. This is vital because the cost of LifeStraw is considerable, especially in contrast to Solar Disinfection.

The researchers conclude: "There was indirect and sometimes direct evidence that people in Panpara (1) did not appreciate the fact that [LifeStraw] was for individual

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[1] Due to time conflicts, the team had to substitute LifeStraw for a product with almost identical features called FrontierStraw (see [7]). For convenience, this document does not distinguish between the two.

use, (2) did not take advantage of its portability and (3) did not find it easy to use. [...] In addition, a large number of comments on the exit surveys indicated that people felt that they were unable to consume a sufficient quantity of water through [LifeStraw] compared to the other two technologies. Many people commented that [LifeStraw] was slow and cumbersome to drink through." [7]

These observations are a bitter pill for an award-winning technology to swallow. Did the selection committees fail to observe the reaction of the target population before handing out their prizes? Was the western media too fast to extrapolate their individualistic tendency to other cultures? – In defense of the designers as well as the critiques, it has to be noted that both studies mentioned above reported the device to function properly throughout the testing period which, given the novelty of its manipulation in the participants' context, is a challenge in itself.

Nevertheless, it speaks for itself that there are only 200,000 LifeStraws in use today, all purchased and distributed by partner groups such as the Red Cross, UNICEF and Rotary International [9] – a far stretch from the 10 million copies that were originally planned [8]. There is no doubt that these filters have saved lives, particularly in emergency situations after flooding or earthquakes, but they very clearly don't seem to offer a sustainable solution in the long run. And although Vestergaard Frandsen, the developer of LifeStraw, does not publish any acceptance results of the device presented here, the troubles linked to its individualistic aspect must have been observed amongst their ranks as well, as shows their introduction of a 'LifeStraw Family' version earlier this year. The new technology is to be installed in the house, providing safe drinking water to the entire household and at a higher flow rate. The company is now promoting their original invention, LifeStraw Personal, as a complimentary tool only. [13]

From an outside perspective, it seems that LifeStraw Personal was only the first iteration cycle in a series of design attempts, and under that light the public praise clearly appears strange.

**Section 3. Case Study of the Treadle Pump**

On the first view much less outstanding is the Treadle Pump, a technology developed mainly for irrigation purposes in India, Bangladesh and Nepal. The region, home to 500 million of the world's poorest people, remains dry for a majority of the year, allowing for only one crop a year. Nevertheless, the area hides one of the world's most remarkable groundwater resources, at a depth of 1.5 - 3.5 meters and freely available to farmers owning a pump. [20] The available hand pumps are often too slow and cumbersome for irrigation, and the only viable solution for many farmers is the use of a diesel pump. However, such gear requires a substantial financial investment and represents thus an infeasible solution for small and marginal farmers.

**Fig. 3:** The Treadle Pump in action

The social impact of this disparity is significant: Affluent farmers are able to grow multiple crops a year while families with less property migrate to the cities in the search of low paying casual work outside the growing season. Since the whole family moves with the work, children no longer attend school regularly [26], and as the owners of a diesel pump eventually buy the land of the migrants, the poverty gap widens even further. "I saw people irrigating through the hand pumps. And because it is very to difficult to operate them by hand, they were using their legs muscles to operate their hand pump, and that is the idea I got", says the director of IDEI[2], Amitabha Sadangi, about the birth of the Treadle Pump. [25]

Made out of bamboo and two steel barrels, the Treadle Pump lifts groundwater from as low as eight meters up to the surface, and is powered by human feet alternately depressing the bamboo pedals. Manufactured by a supply chain entirely located in the country of sale, the (unsubsidized) market price of a bamboo treadle pump ranges between 10 and 15 USD. This investment generally pays off for the farmer after one year of additional crops and over the expected pump life of eight to twelve years, the farmer's annual net income increases on average by 100 USD. Researchers concluded that "for a marginal farmer [...] with US$ 12-15 to spare, there could hardly be a better investment than a treadle pump." [20]

Concerning the design process of this technology, IDEI carried out three years of field trials under a variety of conditions prior to mass production of the pumps, setting a strong emphasis on simplicity, local production and affordability. Furthermore, since the villagers carry the entire cost of production, the observed demand for the product is not inflated by subsidies, assuring that the people's interest is heard through standard market interaction. Coupled with the use of local manufacturing capacities, this approach can be called participatory as it is "driven by a belief in the importance of entrusting citizens with the responsibility to shape their own future." [10]

The Treadle Pump has earned particular appraisal for "self-selecting" the poor and putting to productive use the region’s vast surplus family labor. Indeed, studies have shown that although the risk-friendly first adopters tend to be less poor, as the tech-

[2] International Development Enterprises India

nology blends into the social fabric, the poor buy and stay with it while the less poor acquire their own diesel pump or switch back to buying water sold by a diesel pump operator. [20] From a convenience perspective, this behavior might not surprise, but for product designers and policy makers, it is indeed a feat to effectively cater to the poor, to avoid excluding part of the low-income population and give no attention to needs specific to the non poor. Substituting manual labor for financial investment seems to be the key to the success of the Treadle Pump, and might be so elsewhere.

Another aspect of this substitution is the reduction of fuel dependency and greenhouse gas emission, for which the technology has been offered the Ashden Award for sustainable energy. [26] Indeed, appropriate technology must strive to be ecologically sustainable, and contribute to the solution of environmental problems in the sense that it offers new and innovative ways of exploiting resources. [6] At the same time, it has been rightfully asserted that poverty is not the primary cause of environmental destruction [11] and that the reduction of fuel consumption in poverty alleviation programs can be at most a 'positive externality', since "a small farmer is unlikely to buy a Treadle Pump because it will save diesel for his country or spare the world a bit of global warming." [20] At the design level, this rationale has to be taken into account when questing for an environmental-friendly solution that does not, however, interfere with the product's benefit in the eyes of the target population. The true art is to open ways for ecologically sustainable development, knowing that this specific quality might not significantly raise the villager's interest.

IDE estimates the Treadle Pump to have an ultimate market potential of 10 million in India, Bangladesh and Nepal. In that light, after analyzing the evidence for its positive social impact, the International Water Management Institute writes: "If and when IDE does saturate this potential market, it will have accomplished one of the most ambitious and well-targeted poverty-alleviation interventions the world has even seen, by increasing the net annual income of South Asia’s poorest rural households by one billion dollars, and that, at little cost to the public funds." It goes on to say that the main challenge presently lies in marketing, in encouraging farmers to make their first commitment to this new technology. In fact, Treadle Pump sales in Bangladesh have boomed in the early 1990s with yearly sales of well over 100'000, while the numbers remain stagnant both in India and Nepal. Among their suggested explanations is one related to technology design: According to their assessment, the market for Treadle Pumps is far more responsive to price than is generally believed. Quality, on the other hand, seems to be of a lesser importance, at least for first-time buyers. They thus advocate against IDE India's strategy of offering a single high-quality / high-price product, arguing that multiple price-quality combinations would raise interest among a greater number of farmers. [20] There is certainly a need for a threshold of minimal quality standards but, if safety permits, it might be beneficial to consider options of lesser quality than the developer would want for his own backyard.

## Section 4. Case Study of the SolarPedalflo™

In areas where the groundwater level is too low for a bamboo Treadle Pump, there is generally no way around professional drill rigs. Matched with a suitable pump, that borehole can then provide better-quality drinking water than open wells, rivers and lakes (if the latter are available at all). The SolarPedalflo, subject of this third case study, is one way of bringing that precious liquid to a developing community.

Powered primarily by the sun or, alternatively, by a pedaling human, it offers access to water as low as 55m. After filtration, an optional chlorinator disinfects the groundwater to ensure its potability, and it can then be pumped to an elevated storage tank – something that is impossible to achieve with a hand pump.


**Fig. 4:** The SolarPedalflo™ in action

Unlike the previously discussed technologies, this innovation does not operate on a private basis (LifeStraw), nor is it a household possession (Treadle Pump). In fact, the SolarPedalflo delivers a constant flow rate of roughly four times that of a hand pump and is providing mainly drinking water, so its volume suggests a centralized water system for the entire community. USAID has published articles about two such installations in Mali [5] and Sri Lanka [15], both of them coupled with the formation of a village-level oversight committee that operates the pump and shares the duties of pedaling in case of clouds and an empty storage tank. In a common meeting, the villagers decided on either a per-bucket policy (Mali) or a monthly fee (Sri Lanka) that provides for maintenance costs.

However, it is unlikely that a developing community will be able to afford the up-front cost of up to 25,000 USD including borehole and transportation.[3] But where the alternative is to install four hand pumps with a cumulative cost of 32,000 to 36,000

[3] source: http://www.freelists.org/archives/fsf60k/05-2007/msg00002.html.

USD, the installing agency might well opt for a SolarPedalflo instead. As long as this new technology meets the cumulative needs of all villagers, this might have the healthy side-effect of bringing together neighborhoods that would otherwise be divided over the access to their respective hand pumps, as reported in Mali.

However, it is imperative that there be given special attention to an emergency plan for the case of a pump breakdown, for although the centralized water system increases the average water supply per household, it also sets the community at a bigger risk of going entirely without water. Unfortunately, little consideration seems to be given to this concern so far. However, assuring local production of the technology, combined with an appropriate capacity of the storage container, might offer an elegant solution to this problem. Indeed, if the manufacturing know-how is present locally, this will not only provide further jobs and skill training, but it will also diminish the time required for professional maintenance to be on site.

Next, the danger of overexploiting groundwater resources is another issue needing to be addressed before installing such an increased-efficiency pump that extracts locally a large quantity of water. It might be for this reason that the SolarPedalflo is recommended mainly for regions with high rainfall and cloud cover [15], an environment for which there exists however a more cost-effective way of providing potable water: Rooftop Rainwater Harvesting. [18] The absence of this consideration might result in adverse effects such as the further lowering of groundwater levels, wetland area reduction and a degradation of the water quality due to a salinity increase. [21]

As a last observation, it has to be pointed out how the SolarPedalflo deals with issues of recontamination. The pressurized outflow of the pump opens the possibility of a local water network, but even in the absence of such a costly infrastructure, the technology might turn out to chemically diminish recontamination by the remaining chlorine in the water. Its introduction also offers the opportunity of sensitizing the community to the importance of proper water storage and basic sanitation habits.

## Section 5. Literature Review

Limited to the discussion of three technologies, the design guidelines extracted so far are numerous, but certainly not exhaustive. This section thus aims at complementing the already established principles with valuable insight from the current literature.

There is, firstly, the important observation that "the South itself constitutes the greatest storehouse of ideas for appropriate technologies." [6] The region has proved its potential multiple times, be it in developing devices such as the EATSET[4] or in providing the root idea for the Treadle Pump. Respect is also due to the pastoral societies in some of the harshest arid environments of Africa obtaining a higher productivity per unit area of land than does cattle ranching in comparable environments in the United States. [6] There is rarely an absence of local spadework upon which a suitable innovation can (and probably must) grow.

The role of an outside engineer, in this case, is to distinguish between *felt* and *perceived* needs, as Amulya Reddy points out: "Villagers are completely aware of the fact that thatched roofs (a) leak, (b) catch fire, (c) are attacked by termites, (d) harbour insects and rodents, and (e) need constant maintenance. If asked [...], they may express their perceived need for a tiled or RCC roof because those are the only alternatives that they have seen and are aware of. But, their felt need is really for an improved roof that does not have the defects of thatched roofs. An understanding of felt needs is essential therefore for working out the design criteria for improved technologies." [17] Well aware of designers' prevalent tendency to "develop technologies in

[4] An emergency auto transfusion set, developed by a Nigerian army officer. See also http://www.eatset.com/.

response to imaginary and imagined needs identified in remote and alien settings," he repeatedly emphasizes the vital role of continuous collaboration with the local community, including a presentation of several options before any major effort is launched and going beyond the initial introduction of the new technology.

Indeed, such intensive participation seems to enable the community itself to express their needs more clearly, and a first design iteration may be required to crystal out the felt needs of the local people [6].

Although often neglected, several authors point out the potential in transforming traditional technologies. [6] [17] In an article entitled 'The History of Technology As a Source of Appropriate Technology' [16], Carroll Pursell argues against the idea that technology develops in a linear way, showing how many technological revolutions have not been due to an objectively better solution, but guided by popular fallacies such as 'what can be done will be done', 'people rather than guns kill people' and 'bigger is always better'. For this reason, the study of historical approaches to various problems constitute a rich pool of ideas for appropriate technologies – as well as warnings of unforeseen side-effects.

"Of various technologies contending for dissemination, those technologies succeed in spreading [...] that simultaneously solve several problems," concludes Reddy after several years of experience with rural development [17]. And indeed, attaining multiple objectives seems to be not a bonus, but an absolute necessity in many development contexts. It is true for any attempt to introduce the poor to more environmental-friendly solutions as has been elaborated in the case of the Treadle Pump, but is equally true for many health-related systems as illustrated in [24], and is most certainly key in addressing crises such as the Arsenic contamination in vast parts of South Asia. As a colorless, tasteless, and odorless poison with no immediate effects, the success of any intervention will critically depend both on sensitizing communities to the problem and linking it to other, more observable features for which the villagers have a felt need.

Lastly, if the goal is to empower people – which is the prerequisite for any sustainable development –, Korten's claim needs to be given more attention: It is not enough to invest design efforts into creating tools for the South, they need in return be granted the freest possible access to beneficial technologies controlled by the North [11], be that the relaxation of healthcare patents or the inclusion of local representatives in the top levels of foreign manufacturing companies.

## Section 6. Conclusion and Design Lessons

Community development and increased access to safe drinking water are matters far too important to be left in the hands of western technologists who have a far too narrow understanding of the manifold relations between traditional habits and cultural convictions, between resource management and power balance, between financial investment and the daily fight for survival. Nor is the outside engineer a necessity for technological development, as shows the case of the Barefoot College in India [19] or the EATSET device mentioned earlier.

Nevertheless, there is great potential in the fusion of local ingenuity and community resources with current research insights and the problem solving approach of a trained engineer. In many occasion, such an outside person can act as a catalyst, helping to "speed up natural processes of innovation and adaptation in the face of changed environmental conditions." [6] At all stages of the process however, community participation is crucial, as is the willingness of the designer to accept the people's priorities above his own. Western designers must come to understand that specialized products are not the main resource that they can offer to developing communities: Their analytical skills, their technical expertise and their broad information network are of bigger value than their output. Offering those resources to the community will boost their potential for innovation and it is in that service that the technologist might find his personal goal accomplished, namely that of developing a more appropriate technology than he could ever have thought of.

Part of his contribution, however, will consist in knowing about existing approaches and consider insights learned from other technology introductions. The following design principles have been extracted from the study of three such attempts, hoping that they may steer both the community and the engineer away from past errors and towards a more promising direction:

- **Continuous participation.** Most crucial of all is the continuous inclusion of the local population in all stages of the program, starting with a needs assessment and ending with a final evaluation that ensures sustainability. Modesty is required of the outside consultant in admitting his limited understanding of the true social, cultural and environmental conditions.
- **Observability.** Whatever the goal of the technology, it must have an observable effect to the community to stir any interest. In some instances, this might mean that the process is deliberately kept visible to reassure villagers of its operational reliability, in other cases this might require additional training to sensitize the population to a particular issue in healthcare or ecology.
- **Trialability.** Given the Poor's innate averseness to financial risks, the option of testing a new technology with minimal economic consequences critically increases their readiness to test a new device.

- **Quality levels.** In the same idea, offering several price-quality combinations facilitates the introduction of a new technology into the challenging market of the Poor, given that certain safety and robustness limits be satisfied.
- **Profitability.** In the long run, the only economically sustainable option is to build a profitable supply chain, avoiding subsidies wherever possible.
- **Shape of demand.** Design for the poor runs the risk both of catering to the non-poor as well as excluding certain demographics of the poor. The observed scalar market demand is thus not a sufficient measure of the appropriateness of a technology.
- **Ecological appropriateness.** Appropriate design can play a vital role in ecological preservation by offering new ways of exploiting resources. The inclusion of environmental benefits has to be reconciled with the end-users different perception towards global warming however.
- **Change in culture.** Understanding the social and cultural context is indispensable for the impact assessment of any new device. This is particularly true when introducing a technology that changes the scale of resource provision, by transforming household affairs into individual concerns or by raising neighborhood issues to the community level.
- **Increased dependency through centralization.** Although centralization often has its own advantages, it also increases the dependency on the one centralized technology as other small-scale supply systems are abandoned. Consequently, the robustness of the centralized system must be assured and an emergency plan must be set up for the case of a break-down.
- **Appropriate evaluation time.** Assessing the appropriateness of a technology requires time and open communication with the rural population. Overhasty praise is often the result of a lack of cultural understanding.

- **Awareness of alternatives.** There is hardly a situation without a series of solution attempts. Although it is vital to take into account context-specific requirements, the consideration of concurrent technologies may avoid unnecessary investments of time and finances.

With the goal of extracting specific design advice, the scope of this paper is fairly limited, which lead to raising only issues that were directly related to technology design. To put its results in perspective, however, it is vital to note that appropriate design represents merely one step in the process of addressing the challenges faced by developing rural communities. Sensitization, political and social empowerment, education, financing and economic implementation are other aspects of crucial impact. This paper aims at highlighting important reflections linked to one stage of the program cycle, and is to be seen as only one element in a collection of critical literature.
Indeed, providing elegant engineering solutions is not enough, and the emphasis has to move "from hardware to processes" [6] without losing sight of the importance of each step. By accentuating the long term effects of the design decisions, it is my hope that these insights will bridge the gap between idea generation and technology infiltration – stages that are too often separated by laboratory walls, guided by entirely different people and executed as a one-way street going in the opposite direction.

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