BARRIERS AND SOLUTIONS TO OPEN SOURCE APPROPRIATE TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT: INNOVATION THROUGH COLLABORATION

By

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Abstract

It has been proposed that the field of appropriate technology (AT) - small-scale, energy efficient and low-cost solutions, can be of tremendous assistance in many of the sustainable development challenges, such as food and water security, health, shelter, education and work opportunities. Unfortunately, there has not yet been a significant uptake of AT by organizations, researchers, policy makers or the mainstream public working in the many areas of the development sector. Some of the biggest barriers to higher AT engagement include: 1) AT perceived as inferior or 'poor persons technology', 2) questions of technological robustness, design, fit and transferability, 3) funding, 4) institutional support, as well as 5) general barriers associated with tackling rural poverty.

With the rise of information and communication technologies (ICTs) for online networking and knowledge sharing, the possibilities to tap into the collaborative open-access and open-source AT are growing, and so is the prospect for collective poverty reducing strategies, enhancement of entrepreneurship, communications, education and a diffusion of life-changing technologies. Given the urgency of the development challenges world-wide and the importance of breaking down obstacles to higher AT involvement, the same collaborative philosophy employed in the success of open source software can be applied to hardware design of technologies to improve sustainable development efforts worldwide. To analyze current barriers to open source appropriate technology (OSAT) and explore opportunities to overcome such obstacles, a series of

interviews with researchers and organizations working in the field of AT were conducted. The results of the interviews confirmed the majority of literature identified barriers, but also revealed that the most pressing problem for organizations and researchers currently working in the field of AT is the need for much better communication and collaboration to share the knowledge and resources and work in partnership. In addition, interviews showcased general receptiveness to the principles of collaborative innovation and open source on the ground level. A much greater focus on networking, collaboration, demand-led innovation, community participation, and the inclusion of educational institutions through student involvement can be of significant help to build the necessary knowledge base, networks and the critical mass exposure for the growth of appropriate technology. This in turn, can improve sustainable development efforts worldwide.

Co-Authorship

The research project featured in this thesis has been published or submitted for publication with Joshua M. Pearce. Only sections featuring independent work from the main author have been used here. The interviews and primary analysis have also all been completed by the main author. The following is the list of articles:

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Glossary of Terms and Definitions

appropriate technology (AT)	Technology which fits local conditions and can be easily and economically constructed for communities to meet their needs. The emphasis is often on demand-led innovation, small scale, sustainable and low cost solutions which can be easily repaired.
collaborative innovation	Development method that harnesses the power of group peer-review, distributed networking and transparency to harness the potential of collective knowledge and resources. Increases efficiency and robustness.
crowd-sourcing	Outsourcing tasks traditionally performed by an employee or contractor to the general public or a community. In short: utilizing the collective power of many eyes, hands and brains for innovation.
demand-led innovation	Innovation where need or demand is the primary driver for development. Synonymous with user-driven innovation.
knowledge commons	Promoting free sharing and exchange of knowledge for a global collective good.
open access	Free and unrestricted access to knowledge and information sharing. Mostly associated with literature.
open source	Open source is a practice in production and development that promotes and allows anyone to access as well as modify the product's source code or 'the how to'.
open source appropriate technology (OSAT)	Development of appropriate technologies through principles of open source. Technologies built collaboratively and open for anyone to access, view, copy and contribute to the designs allowing for continuous improvements and faster innovation.
service learning	A method of teaching and learning where students participate in applied service work for public good. Integrating classroom work to help solve problems in community and around the world.

sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In addition, development which recognizes limits of conventional growth and looks for alternative ways of growing within self-perpetuating limits of the environment.

List of Abbreviations

AT	Appropriate Technology
AIDG	Appropriate Infrastructure Development Group
ASME	American Society of Mechanical Engineers
ATC	Appropriate Technology Collaborative
CTI	Compatible Technology International
ICT	Information and Communication Technology
IDRC	International Development Research Center (Canada)

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Chapter 1

Introduction

1.1 Development Challenges

The urgency of achieving sustainable development goals has never been more critical given the rising world population, continued climate destabilization, peak oil and the effects of other potential resource scarcities in all parts of the world (IPCC, 2007; UN, 2010). The urgency is easy to understand: 2.6 billion people world-wide have no adequate access to safe drinking water or sanitation (WHO, 2010), while about 4 billion people sustain themselves and their families on less than $2 per day (UN, 2010). Furthermore, approximately 10.8 million children under the age of five die each year from preventable causes (WHO, 2007) of which access to safe drinking water, proper sanitation and nutrition are the most pressing and the most preventable. The majority of the Millennium Development Goals, such as hunger, poverty and healthcare are still out of reach (Black, 2007; WHO, 2010), and some argue that despite the hundreds of billions of dollars of aid distributed since 1950s, as well as billions of debt write-offs, there is very little palpable improvement for those in the poorest of the regions (Black, 2007; Moyo, 2009). In addition, research calculations from the Global Footprint Network show that the global demand on Earth's natural resources surpassed sustainable yields in 1999, and present estimates imply it would take 1.5 Earths to sustain current rate of consumption (Brown, 2011).

1.2 Research Objectives and Overview

There are several research objectives to this work. First, the emphasis is in examining how best to expedite sustainable development efforts and propose possible solutions to increase its efficiency and effectiveness. A big component of this enterprise is in providing socially, geographically, economically and technically appropriate technological solutions to those that need them. After providing an Introduction and outline of thesis in Chapter 1, a review of literature sources, background and the role of appropriate technologies (AT) for sustainable development is examined in Chapter 2. The focus within such sustainable development goals incorporates the technical and non-technical components to ensure the well-being of all people, and especially those living in rural, isolated and impoverished communities.

While the field of AT has tremendous potential for development worldwide, the movement has not yet reached the critical mass of research and exposure. As such, the second aim of the research is to identify and examine barriers and obstacles standing in the way of higher AT engagement and critical mass building. This component is two-fold: first, extensive literature review was performed and analyzed in later stages of Chapter 2 to draw out and categorize the key barriers identified by the leading academics and researchers. Then, in order to assess the importance of those findings against current the situation in the field, a methodology for a study is outlined in Chapter 3, to compare and contrast the literature identified problems to AT.
A series of interviews with organizations and researchers currently working in the AT field was presented to help expose current obstacles to AT development and compare the findings with the

literature identified barriers. The literature review indicated that obstacles to AT consist of a multitude of barriers: some are technical in nature, while others have roots in social, economical, geographical and political arenas (Jéquier, 1976; Chambers, 1983; Carr, 1985; Hazeltine and Bull, 1990; Smillie, 2000). The results of the study, the analysis of the barriers and comparison with the literature review is presented in latter stages of Chapter 3. The results of the interviews confirmed a majority of literature identified barriers and in addition revealed that the most pressing problem for organizations and researchers currently in the field is the need for much better communication and collaboration to share the knowledge and resources and work in partnership.

With these results in mind, and given the rise of Information and Communication Technologies (ICTs) allowing for a more efficient and effective data and knowledge transmission, the next objective of the research is in examining to what extent open collaborative innovation can help break down some of the key barriers associated with the AT development (Chapter 4). If the agencies in the field do not have access to pertinent information, if they are not sharing the tools and resources, and if they are constantly re-inventing the wheel instead of building on the winning technological designs, then without doubt their effectiveness and impact is significantly hampered. Results of the interviews also show that the majority of the barriers discussed can in some form or shape be reduced or minimized by better linkage, collaboration and exchange of knowledge and data – particularly through a greater inclusion of ICTs and collaborative online platforms. With the growing world-wide application of online networking and research tools, the potential for the agencies and researchers working in the field of AT to tap into the the collaborative power of many hands, eyes and brains is staggering. Internet alone allows for a plethora of collaborative and open source enterprises, wikis, forums, online databases and platforms for exchange of knowledge, and their full utilization can have significant impact on the barriers to AT as well as in providing life-saving solutions to billions of people.

Chapter 5 provides some discussion points and focuses on examining limitations to this collaborative approach and the open source AT. A case is made for a larger involvement of student service learning in higher education as one of the solutions to spurring the AT online collaboration and information database growth. Obstacles and issues to open source AT are also analyzed and future research recommendations are made. The research objectives and the key findings are revisited in Chapter 6, with concluding remarks made. Appendix A contains Interview questions and information data, while transcriptions containing key points from the interviews can be found in Appendix B.

Chapter 2

Literature Sources and Appropriate Technology Review

2.1 Literature Sources

2.1.1 Appropriate Technology and Development

An extensive literature review has been performed in all areas of this research - from appropriate technology, sustainable development, technical design, open source, collaborative innovation and interview methods, providing background knowledge and building on the previous studies. In the field of appropriate technology, the core findings on the background, history and barriers came from Schumacher (1973), Jéquier (1976), Chambers (1983) and Carr (1985) who wrote at the height of the AT movement. E.F. Schumacher and his influential book *Small is Beautiful: Economics as if People Mattered* (1973) is seen as the pinnacle of the AT movement. Hazeltine and Bull (1990), Ryan and Vivekananda (1993), Smillie (2000), Sawhney et al. (2002) and Smith (2009) wrote at the resurgence of the AT movement, and also provided a great base for the research direction and barrier examination.

In addition, a general review of development critique through the readings by Chambers (1983), Black (2007) and Moyo (2009) offered insight into the barriers to sustainable development which aligned very much with the barriers facing AT development: especially the issues of rural development, poverty and self-sufficiency. As such, breaking down barriers to AT can lead to a more efficient process of sustainable development given they have a common goal objective and are affected by similar barriers.

2.1.2 Technological Design

As the research question of AT is irrevocably concerned with the successful introduction of technology, a further evaluation of literature review through Papanek, (1971), Thomas, (1994), Tenner, (1997; 2004), and Smith (2009) provided solid background on the role of technological design and dissemination to match the local, social, economic and environmental conditions. Victor Papanek's approach and ideas in *Design for the Real World* (1971) are often viewed in the same light as Schumacher's *Small is Beautiful* due to his vision and advocacy for responsible design for the planet and for human society. Further discussions by Thomas (1994), Smillie (2000) and Smith (2009) also contributed significant content in regards to sustainability and functionality of AT design and dissemination providing, critical feedback as to the role and function of technologies for development.

2.1.3 Open Source and Knowledge Commons

The review of open source literature was headed by the writings of the founder of the open source initiative, Eric Raymond (1999), and his contemporaries featured in the collection of essays by Chris di Bona (ed) *Open Sources: Voices from the Open Source Revolution* (1999). Additional content and themes for this section came out of Deek and McHugh (2008), Söderberg (2008), Bonaccorsi and Rossi (2003) and Brousseau and Curien (ed), (2007). Writings by Hess and

Ostrom (2007), Benkler (2006), Chesbrough (2003) and Watson (2009), provided the critical discussions points on open access, knowledge commons and the growing rise of collaborative innovation via ICTs. The same authors contributed to the base for the open source appropriate technology section, with Nitin Sawhney (2002), Pearce and Mushtaq (2009) and Buitenhuis et al. (2010) providing the in-depth specifics of open source AT.

2.1.4 Interview Basis and Methodology

The appropriate technology and open source literature review provided a great insight into the barriers facing the AT development. However just like majority of the literature, the case studies were mostly from the height of the movement, the 70s and 80s, and analysis research consisted of particular case studies. *Appropriate Technology for Development: A Discussion and Case Histories* by Evans and Adler (ed), (1979) was especially insightful in offering numerous case studies and analyses of various AT applications. The issues and concepts discussed, matched the barriers brought up by the previously mentioned AT experts and researchers. While some of the studies included several brief interviews about a particular project there were no recent or group interviews on the problems and effects of AT dissemination. Thus, in-depth interviews were chosen as a main method of research and analysis for this thesis. The interviews followed the semi-structured 20-30 minute interview method as devised by Mikkelsen (1995), supplemented by an informal conversational interview technique of research method discussed by Babbie and Rubin, (2007). The responses were analyzed using logical analysis procedures based on Patton (1990), and pattern coding by Miles and Huberman (1984).

2.2 Development Matters: The Complexity of Sustainable Development

Development is by no means a simple task as it functions within complex social, political and economic conditions. Furthermore, as successful technological dissemination is a vital component of development efforts, this can provide another obstacle because technology itself is influenced by those same social, political and economic elements in which it operates (Smith, 2009; Thomas, 1994). Evans and Adler (1979) explain how the immense variety of cultural, economic, climactic and political circumstances throughout the areas of the developing world have considerable impact on the diversity of development needs, and thus, a danger lies in generalizing community needs and solutions. Such approach can result in a plethora of negative consequences which further perpetuate problems of un-sustainable development. Evans and Adler also add that in discussions of technology and development, the means must not become confused with the ends, in that the inclusion of technology is not the objective of development, but rather the means for attaining development (Evans and Adler, 1979, p 24). Indeed, history has no shortage of failed attempts in transferring foreign, highly-mechanized and energy-intensive technologies in anticipation of a successful uptake through poor assumptions or incomplete feasibility studies resulting in the opposite (Chambers, 1983; Carr, 1985; Smith, 2009; Black, 2007). Too often the emphasis focuses solely on technology, or in particular, the wrong type of technology, which does not match or complement particular cultural, social, economic or political circumstances (Chambers, 1983; Carr, 1985; Black, 2007; Smith, 2009).

Examples of brazen disregard for local conditions, ecological sustainability, and the people for whom the change was intended include large-scale energy projects such as dams that dislocate thousands of people and change landscapes to provide electricity for urban centers, or introducing highly mechanized machinery for mono-agriculture in areas where agriculture is small in scale, community owned and poly-culture in design (Black, 2007). Other examples can be more subtle in severity but nonetheless demonstrate the complexity of the development process and the importance of local conditions in the project planning. For example: i) introducing bicycle grinders to communities where women traditionally grind flour, but only men ride bicycles; ii) promoting smokeless cooking stoves to reduce respiratory ailments when smoke is one of the ways of combating mosquitoes and malaria; or iii) building solar cookers in places where traditional meals are served in the late evening (Ryan and Vivekananda, 1993).

Furthermore, the reality of development challenges are such that even when all of the proper feasibility studies and planning take place to the best of one's knowledge, the integration of any new or modified component to people's lives is not without an effect, and this is especially the case when it comes to introduction of technology (Tenner, 1997; 2004). As technology does not function in isolation from social relationships, more emphasis and research must to be placed on the ways technology is introduced, designed and transferred to developing communities, as well as understanding and solving barriers to that process. As James Smith explains in *Science and Technology for Development*: “All technologies carry with them risks, be they foreseen, unforeseen, or little understood. Conversely, the benefits of technologies may be far greater than we can foresee. We respond to these uncertainties by attempting to maximize the benefits and minimize the risks of technological change.” (Smith, 2009, p.95).

As the leading development critics indicate, any approach to development must involve the long-term careful investigation of the circumstances, including preliminary analysis of statistical social, technical and natural data, and must work with the local communities as partners in learning (Chambers, 1983; Carr, 1985; Smith, 2009). The primary focus of development and AT is to always work with the local communities as partners to “enable them to use and augment their own skills, knowledge and power” (Chambers, 1983, p. 74) for their own future and development.

2.3 History of the Appropriate Technology Movement

In general, Evans and Adler (1979), succinctly summarize how technological development in many cases can pose the following obstacles: lack of community choice about chosen technology, poor maintenance and support, excessive technological cost, lack of local contractors and suppliers, lack of technically skilled labour, and too much emphasis on urbanization and/ or rural displacement. In addition, the principal issues concerning the application and effects of technology in the developing world include: depletion of the Earth's resources, exacerbating wastefulness, materialism, inequitable wealth distribution and alienation from the natural habitat (Evans and Adler, 1979, p. 24). Drawing on these challenges and seeing first hand the problems associated with rural development, economist E.F. Schumacher (1973)concluded that conventional aid policies were ill-equipped to tackle the real issues of poverty, since their efforts are mostly aimed at urban and industrial environments which are far removed from the rural and agrarian systems which constitute the crux of the development matter. Working as an economic adviser in developing countries for many years, he concluded that the most appropriate type of technologies for developing countries are likely to be a range of 'intermediate technologies' which are “more productive than the often labour-intensive but inefficient traditional technologies, but less costly and more manageable than the large scale, labour saving and capital intensive technologies of the industrialized society” (Evans and Adler, 1979). This is how appropriate technology was first conceptualized by Schumacher in his influential book *Small is Beautiful: Economics as if People Mattered* (Schumacher, 1973). Unlike many of his contemporaries, Schumacher's principles on economy, development, and human relationship to resources was very much influenced by Buddhist philosophy which are reflected in his writings. He stressed the need for “meaningful, creative and purposeful work” utilizing “technology with a human face” compatible with human need for creativity (Schumacher, 1973, p. 16-30). Very much in lieu with the growing environmental movements of his time, Schumacher believed that human life is dependent on the ecosystem of many forms of life and thus the need to “treat natural resources not as expendable income but as an irreplaceable capital which mankind has found and on which it depends for everything” (Schumacher, 1973, p.11). According to Schumacher, the correct objective of development is not to solely increase productivity and wealth, but also to increase general well-being of people while preserving the quality of life and environment. Therefore any successful development and subsequent technologies introduced have to incorporate local conditions, be in line with the carrying capacity of the planet and aim for human dignity and self-reliance (Evans and Adler, 1979; Schumacher, 1973, p. 16). As such, technologies should be affordable and manageable, allow for an equitable distribution of capital investment, create employment and work opportunities where people live, foster use of local capital, skill and raw material, and reduce over-reliance on foreign assistance (Evans and Adler, 1979. p. 42).

Upon his return to the U.K., Schumacher established the Intermediate Technology Development Group (ITDG) which later became Practical Action, and focused on designing elegant, appropriate and low intensity technologies to match the purpose and needs of those that use it. Inspired by permanence, he also called for a re-evaluation of the Gross National Product as the sole measure of development success and of human happiness. The advocates of appropriate technologies in the 70s elaborated on Schumacher's intermediate technology concept and defined AT as those "that are cheap enough to be accessible to nearly everyone, simple enough to be easily maintained and repaired, suitable for small-scale application and self-educative in environmental awareness" (Pursell, 1993). As a result, appropriate technology became defined as that which is appropriate for a particular community at a given time and place in terms of size, scale, and usability (Pursell, 1993).

Victor Papenek's approach to product design and usability also contributed to many appropriate technology backbone principles and played a key role in its early development. A designer and educator, Papanek wrote in the same period as Schumacher. His book *Design for the Real World:*

Human Ecology and Social Change (1971) was the first of its kind advocating for 'an honest and optimal' use of materials and tools, designing through bionics (biomimicry), 'never using a material where another can do the job less expensively and/ or more efficiently', and designing for the poor and marginalized (Papanek, 1971, p.6). Working in the industry at the time of growing consumerism and environmental degradation, Papanek felt that industrial designers and the industry in general were very much co-responsible for the appalling state of environmental and social affairs, because as he put it: "Determined more by guesswork and piebald charts than by genuine wants of consumers, the values of design have degenerated to lowest common denominator and are being repeated millionfold through mass-production" (Papanek, 1971, p. 46). Recognizing the extent and influence of design industry on human environment and lifestyle, Papanek saw industrial design as one of the most dangerous professions (Papanek, 1979). Instead he advocated for responsible, ecological and user-friendly design with maximal material efficiency. One of Papanek's first contributions to AT was building a low-cost educational TV set for Africa with UNESCO's team of designers (Papanek, 1971, p. 66). Utilizing local labor and as much local materials as possible, they were able to manufacture a single channel TV sets for only $9 (1970s dollars), compared to typical models available at that time in the US for $119.95 - although the actual manufacturing process in Japan cost around $18 (Papanek, 1971, p. 70). That experience further enticed Papanek's advocacy to design for the millions of impoverished people living in decrepit housing without proper sanitation and clean water. One of the ways he foresaw improvement on a global scale was in joint undertaking of global designers to donate 1/10 of their free time and talents to help solve global design challenges (Papanek, 1973). Living before the advent of Internet, Papanek could not appeal for the world's designers to get together in person and work collaboratively on problem solving and sustainable development - the barriers and costs of distance, language and time would have been far too great. But he did recognize opportunities for heightened individual contributions to the collective approach of solving development challenges. Today, practically every college and university has an internet connection, and thus can access and use free video-teleconferencing tools (Skype), free word processing (Open Office), or graphic animation (Blender) to allow faculty members and students the ability to contribute and take part in whatever research and development aspect they are interested in much faster and more efficiently than ever before.

Despite the noble principles and immense opportunities of the rising appropriate technology movement, the momentum slowed down significantly in the 1980s as a result of political and economic changes. Carroll Pursell (1993) cites several political and cultural components which contributed to the decline of the AT movement. One of them was the "re-masculanization of technologies in the 80s after the loss of the Vietnam War" which created such political and social surroundings where "soft energy paths" and Buddhist philosophies did not meet the criteria for top funding (Pursell, 1993, p. 635). Furthermore, the ambiguity of the AT definition provided another obstacle: given the complexity and vagueness associated with the terms such intermediate, alternative and appropriate, the terms were often used interchangeably and proved to be infinitely malleable in meaning. This in turn failed to provide a unifying base for the movement and was one of the factors that led to fragmentization of the movement itself (Pusell, 1993). “By the mid-1980s, most of these (development and appropriate technology) institutions had either disappeared or lost their momentum. The technologies themselves, such as solar and windmill powers, methane gas for fuel, emphasis on bicycles and mass transit, recycling, use of natural materials, composting and sustainable organic agriculture did survive, but without an ideological context which could give them a strong political and social meaning” (Pursell, 1993, p. 629).

2.4 Current Situation and Relevance: Making the Case for OSAT

Schumacher's approach to development and the work done since the 70s did not go unnoticed and currently there is a renewed interest in the field of appropriate technology for sustainable development (Buitenhuis et al., 2010). Today, there are dozens of organizations and institutes with a focus on appropriate technology for sustainable development: Practical Action, Appropriate Infrastructure Development Group, National Center for Appropriate Technology, Development Center for Appropriate Technology, Appropedia, Catalyctic Communities (CatCom), Institute for Appropriate Technology, Compatible Technology International, Appropriate Infrastructure Development Group, KickStart, Akvo, Wiser Earth, Village Earth, Oxfam, Engineers for Sustainable World, and etc. Today, AT is still very much defined through Schumacher's core principles in utilizing technologies that match particular social, geographical, economic and cultural circumstances while working with the communities in a partnership to “help them help themselves” (Scumacher, 1973). Thus, the appropriate technology objective is to fit local conditions and be easily and economically utilized from readily available resources by local communities to meet their needs (Buitenhuis et al., 2010). Several things have changed since the time of Schumacher that are leading to a greater inclusion of AT in development. Firstly the mistakes and lessons of failed development approaches of decades past are becoming more documented, analyzed and used as an example of what not to do in both academia and in the field. In addition, Schumacher's and Papanek's principles of sustainable and efficient designs with an emphasis on purpose, functionality and usability are not only the backbone of efficient AT design but are also growing in general exposure and acceptance in the mainstream sustainability circles.

Another great cause for optimism is that aid funding is growing globally (UN, 2010), as is the number of agencies working in the field of development, including local and small scale technical solutions. Most importantly, the consciousness of global sustainability and the understanding of the ecological cause and effect, have also increased significantly. Sustainable development today is often given a more rigorous definition than the one commonly used by the Brundtland Report: development which not only meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987), but also development which recognizes limits of conventional growth and looks for alternative ways of growing within self-perpetuating bounds of the environment (Coomer, 1979, p. 4). The idea of "infinite growth on a finite planet" (Schumacher, 1973. p. 11) is especially challenged today. Current statistics indicate that present state of resource consumption has placed such un-sustainable demand on natural systems, that it would take 1.5 Earths to sustain the current rate of consumption (Brown, 2011).

The effects may not be obvious yet because the wealthiest 20% of the world's population consume 80% of the world's resources (UNDP, 1998). As we work toward improving living conditions worldwide, we have to ask ourselves what kind of development we are promoting and what consequences await when the remaining 80% of the world's population start to catch up and match the rate of consumption currently reserved for the privileged 20%. This is not to say that there cannot be development, growth and innovation, but it has to happen with a much greater emphasis on the resources and their effect on the planet as a whole.

This is exactly why the philosophy and design behind the appropriate technology can have global implications and possibilities. AT solutions can provide the 'meeting in the middle' principle where the massive energy intensive systems of the Western world are scaled down to match the purpose and needs of the communities without compromising those of the future generations, while simultaneously upgrading those of the developing and rural regions of the world. In other words, AT is not intended solely for 'those poor people over there' and many of its concepts can and should be designed for people's needs everywhere. The emphasis is on natural, intrinsic, smart, creative, elegant, robust and efficient technologies and practices that match the user in scale and complexity, and aim to achieve long term sustainability. 'Less' can indeed be 'more' by introducing appropriate tools and technologies that may seem smaller in scale and complexity, but will actually be better utilized by the communities with the least adverse effects. Some of the standard AT innovations include water purifiers, food processing tools, solar cookers, biodigesters, and lighting solutions. However, more recently the AT criteria are starting to include 'high-tech' and complex technologies such as solar photovoltaic powered lanterns, electricity generation, as well as cell-phones and computers which are becoming integral components of many developing communities (Arunachalam, 2002; Tcheeko et al., 2006; Ashraf et al., 2007). The positive impact of relatively simple life saving technologies, such as water purification systems, could make is substantial (Hashmi and Pearce, 2011), and yet the research and development (R&D) investments in AT trails behind large-scale high-tech enterprises which may increase economic efficiency for the select few but not for everyone (Jequier, 1976; Evans and Adler, 1979; Carr, 1985). Compounding the AT challenge further, there has not yet been a serious uptake of AT as a principle means of enabling sustainable development by most development organizations, researchers, or the mainstream public. While there are a growing number of organizations, researchers and communities working on facilitating sustainable development through AT all around the world, the full capacity and potential of that research and knowledge is largely untapped because it is not often published or shared with the communities who need the information (Pearce et al., 2011). The research tends to be scattered and very much influenced by trial and error due to work taking place in isolation (Pearce, 2007; Buitenhuis et al., 2010). Thus wheels are re-invented, lessons re-learned, and precious resources and time spent, while an existing piece of knowledge which would have been beneficial to a project existed but was not readily available.

To break down barriers to AT, and facilitate growth and innovation, it has also been proposed that the principles from the highly successful open source software movement can easily be applied to hardware development in order to share, collaborate and build on winning AT designs and improve development efforts all around the world (Sawhney et al., 2002; Buitenhuis et al., 2010; Pearce et al., 2011). Open source computer software is currently responsible for over 50% of Internet software (Deek and McHugh, 2008; Netcraft Web 2011), while open source innovation, crowd-sourcing and online collaborative work are also growing in application worldwide (*Chesbrough, 2003*; Benkler, 2006; Watson, 2009). The open source component of AT would allow for continuous improvements of development solutions because knowledge and technologies would be built jointly in synergy, and would be open for anyone to access, view, copy and contribute to the designs. Early studies on this topic show that the collaborative design processes, appropriate tools, and access to technical information enables more effective and rapid development of AT for both industrialized and non-industrialized regions (Sawhney et al., 2002; Buitenhuis et al., 2010). In addition, advances in Information and Communication Technology (ICT) software and hardware have allowed for new ways of disseminating information via wikis, Internet and mobile phones, making the case for OSAT (Pearce and Mushtaq, 2009; Buitenhuis et al., 2010). As such, with Internet platforms for storing, translating and sharing data much faster and more efficiently than ever before, there is a real opportunity to improve sustainable development efforts worldwide, and to facilitate AT growth by eliminating many barriers that keep it from scaling up (Buitenhuis et al., 2010). Given the urgency of the development problems world-wide, as well as the new found opportunities for OSAT, the need to study and identify barriers to scaling up such projects are clear. More on this in Chapter 4 after barriers to AT have been discussed.

2.5 Literature Identified Barriers to AT

A number of barriers to AT deployment have been identified in the literature review. Some barriers are purely technical in nature, while others have roots in social, economical, geographical and political arenas (Jéquier, 1976; Chambers, 1983; Carr, 1985; Hazeltine and Bull, 1990; Smillie, 2000). They are often interconnected and require study and understanding to enable the fullest potential of OSAT.

2.5.1 Defining principles

Even the definition of appropriate technology can be a significant barrier. If defined too rigidly, AT can be seen as holding back modernization and infringing on competitiveness by denying developing regions the same technology as in developed regions (Carr, 1985). On the other hand, not defining it at all can lead to ambiguity and marginalization of the AT movement, as was witnessed during the 80s. Poor implementation of the AT principles can also bring arguments of a new form of neocolonialism, implying that modern technology is not right for developing countries and therefore they should receive second-best, more primitive technology (Carr, 1985). This response to the concept of AT is common, yet none of these are actual implications of the AT principles because, as the definition of AT indicates, the emphasis is on utilizing technology that works best for given location and circumstance. As Smillie points out: "The issue for developing countries is not a trade-off between high and low technologies: it is a trade-off between appropriate and inappropriate technologies" (Smillie, 2000, p. 256). If the technology in question is smaller in scale, cost, complexity, uses local materials, eliminates the need for patents and royalties, involves decentralized renewable sources of power, and is easy to operate and fix by local communities, then these are the advantages not drawbacks. This is not to say that developing regions of the world can never employ complex, patented and labor-saving technologies, or that there are no regions where such highly mechanized technologies are not already working or can work. Nicolas Jéquier explains in *Appropriate Technology: Problems and Promises,* that “The aim of AT in principle is generally not to replace existing industrial systems but to promote technological innovation in the areas where it is weak or ineffective” (Jéquier, 1976, p. 36). Carr also reminds us that the primary function of AT is to enhance the economic position of those who have not been given the opportunity to fully participate in the current economic process - namely the rural, isolated and impoverished (Carr, 1985). Therefore, whether the name is *appropriate*, *intermediate*, *low impact* or *low cost* technologies, the fact of the matter is that AT should represent a movement toward more holistic, smart and sustainable engineering that satisfies the needs of local communities but does not do so at the expense of the ecosystem, nor the lives of the future generations. While a more unifying consensus on the meaning would help to disambiguate the AT, a point to keep in mind is that there is no criteria that makes up the whole definition of appropriate technology because it changes with the times much like the social and technical fabric of our society does. While the definition of AT is a fluctuating concept which depending on the given circumstances, the lack of consistency and variations in interpretation can lead to division within the movement. That said, satisfying certain components of AT will not always lead to immediate or replicable results: what may be appropriate in some places may not be in others, even if some of the underlying conditions appear to be identical. As such the emphasis of AT should be evaluated on a case-by-case basis for a particular community at a particular time and place in terms of size, scale and usability (Pursell, 1993).

2.5.2 Technical Aspects

The literature also suggests that the complexity of technological design, implementation and dissemination, constraints of permanence, robustness and transferability of AT to technical, political and economic spheres are among the key technical barriers (Carr 1985; Smith, 2009). As discussed earlier, technology does not function in isolation from social, political and economic relationships (Thomas, 1994; Smith, 2009), and as James Smith explains: “No matter how tightly science and technology are intertwined with development, the relationship only ever reflects just a slice of all of which that relationship represents (Smith, 2009. p. 120). As such, “it is clearly not sufficient to think of technology antiseptically as something inert, neutral and devoid of its own context; as something to be transferred via development through osmosis or summoned through the calculus of poverty.” (Smith, 2009, p. 20). Marilyn Carr also reminds us that even in AT work, too often the focus is on the hardware as opposed to the 'software' or the 'know-how' of the technical application, and this needs to be remedied (Carr, 1985). In addition to all of the known barriers, and despite best intentions and the amount of feasibility studies, the unknown components still make development work a highly risky enterprise. However, the better the analysis and understanding of socio-technical relationships and the subsequent problems associated with the technological diffusion, the better the chance of improving project effectiveness and problem-solving.

Versatility and robustness of AT is another key barrier. Global inequalities in relation to technology vary in lack of access to resources, knowledge, markets, economic and political dynamics, which all limit the ability to fully exploit technological opportunities (Smith, 2009, p. 122). Very few technologies truly survive the test of time given that human innovation never stops, but fundamental differences in the purchasing power of those living on $2 a day versus the rest of the world, make it imperative that AT be durable and easily repairable (Pearce et al., 2011). In addition to robustness, successful employment of AT must be versatile in application to help local communities economically as well as ecologically.

Compounding the challenge of AT further is the difference between rural and urban development. The barriers of distance and time make it difficult to tackle rural poverty, which is segregated from the mainstream and yet that is where development is needed the most (Chambers 1983). People living in rural areas do have similar needs as those living in urban centers in terms of food, water, shelter, education and employment, however the scope and manifestation of those needs are drastically different and yet deserve equal attention as urban development. This is especially important to prevent rural exodus in search of food and resources which further exacerbates urban malaise (Chambers 1983; Carr, 1985). Further barriers to rural AT development include technocratic over-emphasis, lack of institutional support, brain drain and ignorance as well as arrogance (Chambers, 1983; Carr, 1985).

2.5.3 Organizational Aspects

On an organizational level, access to stable funding, critical mass building, mainstream exposure, and a better institutional support of AT, are the barriers to a better AT implementation(Chambers 1983; Carr, 1985; Smillie, 2000). Statistically, diarrhea is the leading cause of illness and death globally with 88% of deaths caused by a lack of access to sanitation facilities, availability of water for hygiene, and for drinking (UN Water, 2010). As a result, the impact of simple life saving technologies could make for millions of the world's poorest is staggering, and yet the R&D investments in technologies involving sanitation and water access, as well as the general media spotlight are practically non-existent. On the other hand, world military annual expenditures in 2010 alone were estimated at $1.6 trillion dollars - with the US accounting for 46.5% of the world total (Global Issues, 2010). If only a fraction of world military spending was re-invested in funding technologies like AT, with adequate access to water, food, shelter, education, and general well-being, the global development situation would improve significantly. As a result, arguably, there may be less impetus for the mortal combat itself, and the struggle for power and resources.

As Chambers (1983) pointed out, the barriers of distance and time make it very difficult in tackle rural poverty which is segregated from the mainstream and urban development. This is where better organization and collaboration among all stakeholders in the AT field can be especially beneficial. Carr (1985) maintains that for a technology to be really appropriate and to reach the masses who would benefit from it, a great deal of effort has to be put into encouraging economic change, providing institutional back-up, reduced roles of outsiders, and understanding of the interactions between technological and social changes. She, like many AT experts, explains that too much outsider involvement has overshadowed input of the people for whom the technology is intended for and on whom the success of development depends (Chambers, 1983; Carr, 1985; Smith, 2009). Experience shows that for a technology to be really appropriate and to reach the masses who would benefit from it, a great deal more effort has to be put into including local knowledge and participation within the project (Evans and Adler, 1979; Carr, 1985). Experience shows that considerable work is needed to ensure a continuous feedback with the project stakeholders, and increasing collaboration with the researchers in the field as well as the communities (Chambers, 1983; Black, 2007; Smith, 2009). A better collaboration between researchers and organizations would help eradicate inefficiencies and provide the solid knowledge base for continuous improvements and innovation for the benefit of all (Pearce, 2007; Buitenhuis et al., 2010).

Chapter 3

Examining the Barriers to Open Source Appropriate Technology: Interview Methodology, Results and Analysis

3.1 Goal and Purpose of the Study

The appropriate technology (AT) experts provided the background and an extensive list of barriers to AT, and so the next step was to compare and contrast those findings with the current situation in the field to confirm and expand the list of barriers. Therefore in the summer of 2010 17 interviews were conducted with 21 participants from the AT and open data field. The interviews followed the semi-structured, 30 minute method developed by Mikkelsen (1995), and supplemented by informal conversational techniques (Babbie and Rubin, 2007). All of the interviewees were asked the same questions about key barriers as well as solutions to higher engagement of OSAT within the context of sustainable development. As such, the interviews provided a wide scope to examine the research question and offer qualitative data on overcoming the most pressing obstacles to OSAT, giving interviewees an opportunity to elaborate on any topic or details they deemed necessary to further the breadth of the research.

3.2 Data Collection

Once the University ethics board clearance was granted, prospective interviewees were sent a letter outlining the purpose of the research as well as the consent form with sample of questions which can be found in the Appendix A. Attempts were made to include a diverse group of participants to balance the type of respondents, but time and availability restrictions limited the ability to obtain equal representation of respondents from all sectors of AT development. The final interview group breakdown included five academics working in the field of development, eight non-governmental organizations, one governmental, two entrepreneurial organizations, and two independent voices of which one was an open data activist.

The majority of the interviewees were chosen by the 'reputation method' as devised by Laumann and Knocke (1987), which implies that respondents are selected based on their merit and reputation in the field. Although the field of AT is still growing, there are half a dozen organizations considered to be at the forefront, which were thus chosen as the key interview prospects. They in return recommended additional prospective interviewees and colleagues. A number of academic participants emerged from discussions and peer recommendation from the 2010 National Collegiate Inventors and Innovators Alliance (NCIIA) Conference in San Francisco. Of those that agreed to participate in the interview all but one granted the permission to record the interview, and all but one gave permission to use their name in a publication. Most interviews were 30 minutes long, although some were longer. Four of the interviews were conducted in person, two via e-mail correspondence, while the rest were done over Skype. As per the ethics guidelines, the interview data, including audio files, transcriptions and consent forms are stored in a locked location on an encrypted disc using the open source software TrueCrypt.

The academic researchers included professors from Arizona University, Cooper Union, Hope College, St. Thomas and Western Washington University. Respondents from Non-Governmental and Not for Profit Organizations participating in the interviews were associated with: American Society of Mechanical Engineers (ASME), the Appropedia Foundation, Appropriate Technology Collaborative (ATC), Appropriate Infrastructure Development Group (AIDG), Compatible Technology International (CTI), Digital Green and Practical Action. Governmental agency input was provided by a researcher from the Canadian International Development Research Center (IDRC). The research also included feedback from the entrepreneurial sector - Ayzh and Kopernik, as well as open data movement activist David Eaves and development activist Vinay Gupta.

3.3 Analysis Process

Once completed the interviews were transcribed and coded for key barrier categories that were counted to assess their frequency while extrapolating themes, patterns and most discussed barriers. To analyze the data two techniques were employed: logical and pattern coding. First, the interview responses were analyzed using logical analysis procedures, based on the method by Patton (1990), which explored emergent themes and barriers throughout the interviews and their frequency. Next, the pattern coding was employed to group summaries of data into a smaller number of overarching or linked themes (Miles and Huberman, 1984).

3.4 Interview Results and Discussion

Five barrier themes or categories to OSAT development were identified through the process of coding the interviews: 1) *social barriers*, 2) *communication and information specific barriers*, 3) *barriers to open source technology*, 4) *barriers to technology (AT or in general)*, and 5) *social and technical barriers inter-connected*.

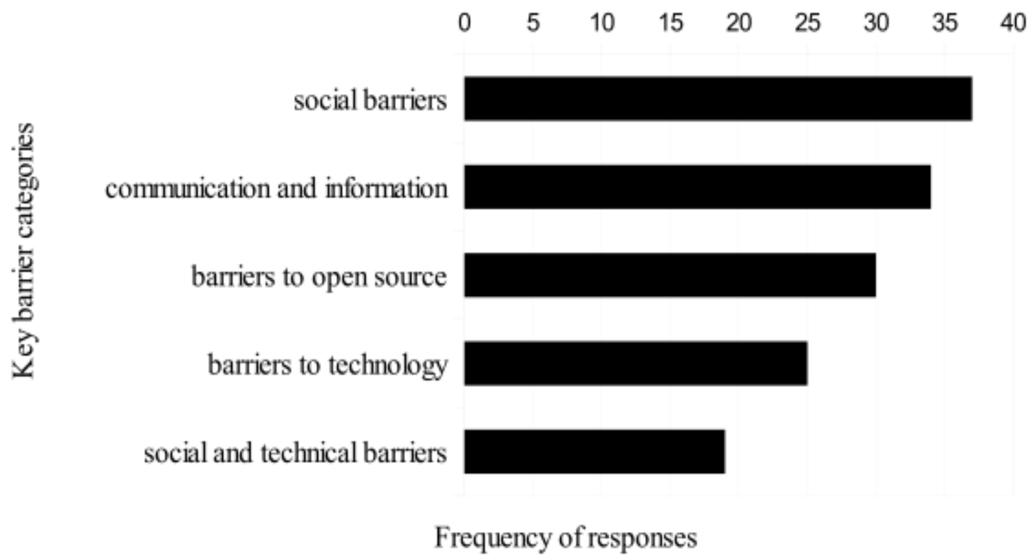

Figure 1: Breakdown of the five key barrier categories.

The most commonly identified barriers were those that fell into the social realm, followed by communication and information category. Barriers to open-source, technology and the socio-technical barriers followed next. The breakdown can be seen in Figure 1. To clarify: social barriers were those that dealt with culturally or socially specific undertones such as developing trusting relationships, respecting particular cultural norms or dealing with socio-economic limitations. The technological barriers refer to those that explicitly related to the technological problems such as robustness, specifications and function. As society and technology are intertwined a socio-technical theme was also identified. Barriers that fell into this category included definitions of technological appropriateness, local manufacturing, design of technologies and engineering methods, dissemination and adoption of technology as well as marketing and advertising. Such a finding indicates once more that technology alone is not the sole component of development challenges – nor is it the biggest one. Jeff Brown who works with Engineers Without Borders USA agreed: “The biggest challenges are cultural; there is a lot of room for anthropologists and social scientists here to study.” In addition to the general category breakdown shown in Figure 1, further coding of the interviews was performed by pattern coding (Miles and Huberman, 1984), and provided a more in-depth individual category barrier classification, seen in Figure 2.

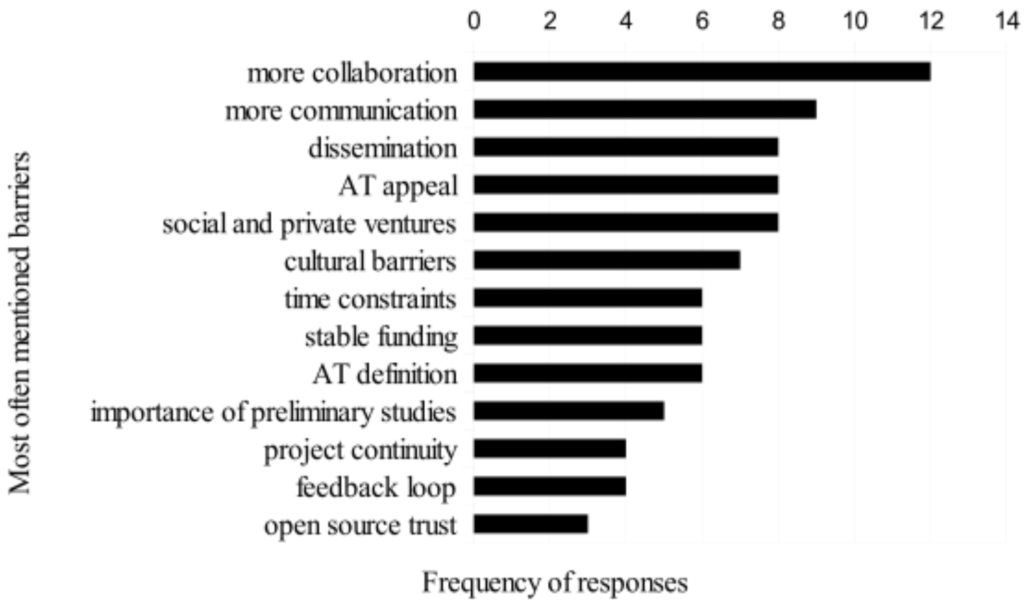

Figure 2: The classification of the largest individual barriers brought up by the interviewees.

3.4.1 Collaboration and Communication

The most commonly cited barrier, mentioned by twelve respondents, was the need for better collaboration to share knowledge, data and feedback, and to not reinvent technologies and re-learn lessons. Similarly, better communication and access to knowledge was another top issue brought up by nine respondents and falls in the information category. While researchers spoke of the need to share details and design specs of successful projects, they also commented on the importance of sharing problems and limitations encountered in the field as well, because that knowledge can be equally valuable. In addition, better linkages with other agencies in the field, knowing who has what technologies, skills and tools to offer, as well as having ways to showcase technology or needs are sure to help minimize problems with technological dissemination and implementation. As Roger Salway and Bert Rivers from Compatible Technology International explain, it is not enough to just build the technology - one also has to advertise it and “Find ways to let others know you have a better mousetrap”. The collaboration barrier was mentioned by respondents from all fields and is a clear indicator of its importance. If agencies in the field do not have access to relevant knowledge and do not practice collaboration, the chances of passing that same knowledge and habits to communities for their own self-directed development is also likely to be very poor. Given that all of the respondents were aware of the problem and want it resolved, perhaps the intent to collaborate is present and what is missing are the right tools and platforms to facilitate the exchange of knowledge and collaboration - or are at least not widely known. Five interviewees also talked about the importance of proper preliminary research and surveys to determine the needs of communities, as well as the appropriateness of given technologies and projects.

The importance of project continuity and feedback with the community was also a key component for a successful AT implementation. For example Appropriate Technology Collaborative (ATC), Compatible Technology International (CTI), Appropriate Infrastructure Development Group (AIDG), Practical Action and Arizona University’s Global Resolve all stated that background research and feedback were key factors for success of their projects. They allowed for learning the needs, purchasing power and composition of the communities. Feedback was also an important ingredient to this success. As Steve Crowe from AIDG and Alterna points out: “A lot can happen even when the project is completed and that data is very valuable”. Meaning that even after a technology is introduced or a project is officially completed, alterations brought on by a technological change continue to generate effects which may take time to manifest. Feedback with communities ensures that those changes are taken into account, and future projects with similar components can learn about it. Mark Henderson from Arizona University agreed. His team designed a low cost wood powered lighting solution for off grid communities as part of Arizona U. Global Resolve. Originally the invention was powered by gel fuel but was re-designed to burn biomass and match the fuel source availability of Ghanaian rural communities. The Twig Light is composed of a compact thermoelectric generator that bridges two aluminum chambers, each 15 cm long. Water cools the lower chamber, while the burning twigs heat the upper combustion chamber. The temperature difference between the two chambers drives the thermoelectric generator, which powers a bank of LEDs (Engineering For Change, 2010). As Dr. Henderson explained, there is no such thing as too much information and feedback because it helps to minimize and anticipate problems. For example, the Twig Light was designed to take only few twigs at a time, but naturally the community assumed if few twigs are good, maybe 10 are even better! Too much heat melted the solder and destroyed the device. Such and additional feedback and market demands have inspired the team to re-design the Twig Light once more leading to a new model which burns charcoal.

3.4.2 Technological Dissemination

According to eight respondents, the next biggest obstacle to AT research involved the actual process of technological dissemination and implementation, including the adoption issues. As we've seen with the Twig Light case, the implementation is comprised of many elements, feedback and community circumstances being crucial components that help increase successful dissemination. The problem of technological dissemination and uptake was also identified in the literature by Carr, 1985; Ryan & Vivekananda, 1993; Hazeltine 1999 and Smillie, 2000. Jason Morris, an industrial designer from Western Washington University who worked on the Hoima cargo bicycle design in Uganda agreed that implementation is a much harder problem than design, and how barriers can fit both into social and technical barriers and cover design, implementation as well accessibility and acceptability. In terms of technology specific barriers as key components to a successful technological implementation, most mentioned were the AT design, robustness, and the definition of appropriate technologies. Bert Rivers from Compatible Technology International (CTI) emphasized the need to ensure technologies are robust and durable, because once a technology becomes an integral part of a given community, as their food grinder did in Kenya, should something go wrong with it, people's livelihoods are jeopardized.

Three interviewees (Toby Cumberbatch, Vinay Gupta and Steve Crowe) explained that while there may not be such a thing as universal engineering that fits all conditions, there is something to be said about the universal appeal, functionality and robustness of technologies to help with dissemination, uptake and functionality. General functions of technologies can be applied globally with locally specific functions by designing robust, efficient and relevant technologies with focus on demand-led innovation. Jequier (1976) noted how the remarkable market receptivity to modern technologies is not a coincidence: “Such technologies are reliable, convenient, easy to use, relatively inexpensive and meet a need which traditional technology can not, or not as conveniently” (Jequier, 1976, p. 52). Interviews also revealed that the dissemination barrier was linked to other issues such as stable access to funding, time constraints, and connecting those with technology to those that need it. Similarly, the transfer of technology and techniques used are just as important in dissemination as the technology itself, as mentioned by four interviewees. In conjunction with the dissemination barrier category, three interviewees spoke of high shipping costs as well as duty charged on imports as a challenge for the implementation of OSAT projects.

3.4.3 Defining Principles

Six respondents commented on the importance of broad AT definition. Steve Crowe explained that sometimes limiting the definition of AT also limits the ability to bring down the price of technologies, or that they may not have all of the functions and the appearance people want. Stigma associated with appropriate technology was another important barrier for seven respondents, especially AT seen as low or second-rate technology. Zubaida Bai mentioned how “some people do not even consider AT to be technology, or they do not see how even simple things can change someone's life”. Jason Morris agrees: “There is a social stigma attached to bicycles and that is that they are poor people's technology. People ride cargo bikes only to be able to save up and afford a motorcycle one day”. Activist Vinay Gupta of Hexayurt project commented how such misrepresentation and low appeal of AT is one of the main culprits of poor public interest and funding by major agencies. He adds that an image of a starving child creates an instant visual and emotional response by donors and mainstream public, but a similar reaction is nearly impossible to replicate when stressing importance of sanitation, toilets and proper housing. As mentioned, six respondents also commented on the importance of having a broad appropriate technology definition with an emphasis on local specific undertones to ensure that the design and reach of AT matches local conditions, needs and purchasing power. John Barrie, the Director of Appropriate Technology Collaborative explained how “In the beginning, the AT definition was low cost and low impact technology that can be built in the country and didn't include electronics, but now electronics are ubiquitous. AT today includes a wide range of technology designed to help low income people to have a better and greener life and to provide jobs as well – in other words provide sustainable technology and potentially pre-empt some polluting practices of the Western civilization.” Within the AT definition, several interviewees also commented that while there may not be such a thing as universal engineering that can fit all conditions, the general functions and the need to design robust technologies with focus on demand inspired innovation was a concept agreed upon by everyone. Along the same line, three respondents commented on the impact of the general appeal and design along with the functionality of technologies – perfect example being cell-phones, which do not seem to have any troubles in uptake. This of course has a lot to do with functionality but also with the design, function and the universal appeal. The issue of appropriateness was among the key barriers discussed by Carr and Jequier in the literature review. For example, in *Appropriate Technologies: Problems and Promises,* Jequier noted: “Appropriateness is at best a fluctuating concept” because any functioning undertones will depend on local conditions and a multitude of other factors (Jequier, 1976, p.19).

3.4.4 Socio-Technical Barriers

As technology and society co-exist and define each other, many of the barriers to AT exhibited a mix of both social and technical components. The following examples demonstrate several of such instances. For example, Apurva Joshi from Digital Green which provides educational videos to farmers through rural India explained that: “Technology cannot be forced upon people – they must see the benefits and feel the need for it. Farmers who are looking to make ends meet are only concerned with what works and simple solutions.” Steve Crowe noted that a big component of the socio-technical relationship comes from the simple fact that:“There is still a lot to learn about people’s usage patterns, desires and needs”, which ties well with Jeff Brown’s comments how the biggest barriers are cultural and that there are a lot of things for anthropologists and sociologists to study. Camille George from St. Thomas University, who led senior design students on several international service-learning trips also noted barriers that demonstrate the socio-technical cause and effect relationship. One of them is the gender divide and the possible detriments of mechanization on women. She noted how adding technological improvements irrevocably changes women’s roles - “As soon as something becomes mechanized it leaves the women’s realm and enters that of men” she explains. This has to be taken into consideration.

During her work in Mali on evaporative cooling, Dr. George also noted low self-confidence of communities in their own technology and skills, which of course can be detrimental: not all things from the West are superior to traditional, low-cost solutions . She added how technological dissemination is very much influenced by the cultural and social circumstances of an area, including size, complexity, and religion, and agrees that this is another reason why background preliminary work is of crucial importance. Matching the literature review, three interviewees also brought up the need for much better institutional support for AT development, including the increased financial and political support.

3.4.5 Economic Relationship

Five interviewees commented on financial burdens as significant barriers to their AT work. These include: unstable funding, project design and R&D, travel, operational costs as well as taxation systems. For example, Mark Henderson commented that student immersion and exposure to communities they will design for is critical. Students often do the work but solve the wrong problems because they haven't been to the village to see what the people's needs are. This matches Papanek's principles of demand-led responsible design. However, travel and immersion can be expensive and pose further barriers. He added that perhaps this can be mediated through some form of virtual experience, where for example cameras and ICTs can be utilized to give some students exposure and familiarity with the community without traveling.

The reality of socio-economic limitations facing rural and disadvantaged people was also brought up as a key barrier, specifically that the price of technology has to match the purchasing power of communities. These were also barriers identified in the preliminary literature review. In regards to problems of aid for development of which Smillie (2000), Black (2007), Moyo (2009) were the most vocal critics, Vinay Gupta and John Barrie agreed that this aspect can also be a problem for AT. John Barrie spoke of complications in providing technology for free: mainly lack of project continuity and accountability, as well as market distortion where people may choose not to purchase a system in hope that a non-profit organization may bring one for free – which is seldom guaranteed. This issue only strengthens the case for exploring creative financing options, such as micro-financing, in order to provide affordable life-changing solutions, but doing so through self-sustaining healthy business development. Gupta also added how blind aid donations and lack of accountability in the development aid sector are creating a culture where often "One side doesn't want to know the full truth and the other side doesn't want to tell". Meaning that donors are just as responsible for success of development programs and need to be more curious about the success rate of projects and where the money is actually going, especially since according to Gupta a lot of the aid organizations are very much donation-driven instead of result-driven. Gupta was also quick to point out that structural competition for funding and projects between agencies keeps certain technologies such as AT out of the picture, which supported in the literature (Heyse, 2004; Moyo, 2009).

Steve Crowe also commented on technological versatility within economic systems being a key to a successful project implementation. For example he noted that the AIDG's bio-digesters were successful because “They are good for people's health and environment, but also provide energy and can be a source of income”. He adds: “When you're worried about when you get the food for the next day, you're not going to think about environment, health and the long term future”. Therefore engaging as many different facets of people's lives within the technology introduced provides a multitude of services and increases chances of adoption and successful partnership. John Barrie added: “Because poor people are very cautious with the money they have, it takes time to develop trusting working relationships and for people to commit to projects and systems they are unfamiliar with”. John Barrie added that early adapters are the key and they help bring the price of the systems further down. A great success story with one of ATC's solar LED systems coming out of Guatemala is that the switch from kerosene to solar allowed local communities to increase evening productivity for needle and housework because the lighting was better. In addition, the financial savings of the switch (solar system was cheaper in the long term than kerosine) provided extra income sufficient for the families to consider sending their children to college which was previously unheard of.

The need for better linkages with other agencies and marketing was brought up by five respondents and coincided with the growing importance of business partnerships to move technologies and projects forward. For example, Camille George commented that she as a researcher has skills and experience to bring a project far, however when it comes to product marketing and manufacturing on a large scale she wonders if that may be the time to pass the project to someone with those specific skills. This is where a better linkage between agencies and organizations can be of crucial importance. In addition, some interviewees commented on the need to be more inclusive of the private sector to help facilitate dissemination and business opportunities. Several respondents such as Scott White (Kopernik), John Barrie (ATC) and Zubaida Bai (Ayzh) were particularly vocal about the potential of incorporating the private sector. Zubaida Bai explained "Just because one thinks and works in social good doesn't mean one should live in poverty. One should be able to raise one's own livelihood and raise the livelihood of others." Scott White of Kopernik added that this is an interesting time for social ventures, due to the variety of business opportunities available through the world wide web. Given the number of respondents who commented on the problems of dissemination and uptake of technologies, problems of funding as well as aid, there is clearly room for social enterprises to enable healthy and creative marketplace for the development of AT while working for and with communities that need them.

3.4.6 Open Source and Knowledge Commons

Given the quantity of collaboration and communication barriers present in the field, it did not come as a surprise that an overwhelming number of respondents were interested in the idea of an online database or a repository for knowledge with features to enable collaboration and exchange of data. Several respondents were open to open source AT (OSAT) principles, but felt they still had to learn more about it. Overall, the interview results in the arena of intellectual property, open source and open access showed a lot of support on the ground level due to cutting operational costs and providing compatibility (eleven respondents). Dr. David Grimshaw of Practical Action, who has also worked with Science for Humanity and DFID, expressed a growing impression that "In the future, ideas will be developed very differently, much in the style of crowd-sourcing, and there has to be a way to pool resources, technologies and ideas together." Examples of this paradigm are already taking shape, with online AT projects such as the Appropedia Foundation, Catalytic Communities (CatComm), Engineering for Change and Practical Action already making a significant contribution to AT online development (Pearce et al., 2011). However, there are shortcomings to this kind of self-directed online learning. As Jeff Brown noted: "The web is a great repository of knowledge, but it is not a substitute for actual work in the field' and 'there is a real danger of convincing yourself you know all the answers".

Vinay Gupta of Hexayurt was also in support of open access and open source for better knowledge and technology exchange, but he emphasized the problem of competing databases and too much scattered information presenting the need to consolidate the knowledge and databases together into one stream. This aspect was already noted by one of the interviewees who felt that there is already so much information available online and one is not sure where to begin to search. In addition, only a handful of interviewees were familiar with open source licenses or contribute to open source AT themselves. The issue of trust was the main barrier to a greater open source engagement for three respondents, while simply not having the time to learn more and participate was noted by two respondents. Several respondents who did engage in OS development noted that there is still quite a bit of convincing to be done higher up among the executives and directors about open source reliability and security compared to the traditional proprietary solutions. Open Data Movement activist David Eaves, and a researcher from IDRC Canada agreed that a big component of this is in the perception that open source product quality is low. David Eaves explained how "Free is simply not seen as trustworthy in terms of quality, given people and governments are simply used to paying large amounts of money for products and services". For Appropedia, ATC, Ayzh and Digital Green, open sourcing innovation and employing anti-copyright solutions was a clear choic. As Zubaida Bai pointed out, "If the goal is to provide high quality low cost solutions, intellectual property would impede on that vision. The main thing is that technology reaches the intended people, and if that happens with copying, we as a business are ready for it."

The potential of Internet technologies for collaborative innovation and development is strong. Using the example of William Kamkwamba (2009), a 14 year old boy from Malawi who used spare scrap parts and designed a windmill electricity system for his family based on a photo he saw at a library, Gupta explained: "Ten years from now there will be 2 billion people with a broadband Internet access, but no toilet. It is likely that those people will go online and find solutions and self-educate using the Internet." The rise of 'Do It Yourself' websites, instructional videos, self-help blogs and online knowledge databases is an indicator of that trend. However, as mentioned not everyone is aware of OSAT or participates in the online collaboration. Chris Watkins from Appropedia is aware of this and added that while only a fraction of Appropedia's contributors remain engaged in the long run, on the positive side they learn the tools of wiki language and online collaboration. Most importantly, their contribution adds to the knowledge base others can build on which is never lost. Appropedia's plan is to expand and reorganize content, improve the site skin (layout) and visibility of the website, as well as add various navigation features to make it easier for visitors to contribute, ask questions and remain engaged.

Noha El-Ghobashy and Iana Aranda from the American Society of Mechanical Engineers (ASME) also agreed that open source features can generate positive change. ASME recently set up a collaborative open source portal called Engineering For Change, to provide a knowledge repository as well as a converging place for organizations, NGOs, researchers and communities to work on development challenges. They recognize that user-features are important in ensuring accessibility, participation and engagement, which in turn facilitate database depth. Their plan is to interface their portal with the short message services (SMS) platform to allow even faster and easier sharing, promote user feedback and make the website truly open source where the users will dictate the web site's applications and features.

3.4.7 Research Limitations

Although this study successfully confirmed literature identified barriers and expanded the research on OSAT, it did suffer from several limitations. While the organizations and individuals interviewed for this study are among the top in their field, they nonetheless represented only a portion of those working with ATs and therefore barriers presented here are by no means complete. The objective was to obtain an equal number of respondents from all sectors of OSAT involvement, but not all of the persons contacted agreed or had time for the interview. As such, the break-down is not equal in representation and this is something to keep in mind in future studies, because all of these sectors are important to the field of appropriate technology and their voices have equal barring and relevancy. As such, future studies should expand the list of interviewees as much as possible and include as many voices involved in the AT development. In addition, this research focused on the biggest barriers to AT and OSAT, and thus the list of barriers provided is not exclusive. Future work should also include a much larger number of open source and open access organizations and explore open source hardware barriers in relation to open source software. In addition, this study could be improved by including more viewpoints directly from the manufacturing AT industry, as well as of critics of appropriate technologies and those who see serious limitations to this kind of open collaborative development process. Finally, and most importantly, the future work should focus on obtaining feedback from communities employing the technologies to get further insight into their needs and viewpoints on barriers and development of AT. Once again, time and resource limitations did not allow for such feedback to be obtained for this research, but will be a part of any future work.

Chapter 4

Breaking Down Barriers to Open Source Appropriate Technology Collaboration

4.1 Open Access, Knowledge Commons and The Future of Innovation

The interview suggest that the most afflicting barrier to AT advancement is access to information and better collaboration. Given that majority of the interviewees were very much receptive to the idea of knowledge commons, there is a great potential to explore a more collaborative AT development. If 'knowledge is power', better access to pertinent information can provide better decision-making, save the precious resources, time and funding, and speed up development efforts world-wide. This concept has further bearing with the rise in access, affordability and opportunities brought on with the Internet applications. Information and communication technologies can also be of significant help to decrease or even eliminate some of the barriers that persist in the AT field. These include, communication and access to data, linking technology seekers with donors and technology providers, spurring business opportunities, crowd-sourcing, building online libraries, as well as providing a place for feedback and project continuity. Barriers such as dissemination, funding and marketing can also be lessened through better collaboration and networking via Information Communication Technologies (ICTs). The principles of knowledge commons and collaborative design are not new, but their application to AT is only starting to grow, and can be critical to future development efforts. The key premise is once again that greater access to knowledge and tools allows for better and faster decision-making, and increases efficiency and effectiveness of projects. As Hess and Ostrom (2007) affirm, “the more quality information, the greater the public good”.

Internet and Information Communication Technologies have become an integral part of the world economy, communications, research and a way of life (Brousseau and Curien, 2007). Internet access and use is increasing in all parts of the world (Internet Stats, 2011), and so too are the endless opportunities for exchange of information, innovation and development. Given the potentials, many organizations and researchers are already incorporating Internet platforms and collaborative approaches to their development processes. In the same sense, open educational tools like Wikipedia, Project Gutenberg, Open Journal Systems, the Human Genome Project, Scientific Commons, and other open access platforms provide just a few examples of collaborative knowledge sharing taking place online. It can also be argued that the speed by which the World Wide Web evolved is directly linked to the amount of open software applications and programs the Internet runs on, as well as the fact that the Internet's inventor, Tim Berners-Lee, zealously resisted privatization and enclosure of the Internet in its early stages (Berners-Lee, 1996). Berners-Lee is still a vocal proponent of a free and accessible Internet for all, especially for the 80% of the world's population who do not have access to it, of which many are poor and living in rural and/or underdeveloped areas. (Fildes, 2010). He suggested that access to the Web is as crucial as access to water and health care because it can allow people to “Create their own communities and share their own information about health, agriculture and business" (Fildes, 2010). As such, the more open, accessible and affordable the means and platforms of communication and collaboration, the greater the chance to truly capitalize on the opportunities brought on by the ICTs for global development. The potential for sustainable development through onine collaboration are perhaps best exemplified in the success of the open source software movement whose philosophy can easily be applied to hardware design for AT.

4.2 The Openness Factor: Background on the Open Source Movement

If the World Wide Web of connection and development is an example of what happens when channels of communication are left open for participation and growth, then the open source software demonstrated how well a tool like the Internet can be used for collaborative development of products alternative to proprietary style of development (Raymond, 1999). The most influential open source project is the Linux operating system instigated by Linus Torvalds in 1991. Today, Linux is the operating system of choice for 82.8% of the top 500 supercomputers in the world (Top Supercomputers, 2010). Although a zero dollar budget, the Linux project had one advantage not even the wealthiest software corporations could afford: a large number of dedicated beta testers and co-developers working together online to build and continuously improve the software code, making it robust, relevant and innovative for developers and users (Raymond, 1999; Bonaccorsi and Rossi 2003; Soderberg, 2008). Most of all, the product is available for a download completely free of charge. This open collaborative model that, programmer and open source advocate, Eric Raymond refers to as the "bazaar" style of innovation, makes the software more relevant and reliable to users, because the creators of the software are also users and co-developers (Raymond, 1999; Kogut and Metiu, 2001). Raymond explains that a key premise behind open source success has always been to ‘help one's neighbour’ and provide an alternative to proprietary software and copyright laws which infringe on users natural right to copy in order to innovate (DiBona et al., 1999, p. 54). Copyright and patent law intends to reward and protect the inventor against unlawful exploitation, thereby spurring further innovation due to reward system of intellectual property (IP). However, given the exclusive monopoly of IP licenses, the owner of the patent or copyrighted property has the monopoly right to withhold the access and use of the intellectual creation from anyone else but the owner, thereby limiting knowledge sharing and the innovation process (Merges and Nelson, 1990; Hemphill, 2005). However, the profit motive is enough of an incentive to disseminate and share the asset by collecting royalty fees or monetary compensation from the licenses while maintaining full ownership (Hemphill, 2005). Current IP law therefore enables opportunistic monopolies and forces the ‘re-invention of the wheel’ in both software and hardware contexts instead of enabling innovators to build on the existing technology improving designs to maximizing efficiency as well as innovation capacity. The open source and free software movements recognized the danger IP law posed to development and accessibility of software and web applications in the early days of Internet and set out to establish an alternative licensing system to promote innovation and development while granting the creator authorship rights. Currently there are a number of Copy Left, GNU General Public Licenses, and Creative Commons Licenses with a multitude of licensing options to protect the creator's innovation while allowing for others to access, copy, modify and improve designs as long as they license it under the same degree of openness (Free Software Foundation, 2011) . Today there is a wide range of quality open source software products to satisfy any personal or corporate needs. Some of the products include Apache (web server), MySQL (database system), OpenOffice (word processing), Blender (3D graphic animation), Gimp (image editor), PHP (web development), Moodle (virtual learning system) and Mozilla (web browser and e-mail client).

The success of open source software provided an alternative to expensive and proprietary systems, reduced research and development costs (Lakhani and von Hippel 2003), and showcased alternatives to the linear hierarchical structure used to design products (Mockus et al., 2002). Furthermore, it demonstrated the efficiency of distributed collaboration, demand-driven innovation and the power of the Internet for a global collective good. The success was a social triumph as much as it was technological, and demonstrated the potential for a similar integration, organization and innovation of science and technology (Zelenika and Pearce, 2011). This open and collaborative principle of licensing and can easily be transferred to hardware designs to propagate appropriate technological innovation for sustainable development. The philosophical principles behind open source software are very similar to Schumacher's principles of designing affordable and flexible technologies for development, working in synergy and partnership with each other as well as nature, celebrating human creativity, and facilitating innovation and independence (Schumacher, 1973, p. 40 - 65). In fact, as a designer, Papanek also recognized dangers of patents and copyrights in holding back development, especially when someone’s life depends on that innovation. As he says: “Ideas are plentiful and cheap, it is unjust to delay a release of a design by a year and a half and make money off needs of others.” (Papanek, 1979, p. 6) This concept is all the more relevant when it comes to life-saving technologies or inventions for disadvantaged, marginalized and poor people of the developing regions. A big proponent of do-it-yourself paradigm as well as biomimicry, Papanek saw copying and building on ideas as a key to innovation. These are the exact sentiments of the open source proponents who see copying and modifying a human right, and a natural progression of development.

4.3 Examples of Crowd-Sourcing for Development

Many people and organizations are starting to employ distributed computing to utilize the collective power of millions of eyes, hands and brains- also known as 'crowd-sourcing'. For example, in the European institutional decision-making there is a growing interest in policy orientation towards forms of public participation and promotion of the open method of coordination (Bouwen and Taillieu, 2004). In addition, as people come online to learn, share and socialize, they are also gradually recognizing and taking up the ability to add content rather than be passive receivers of information. As Tom Watson explained in CauseWired: Plugging In, Getting Involved, Changing the World, “Newer generations have never known life without the Internet; they are developing affinity to the world wide web of connections and finding a multitude of applications” that are changing the world one click at a time (Watson, 2009). In addition, “This new technology and the human urge to communicate is creating the basis for the golden age of activism and involvement, increasing the reach of philanthropy and improving the openness of our major social institutions” (Watson, 2009). Yochai Benkler adds that the intrinsic human desire for acquiring and sharing knowledge, with the Internet as a platform, is a key driver in making it easier and faster for people to participate in the online peer-to-peer (P2P) social exchange (Benkler, 2006). Because information, knowledge and culture are central to human freedom and development, the change brought on by the networked information environment hold a lot of promise “first as a dimension of individual freedom, as a platform for better democratic participation, and in an increasingly information dependent global economy, as a mechanism to achieve improvements in human development everywhere” (Benkler, 2006).

Apart from open source software success, there are many other illustrative examples of the collaborative innovation potential via the Internet and public engagement. Some of the best examples of online crowd-sourcing are UC Berkley's Open Infrastructure for Network Computing (BOINC), and NASA's Galaxy Zoo and Mars mapping projects.

BOINC is a non-commercial middleware system for volunteer and grid computing. Individuals throughout the world have the opportunity to donate their unused computer power (or idle time) to BOINC and help create the Earth’s most powerful supercomputer with a capacity for 5.428 PetaFlops [1](BOINC Stats, 2010). BOINC's supercomputing projects include a wide range of themes such as Astronomy, Biology, Physics, Computing, Software testing, Climate Studies as well as Humanitarian research on disease, natural disasters and hunger (BOINC Projects, 2011).

In a similar way NASA’s Clickworkers project showcased the benefits of crowd-sourcing and the

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[1] A flop is the floating point operation speed of a processor. A typical computer runs at about 7 GigaFlops. One PetaFlop is 10^{15} Flops.

increased efficiency through collaborative engagement in task solving. The Mars mapping project consisted of identifying and classifying the age of Mars craters. When the project experienced shortage of funding, it was was re-designed into modular tasks and opened to the public for participation. More than 85,000 users visited the site in the first six months, contributing to more than 1.9 million entries. Quality analysis tests showed that volunteer click-workers were as accurate as highly trained geologists on full time salaries (Benkler, 2006. p. 69). Given the success of the Mars mapping, several other projects followed: Galaxy Zoo was launched in 2007 and Galaxy Zoo: Hubble in 2010. They too rely on the power of volunteer click-workers in classifying over sixty million galaxies throughout the Milky Way (Galaxy Zoo, 2011).

Another collaborative online networking example showcasing social humanitarian impact is the Open Street Map project during the Haiti earthquake. Prior to the earthquake of 2010, the mapping of Port au Prince was very poor – the map consisted of only several crudely defined streets and no landmarks or buildings (Berners-Lee, 2010). When the earthquake hit, a commercial satellite company called GeoEye gathered 3,000 square kilometers of high resolution digital satellite imagery of Port au Prince and released it to the Open Street Map to be used for map building (GeoEye, 2010). Within days, over 2000 users started piecing the images and adding layers of content to the map, including roads, landmarks, and most importantly refugee relief spots and hospitals. In a matter of days the OpenStreetMap of Port au Prince became the go-to map for relief workers and agencies as its accuracy and comprehensive detail were unprecedented (Berners-Lee, 2010). What makes the project all the more noteworthy is the speed by which volunteers completed the map - typically it would have taken months for that much data to be assemble, not days.

4.4 Enabling Collaborative Innovation: Open Source AT

Just as UC Berkeley's distributed computing projects tapped into the unused processing power of millions of individual computers, distributed labor networks are using the Internet to exploit the spare processing power of millions of human brains and hands (Howe, 2006). The same crowd-sourcing and open collaborative approach can have profound changes for development of life-saving technologies and techniques worldwide, especially for the 4 billion people struggling for food, water and shelter. The premise behind OSAT design is to tap into the global collective potential, and design in the same open source method as OS software to speed up the development process, exchange of information and help scale innovation (Pearce and Mushtaq, 2009). As mentioned, in the field of AT there are already online wikis, forums and websites operating on the knowledge commons approach to solving the world's development problems. Many organizations are building searchable databases, interactive portals and linking technology seekers with technology providers and financial donors. Organizations such as Appropedia, Catalyctic Communities, Engineering for Change, Full Belly Project, Global Giving, Kiva, Kopernik, Open Sustainability Network, Practical Action, Science for Humanity and Village Earth are among the most active examples.

Appropedia.org, the largest online AT wiki, focuses on sustainable development and poverty reduction using a collaborative approach. In a typical wiki manner, Appropedia is an open platform for stakeholders to come together to create, find and improve scalable and adaptable solutions to AT via designs, schematics, instructions and illustrations about sustainable development. The data is published under the Creative Commons Attribution-Share Alike license (CC-BY-SA)[2], which allows anyone to use the content and copy designs as long as they share derived innovations in the same way and acknowledge the author of the original work. Appropedia is also a big supporter of service learning and student engagement - more on this topic in Chapter 5. Successful open source hardware examples include the Arduino electronic prototyping platform as well as the RepRap, the self replicating 3D printer (Pearce et al., 2010).

Practical Action is another organization featuring a successful online AT database. Originally founded as the Intermediate Technology Development Group in 1966 by E. F. Schumacher, Practical Action is involved in over one hundred projects in communities all over the world (Practical Answers, 2010). Before the advent of the Internet their database on technology and research was kept in hard copy and if someone wanted to contribute to a particular technical guide (such as a food grinder) or inquire on components, one had to contact the Practical Action and the data was entered or sent out manually via postal system. Naturally, all of this changed with the Internet: the instantaneous and low cost attributes of ICTs meant that Practical Action's system became greatly more efficient and effective. Today, Practical Action's Online Resource Center hold a considerable collection of appropriate technology and development literature, and

[2] http://creativecommons.org/licenses/by-sa/3.0/

is open to the public for free viewing. Covered topics include food production, agroprocessing, energy, transport, water and sanitation, shelter building, climate change adaptation and disaster risk reduction. Apart from downloading files, one can also send inquiries and suggestions to their team of experts. Now in its fifth decade, Practical Answers deals with more than 3,500 inquiries every year (Practical Action, 2009). In addition, there is space to review available technologies, as well as testimonial pages where people can share feedback and general knowledge.

Another integral part of Practical Action's resource center are the Technical Briefs that function as fact-sheets on AT in subjects, such as energy, construction, water, food processing, transport and manufacturing. They can also be downloaded free of charge. An excellent illustration of benefits brought on by Practical Action's online AT knowledge database is a success story of a women's group in Zambia (Eason, 2009). Around 70 women were responsible for planting and harvesting crops by hand and delivering it to markets via bicycle and on foot. With poor literacy, access to information was difficult, but a local welder accessed Practical Answers briefs and decided to make trailers for women's bicycles at a relatively low cost. Recognizing the potential benefits of such an enterprise, the women bought into the project. Suddenly they could transport more of the produce to the market much faster and easier than before, and in addition use the trailer as a market stall. From the briefs women also learned that processing foods such as nuts into peanut butter meant they could double their profits. The women and their families gained a better standard of living, higher nutrition levels, and more money for their children's schooling (Easton, 2009).

In the same open knowledge manner, individuals, communities, and organizations are making strides in developing open source and creative commons for AT hardware such as water purification systems (Hashimi and Pearce, 2009), charcoal manufacturing (MIT D-Lab 2011), solar refrigeration, treadle pumps (Appropriate Technology Collaborative, 2011), farm equipment (Open Source Ecology), and shelter (Hexayurt, 2011). For example, the Open Ecology Group and their Global Village Construction Set are working on projects that will make farming both more affordable and sustainable. Their goal is to build “replicable, open source, modern and resilient off-grid communities using open source permaculture and technology to work together for providing basic needs” (Vanderlinden, 2011). In addition, they plan to make the system fully self replicating at the cost of scrap metal. This collaborative network of farmers, engineers and scientists “freely publish their 3D designs, schematics, instructional videos, budgets, and product manuals on their open source wiki, harnessing the open collaboration of various technical contributors”(Open Source Ecology, 2011). Some of their current technology prototypes consist of the high speed compressed earth brick press, a versatile hydraulically-driven skid-steering tractor, a soil pulverizer, a drill press, a torch cutting table and a 150 ton steel hole puncher (Open Source Ecology, 2011).

Just like AT itself, the OSAT online collaboration is presently lacking critical mass and a higher engagement on all levels. For example, in March 2011, Appropedia only had 4,824 registered users and 28,608 content pages (Appropedia Stats, 2011), compared with Wikipedia which had 14,152,902 registered users, and 23,473,747 wiki pages (Wikipedia Size, 2011). As a general knowledge database, Wikipedia reached critical mass and is still engaging users, while the AT databases does not yet have the same success rate. Appropedia is not the first attempt at OSAT. In 2001, a group of graduate students at MIT also recognized the potential benefits of collaborative peer-review and community-based design. They created an open source web based collaborative website called ThinkCycle.org. Inspired by the open source design paradigm and Schumacher's vision of appropriate technologies, ThinkCycle was to be the first open, web–based collaborative platform for sustainable design with a mission to "develop design pedagogy and collaborative tools to address critical design challenges by working closely with universities and organizations worldwide."(Sawnhey et al. 2002, p. 49). However, after a rapid initial growth, as students graduated and left the project, ThinkCycle suffered several problems, such as scaling up and continuity. Currently, their website is defunct. A decade after ThinkCycle was first proposed, Internet access and online collaboration is much more common. Partnered with the growing sustainability movement, increased aid and philanthropy, pressing resource issues and media coverage, the awareness of a global need for basic life-saving solutions is starting to enter the mainstream consciousness. With millions of people online, connected at any point in time, and with better tools, applications and databases to build, share and exchange knowledge, the potential for new OSAT enterprise and a successful global development is within reach.

4.5 The Role of Universities in OSAT

Global databases and websites contain only a fraction of the available content on AT. Furthermore, as discussed by interview respondents, the information is scattered, and at times hard to search, categorize, and build upon. The groundwork laid out by Appropedia, Practical Action, CatCom, and Appropriate Technology Collaborative is being supplemented by new organizations and applications, such as Engineering For Change and Kopernik, to facilitate collective collaboration and better linkage of technology seekers with providers. The contribution of Colleges, Universities, academic researchers and students, which has historically been at the forefront of OSAT development, can still play an instrumental role to expedite development and growth of the OSAT systems. World development problems and AT designs contain both social and technical elements that fit very well within class curriculum, providing students with the valuable hands-on experience while helping to solve global challenges.

Classroom projects can be highly engaging and motivational for students when development and applied components are integrated within a curriculum. The simplicity of the concept is that students can research and help solve real-world problems while fulfilling curriculum requirements. As such, applying principles of service learning to sustainable development offers an enormous opportunity for both science and engineering programs at educational institutions (Logan, 1980; Pearce, 2007a), as well as for problem solving whenever help is needed, such as in developing communities (Pearce et al., 2011). Most of all, hands-on service learning approach represents a vast, and still largely untapped, resource for accelerating sustainable development, and enhancing course-based learning (Bringle and Hatcher, 1996; Panini and Lasky, 2002; Pearce, 2007a; Pearce, 2009). As Bridges and Wilhelm suggested: “Through education, we can inform our students about the global predicament and help them gain knowledge and skills they need to act as sustainability advocates within organizations at which they will one day be employed" (Bridges and Wilhelm, 2008, p.33). Furthermore, this approach allows those with problems to take advantage of free services brought on by the university research and development teams, while students enrich their learning experience (Cohen and Kinsey, 1994; Giles and Eyler, 1994; Pearce, 2001; Pearce and Russill, 2006; Pearce, 2007a; 2007b). More student and classroom involvement would help contribute to global development, as well as help resolve some of the obstacles in AT development, including design, testing, dissemination and engaging online collaboration.

Service learning within engineering has had a long history of enhancing traditional curriculum while teaching sustainable design principles, and has also led to development of such instrumental organizations as Engineers Without Borders USA, Canada and Australia (Logan, 1980; Vader, et al., 1999; Bryden, et al., 2002; Green, et al., 2004; Vaz, 2005). Benefits and characteristics of service-learning programs involve students developing academic skills, increased knowledge retention, sense of civic responsibility and commitment to community (Campus Compact, 2000 p. 17). There are many successful programs offering projects for community development: MIT, Caltech, Brown, Colorado University and the University of Michigan all feature courses dedicated toward developing sustainable AT within the context of engineering or science curricula (Pearce, 2009, Zelenika and Pearce, 2011). Many of the previously-mentioned AT solutions such as water purification technologies, solar refrigeration, thermoelectric lighting, treadle pumps and food processing technology have been designed in whole or in part through service learning and student engagement. While the field of service learning is growing, it is still not standard practice (Sandekian et al., 2005; Bielefeldt et al., 2009) and there is a significant opportunity to leverage service learning at educational institutions to meet their curriculum needs while educating future generations about sustainability (Pearce et al., 2011). Similarly, open source collaborative learning can produce many benefits by sharing design knowledge and allowing an open evolution of ideas based on public peer-review and contributions from diverse list of participants (Sawnhey et al. 2002; Pearce et al., 2011). For example, the Appropedia Foundation hosts a portal dedicated to service learning[3], and acts as a platform for a virtual version of service learning in engineering for development, and for language education through various page translation projects (Pearce, 2009; ter Horst and Pearce, 2010). Appropedia also features a list of past and current AT projects and classes as well as a blog and tools for teachers and students. Benefits of applied collaborative service learning not only enable students to take part in solving real world challenges and learn the social and technical skills of demand-led innovation, but most importantly allow students to see themselves as participants and partners in development. As their work contributes to solving real world challenges, it can also entrench the 'can do' attitude of active participation that is often the main ingredient for action and change for the future (Pearce, 2009; Branker et al., 2010; Corbett et al., 2010; Zelenika and Pearce, 2011). In addition, collaboration via various web channels such as Wikis can teach skills of coding and editing. Appropedia hopes to expand this service learning aspect by involving new schools and partners, as well as increasing funding for projects.

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3 http://www.appropedia.org/Portal:Service_learning

As Raymond wrote “Given enough eyeballs all (computer) bugs are shallow” (Raymond, 1999), meaning, the more eyes collaborating the larger the potential for identifying and solving problems. Collective power of many hands, eyes and brains working together throughout the World Wide Web can develop and provide solutions against extreme poverty, provide food and water security and speed up innovation on a scale never seen before. Various individuals and organizations in the field of AT are moving to tap into this potential, but as true critical mass and the concomitant rewards are yet to be reaped, a higher engagement of various contributors is needed. Significant contribution to solving global sustainability and development challenges can be achieved with a much greater involvement of post-secondary institutions which can provide an infinite amount of classroom laboratory research. Given the urgency of global development challenges and the minimal requirements for much of the AT research and development, the potential of service learning in all departments is substantial. Furthermore, with the help of ICTs and open collaborative networking opportunities, there is an even larger capacity to cut research costs, improve designs, instill social responsibility, and most importantly build sustainable knowledge networks for all.

Chapter 5

Discussion: Obstacles and Issues to Consider and Future Work

5.1 General Obstacles

Firstly, while the organizations and individuals interviewed for this study are among the top in their field, they nonetheless represented only a portion of those working with ATs, and therefore barriers presented here are by no means complete. Future work should be expand the list of interviewees to include as many organizations and researchers working in AT and OSAT as possible, including critics, open source and entrepreneurial sectors. This in turn should help provide a more complete list of barriers to AT and OSAT. Finally, future research should gather much more feedback from the communities and individuals utilizing AT or OSAT solutions to include their thoughts and suggestions on the topic- something which unfortunately this research was unable to do due to time and resource constraints.

The open source collaborative innovation can be of significant help to break down AT barriers, but this approach is not without obstacles as well. Given the novelty of open source and open access licenses (OS/OA), there is a trust barrier associated with the adaptation and propagation of OS/OA, as was documented in the interviews with AT researchers. More needs to be done to demonstrate what open access and open source entail in terms of licensing and showcase their advantages for faster innovation and knowledge dissemination. This obstacle can be overcome with a tutorial and a quick demonstration of licensing alternatives and examples already in use. In regards to actual open source technology collaboration, there is also a learning curve associated with wiki editing functions which may be a deterrent for some. This obstacle can be overcome through online tutorials, or may be remedied with applications to allow easier editing. Future work is needed to examine best practices to engage collaborative participation, development of websites, tools and platforms to organize content, and maintain user traffic. In addition, more work needs to be done to make sure that those for whom the technology is intended for have a voice and a means of contributing to discussions and the work of OSAT.

In discussions with one of the interviewees, it was mentioned that while internet cafes were becoming more predominant in developing regions, most patrons were young males using the Internet for entertainment purposes and not for benefits of appropriate technologies. This may very well be a natural path of progression - even in North America, it took time before Internet and personal computers were adopted by the general populous for more than just chat, e-mailing, video-gaming, music and file sharing, shopping and other less progressive activities. Perhaps more needs to be done to demonstrate various opportunities for self-learning and high via the Internet. As the case of William Kamkwamba and the women's group in Zambia illustrated, there is an immense potential for self-directed education and improvement awaiting millions of eager minds. While internet connectivity and availability is still out of reach for many, the main thing is for the knowledge network and infrastructure to be built, so that once the Internet is available, those who seek such knowledge can find it.

5.2 Building the Network

While there may not be a single ready-made recipe for making a successful wiki or a website, there are guidelines, functions, and criteria to enable the collaborative online design and ensure the growth and prosperity of the initiative. Eric Raymond cites three crucial ingredients for a successful open source collaborative project: i) a clear idea or a defined set of goals; ii) management coordination, and iii) a tool as good as the Internet (Raymond, 1999). As discussed in the AT barriers section, the definition, scope and implications of AT do present a significant barrier because of the ambiguity of what is considered 'appropriate'. In addition, while there are many organizations working in the field of sustainable development and AT, the goals and the approach to development can vary and be a dividing factor. More unity within the movement itself is needed, or perhaps re-designing the AT concept to a simpler name or idea for an easier public perception. Global calamities such as climate change and resource scarcity can be a rallying cause for a more unified consensus and a clear target, such as the Millennium Development Goals. The true test of success or the appropriateness will always be the communities employing the technologies, highlighting the importance of demand-driven innovation and community participation.

While a tool as good as the Internet is available, merely supplying ICTs is not a solution (Ashraf, et al., 2007). Arunachalam points out that the majority of ICT projects flooding the developing world are doing so in an irresponsible manner and for the primary benefit of hardware and software companies (2002). He, like many others, calls for a more "people-centered" approach so that technology contributes toward a participative developmental methodology (Arunachalam, 2002). In addition, as indicated, there are limitations to Internet access and availability in many areas of the world (Buitenhuis et al., 2010). On the other hand, Internet accessibility is growing globally, and so is the use of mobile telephony for numerous uses. In addition, there are also many off-line options such as using memory cards, which can be employed to bring the necessary information to those that need it and take away the resulting feedback, which can then be uploaded online when an opportunity presents itself. Language can also be a significant barrier, especially given many different languages and dialects throughout the world, especially in rural areas of Africa, South America and Asia. This barrier can be solved through multilingual databases enabled by applications such as universal translators, or ensuring that content is presented with a diverse and creative array of multi-media such as drawings, diagrams or videos.

As mentioned earlier, more AT is starting to include electronic components, and this could pose an environmental threat if the waste is not disposed properly. Therefore, all technologies introduced to new communities need to include a full life-cycle assessment, including waste diversion and what to do when the technologies break down or reach the end of their life-cycle.

5.3 Details, Dynamics and Components of Online OSAT

While ICTs can make all the difference for scaling of the AT, the process and the results do not happen spontaneously even with a tool as powerful as the Internet. ICTs are merely tools, and social components, such as user-driven content, participation and the functionality are the defining points for the success of the collaborative structure. The nature of many of the AT barriers indicated that too much emphasis is placed on technology and not enough on the 'software' or the 'know-how'. Social barriers to OSAT have been identified as the most predominant because needs, culture, politics and approach to development varies widely throughout the world. This is why community driven participation and demand-led innovation must be the underlying component of OSAT to ensure the right needs and problems are tackled. In addition, feedback and communication channels must be set in place to ensure that as many stakeholders as possible are involved in the dialogue process, and that as much knowledge and 'how-tos' are disseminated along with technology. Watson explained that success of any project or enterprise depends on deep engagement of the participants (Watson, 2009), of which the sense of ownership is a crucial component. This was an integral element for the success of open source software, where the users were also co-developers. A similar issue was brought up by Vinay Gupta and the literature review, where development is sometimes done "by outsiders for those people over-there". As Schumacher noted the best we can do is help people help themselves; give them the tools and knowledge needed, but the ultimate decision in what to do and how to proceed rests with the people utilizing the technologies. The benefits and potential of AT should be designed for use in all parts of the world, not just for the poor, because there is a danger of stigmatizing AT which can decrease its use, effectiveness and development. More needs to be done to demonstrate the versatility, robustness, appeal and application of energy and resource efficient small scale designs employed in AT, and this includes a higher uptake of AT in develped regions of the world.

Project continuity and accountability can also be a significant obstacle, especially when OSAT development is accomplished in a classroom setting or done by anonymous contributors half a world away. However this is where various rating tools and systems can be of significant help to identify and validate serious and trusted contributors and organizations from the rest. Furthermore, classroom contribution, changes in tenure, curriculum and student involvement can vary and thus provide uncertainty in project success. This was one of the key barriers for the eventual collapse of ThinkCycle. On the other hand, there are numerous examples where continuous student and classroom involvement has had a long tradition and is increasing over time. A perfect example is the MIT D-Lab and numerous Engineers Without Borders chapters. In addition, once the solid backbone and the content is built, others can carry it forward instead of having to build something from scratch. Even in the case of Wikipedia - the best and biggest example of a collaborative wiki, statistics trends indicate a gradual decline in new and active editors (Wikimedia Editor Trends, 2011). Watson argues that in most instances of online collaboration, it is usually a relatively small, committed core group that tends to do most of the heavy work, as was the case with Linux and Wikipedia projects (Watson, 2009). Given that Wikipedia's content is growing more complete each day, the workload has decreased tremendously and therefore there may simply be no need for as many editors as there were in the early stages. Fortunately , the content, mirrored on many sites throughout the Internet, remains available for others to access and build on, leaving room for future generations of Wiki editors to do their part. The same wiki or database approach can work for OSAT development. While there may be changes in the role or involvement of particular organizations or researchers, the work is not lost as it has been historically.

Furthermore, the OSAT database platform should be designed to allow for fragmented collaboration that matches an array of participant skills, expertise and time commitments. The structure cannot be too rigid and should be flexible and adaptable to user needs and demands. This is the principle recently adapted at Engineering for Change[4] established by the American Society of Mechanical Engineers. The design of the databases and the approach needs to be dynamic, multidimensional, and open to allow for a wide and diverse group of contributors as well as benefactors. Another area of future work is improvements in the synchronizing of information from various databases and websites already in existence. As information on AT continues to grow, whether there becomes a single repository for the content or not, there will be an issue of consolidating data or linking websites to yield more efficient searches, thus making it easier to acquire and share knowledge and designs.

Liability concerns over open innovation are another obstacle to consider, especially when

[4] Engineering for Change https://www.engineeringforchange.org/home

technologies and solutions in question, such as water filtration systems, could potentially lead to negative health effects if design or application was flawed. Liability can also be an issue with service learning and student classroom projects which may be given lesser standing than professional organizations. This problem can further be exacerbated through online collaboration where the anonymity could be an issue. This is why a system of checks, validation, voting and community peer-review is especially important to provide 'a seal of assurance' or differentiate between amateur and professional contributions.

Finally, there is a substantial difference between open source software development and that of open source hardware. For example, in software development, the cost of testing the programs and debugging is practically non-existent if one has a dedicated group of programmers and task appropriation, which was especially true in the Linux case. The program or the software can be tested and released instantaneously. This of course is not the case with hardware designs, which often take a long time to manufacture and include various interacting components such as metals and electronics that makes the testing more time and resource consuming. In that respect the time efficiency of open source hardware development may not be the same as that of OS software, but if executed properly the OS hardware design would still offer a much faster and efficient alternative. Any benefits of open collaborative innovation would minimize the costs and time barriers through task appropriation, faster knowledge exchange and resource economization.

Chapter 6

Conclusions

The results of the interviews in this research confirmed that a large number of literature identified barriers since the 1970s still afflict the development and expansion of appropriate technology (AT) today. Some of the obstacles are purely technical in nature, but others contain cultural, social, political, institutional and organizational challenges with equal bearing and importance. Such obstacles include: i) AT seen as inferior or poor person's technology, ii) obstacles of cultural appropriateness, iii) problems of technical robustness, iv) transferability and the fit within current industrial and economic systems, v) barriers of distance and time in solving rural poverty, vi) as well as problems of stable funding and a better institutional support for AT.

In addition, interviews with the organizations and researchers working on AT also revealed that there is a need for a much better exchange of knowledge and collaboration among agencies, researchers and communities developing the AT solutions. Interview respondents repeatedly focused on the need for better communication and collaboration to share knowledge and resources and work in partnership. Marketing, social ventures, and business opportunities were also topics of interest for many in order to scale up and improve their development efforts.
As such, a majority of the barriers discussed can in some form or shape be reduced or minimized by better linkage, feedback, collaboration and exchange of knowledge and data – particularly though a greater inclusion of ICTs. Collaborative online platforms are quickly becoming the

backbone of many social, economic and research-related enterprises and their contribution to the field of technology for development is yet to reach full potential. Information and communication technologies such as the Internet allow for a plethora of collaborative and open source enterprises, wikis, forums, online databases and platforms for knowledge accumulation and exchange, and this holds a lot of promise for the future of development and innovation.

Discussion and interview responses on open source and open access to knowledge were very insightful and demonstrated general receptiveness to the core principles of knowledge commons, open source and innovation through collaboration. There is already a movement toward a greater inclusion of ICTs for distributed collaborative innovation in sustainable development and AT, and this is indicative of a new positive trend. However, as the interviews revealed, not everyone is participating yet. The interest and awareness of the benefits brought on by better collaborative methods is clearly there, and perhaps what is missing are the right tools and and interface to allow for that collaboration to blossom and reach its full capacity. This topic is worth pursuing in a much greater detail given the potential of improved effectiveness and efficiency for researchers, organizations and communities working together to solve sustainable development challenges in such as climate de-stabilization, rising world populations, and resource scarcity. More needs to be done to encourage, showcase and allow for open access and open source collaboration for in the field of AT and within general sustainable development. This includes an increased participation for the researchers and organizations, as well as communities and individuals employing the solutions. Their feedback and participation is of paramount importance as development is to be done with them as active participants and partners.

Furthermore, educational institutions, researchers and students also have an important role to play in building critical mass awareness and knowledge databases of sustainable, small-scale solutions, such as AT. Given the urgency of global development challenges and the minimal requirements for much of the AT research and development, the potential of service learning in all departments is substantial. With the help of ICTs and open collaborative networking opportunities, there is an even larger capacity to cut research costs, improve designs, instill social responsibility, and most importantly build sustainable knowledge networks for all. With a heightened service learning, applied knowledge and research, and a greater emphasis on open source collaborative innovation, positive life-long trends can be instilled to further encourage and advance open collaborative research between all stakeholders for a more sustainable development and a worldwide deployment of efficient technological solutions.

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Appendix A - Interview Consent Form and Questions

Queen's UNIVERSITY

Interview Information and Consent Form

Issues and Barriers With Open Source Appropriate Technology Development

You are invited to participate in research on issues and barriers to development of open source appropriate technology (OSAT). The purpose of this research is to explore currently known problems associated with the development of OSAT, and compare them with insights gained from researchers, academics, students and organizations involved with the field of appropriate technologies and open source hardware.

To this end I, Ivana Zelenika would appreciate the chance to interview you at a time of your convenience. I would prefer with your permission, to tape record the interview for accuracy and reference. You may chose not to be recorded and also if you wish, you may keep your anonymity as a participant by checking and signing the appropriate fields.

There are no known risks associated with your participation in this study. Participation is completely voluntary and this study has been granted clearance according to the recommended principles of Canadian ethics guidelines, and Queen's policies. You are free to withdraw at any time for whatever reason without penalty You are not obliged to answer any questions that you find objectionable or make you feel uncomfortable and may withdraw from the interview at any time. All data will be stored in a secure computer file accessible only to the researchers until published, at which point the files will be erased from the computer. Any information gained by the research will be used solely for the purposes of this study and shared only with the research supervisor. If you so request the interviewer will protect your anonymity as much as possible (your name or associated organization) by removing identifying features from the resulting transcript or the questionnaire. If you do withdraw from the research at any time, all information collected will be destroyed.

Your signature below confirms that you have read and understood the form and agree to participate.

Name _________________________Department______________________

Email________________________________Phone__________________________

Signature_____________________________ Date___________________________

For Email interview please fax your signature or reply via email with an affirmative or this box checked off as "Yes" for your consent: Yes No
Please initial your conditions for the interview:
I am willing to have our conversation recorded? Yes No
I allow the researcher to use my name in publication: Yes No

If you have any questions or concerns, please contact either the researcher, the supervisor or the Ethics Board

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Sample of interview questions

Interview will aim to answer general questions associated with development of open source appropriate technologies and barriers standing in the way. All interviewee's will be asked the same questions. The following are examples of the interview questions:

Do you use open source, appropriate technology or OSAT? Why or why not?

In your view, what are some potential obstacles to wide scale use of OS and OSAT?

What are some solutions to these obstacles?

One of the ideas to expedite appropriate technology is to use open source it as it has successfully been done in the software movement. What are your thoughts on this?

What ingredients do you think are necessary for awareness and critical mass of OSAT/AT organization?

How do you suggest a more concrete involvement of mainstream institutions and funding?

Some could say appropriate technology is a fringe market. What are your suggestions for an integration and awareness of AT and OSAT in the mainstream?

Most applications of appropriate technology have been directed at developing countries: In your view what are some dangers associated with such application?

Unlike open source software, OSAT can be expensive to build, test and manufacture. What are the solutions and resources necessary in facilitating the hardware application of appropriate technology?

What are the financing incentives and economics of OSAT - Can it compete in the open markets like open source software which has some pay per use and free content?

How well can OSAT be integrated within existing technological policies and infrastructure already in place?

One possible solution to integrating OSAT into the mainstream could be establishing a forum or an online database where people can post designs, collaborate on project, share ideas and etc. What are your thoughts on this idea and possible problems associated?

If such a forum is established, would managing the forum, coordinating the groups and executing ideas be an issue? Why or why not?

Appendix B - Interview Transcription Key Points

Academic Voices

Professor Camille George from Thermodynamics Department of St. Thomas University characterized both social and technical barriers in her encounters and research in Mali. The crucial question she brings forward are: who is the appropriate audience, what is the cost of technology and what are the materials involved. She also explains that more collaboration is needed with local communities as well as other NGOs. She also believes local knowledge has a lot to contribute to sustainable development if the locals had more confidence in their own technology – such as the evaporative cooling, which can also work well in the western/mountain states of United States for example. Dissemination of technology is another key barrier. Her team can work very well on designing the technology but to ensure it reaches the intended audience takes special skills such as marketing.

Jason Morris from Industrial Design Department of Western Washington worked on a collaborative cargo bicycle design project in Uganda. The project resulted in a documentary film called Hoima. He groups barriers into manufacturing (technical) and accessibility/ acceptability (social) barriers. Like Camille George, Professor Morris also remarks that implementation is always harder than design, ringing true Schumacher's “an ounce of practice is generally greater than a tonne of theory”. He also touches on the stigma identified in literature review: “There is a social stigma attached to bicycles = poor" (Jason Morris, 2010)

Jeff Brown from Hope College also agrees that understanding the problem, designing it and getting people to use it are among the key components in the implementation barrier. As an engineer he also notes that some of the biggest barriers are actually cultural and there is a lot of room for anthropologists and sociologists to help with in the technological dissemination. He agrees with Dr. George on the need for more people to share their experiences of what works in the field, and that web although a great repository of knowledge is not a substitute for actual work and experimentation.

Toby Cumberbatch who has experience in engineers without borders in Ghana also spoke of adoption problems of how some things get picked up and some simply don't. This is where he thinks global engineering alone cannot work: it needs to match local conditions which differ across the globe. He also stresses the need for follow-up after the project is technically closed. When it comes to communication he thinks databases of appropriate technology can be very useful to share knowledge. He also pointed out that sharing limitations and what failed in the project is just as valuable (if not more) than what worked. Professor Cumberbatch also spoke of administrative barriers with dealing with various administrations and Organizations who exercise some levels of local ignorance and personal agenda.

Professor Mark Henderson from the Arizona University agreed with Professor George and

Cumberbatch that matching the community with the technology is the key. The Twig Light project done by his students was modified to replace gel fuel with charcoal to match the community resources. Further feedback inspired another design modification to allow for charcoal fuel. His team engineered a low cost lighting solution as a part of Global Resolve - a social entrepreneurship program designed to benefit improvised communities around the world. Costs and problems of immersion were also key barriers. He also agreed on community specific needs: students need to travel and be exposed to cultures and villages otherwise they will be solving the wrong problems. This could be a virtual experience. In addition, there is no such thing as too much information shared with local communities: it helps minimize and anticipate problems.

Organizational Feedback

Chris Watkins, Director of Appropedia Foundation shared valuable thoughts on the benefits of online collaboration and what is needed to scale up Appropedia.org and incite more online collaboration and database building. Chris also brings up several points which touch on the barriers to appropriate technology and are rooted in the sole definition of what is 'appropriate'. For example, is appropriate technology really appropriate if it is designed by rich people in developed countries for poor people? Also, is local production really the best way or the most appropriate – for example if mass production reduces costs and increases convenience, it's actually more appropriate for people who are working with limited income. In addition, people in the developing regions of the world want the same technology we have (cell phones, TVs, computers) because it works and provides thrilling educational, communication and entertainment features, so where does this type of technology fit in the AT definition?

Dr. David Grimshaw, head of International program with Practical Action (previously the Intermediate Technology Development Group) and DFID Senior Research Fellow, agrees more research and collaboration is needed with the communities. We also need more demand-led innovation, more ownership and continuity in projects, as well as be more inclusive of private sector given that development driven by aid has not worked in the last 50 -60 years. He also believes that in the future ideas will be developed very differently, much in the style of crowd-sourcing, and there has to be a way to pool resources, technologies and ideas together. He has been involved with Scientists for Humanity and MatterForAll.og. Open -source and semantic web are the great facilitators of this process; open source is gaining a lot of support on the ground level but the lack of support higher up is a barrier. Cost counter-intuitiveness (how can something free be a great value?) is one of the key problems.

John Barrie is the Executive Director of Appropriate Technology Collaborative and agrees that using open source and creative commons licenses is a way to to increase development by allowing others to build on the designs and improve products. For example when a cost of LED lightning solutions goes down, they can reach more people and save money to those families which invested in the technology. In terms of definition to AT he believes it can include a wide range of technology which are designed to help low income people have a better and healthier life, while providing jobs as well. AT did not traditionally include electronics in its early days but now electronics are ubiquitous. Among the barriers he identifies capital (some places have high taxation rates) and bringing down the costs of products – poor people are cautious with their money and can be difficult for them to commit to a new technology they never heard of even if it saves them money. Sometimes the well intentioned agencies provide some technologies for free, but it destroys the market as people are less likely to purchase systems instead hoping that a non-profit may bring another one for free. He is very much in favor of online databases and more collaboration: a place with robust drawings, clear instructions, minimal language barriers, feedback and tracking of project progress.

Roger Salway (Executive Director) and Bert Rivers (VP of of Operations) from the Compatible Technology International agree that simplest technologies are often overlooked by development agencies. For example one of their projects involves providing food grinders in Uganda, and while seemingly simple, these technologies allow communities to process their own produce on location for cheaper and much faster than sending it miles away for processing. Bert brings up the failure in perception that "if you build it they will come", but success lies in having the right technology but also utilizing marketing skills to let the world know what technology you have – better linking with the partners and advertising oneself. Roger points out the importance of feedback which can sometimes take a long time to arrive but when it does it offers a lot of interesting data in how technology is working, what are problems and how is it influencing or changing the communities. There is also a lot more collaboration that can and needs to happen between agencies working in the field to strengthen their voices together instead of being protective over one's role or turf. They also provide the other angle of problem with the AT definition: using the term technology can send a wrong message that they are working with complex high tech, but the need for AT is large given that large scale mechanization utilized for agriculture in North America could not work for many of the rural communities they work with. Big organizations need to realize this and participate on ground level and by providing resources.

Steve Crowe from the Appropriate Infrastructure Development Group also thinks it is important to have a central repository place for everyone in the field to collaborate, and thus provide a go-to place for information. He too mentions that a lot of lessons are learned independently the hard way when data could have been provided. In addition, continuous feedback and communication is very valuable as a lot can happen even when the project is technically 'closed'. In terms of barriers he warns of being too technologically focused given that people's usage patterns and needs play a crucial role as well. In addition, while local manufacturing is very important he too wonders whether it can limit what kind of products can be produced, the cost of the technology and can also limit functions or the appearance that people would want. Not to say that aesthetics should win out over the functionality, but we cannot ignore that people everywhere are influenced by aesthetics (just like us here). In other words, principles of AT are great guidelines but they can also be too rigid and prevent providing something that people need and would want to use. Challenges to a successful AT implementation also include the related policies and how systems are managed, not just technology itself. Steve also comments that the key to successful implementation would be to engage as many different aspects of people's lives, for example the Bio-digesters he has worked with were successful because they are good for people's health, good for environment, provide energy, can be a source of income etc. As he says: “When you're worried about when you get the food for the next day you're not going to think about environment, health and the future”

Noha El-Ghobashy (Director of Technical Programming) and Iana Aranda (Manager of Technical Programming and Development) from the American Society of Mechanical Engineers (ASME) are also strong believers in open source germinating change. They too attest to the problem of organizations having to 're-invent the wheel' because they did not know the relevant information existed. In addition barriers sch as engaging communities, providing feedback and linking those with solutions to those that need solutions are also significant issues. This was one of the main reasons behind ASME's newest project, a website called “Engineering For Change” which provides a forum to connect, collaborate, share knowledge and solve challenges to improve the quality of life all over the world. The intent is to make the whole site open-sourced where users can dictate the features and content of the website. Accessibility and the functionality are the main issues, as well as finding ways to engage and give voice to all people of different languages, cultures and world-views.

Similarly to Engineering for Change, Ewa Wojkowska and Toshi Nakamura started Kopernik because they felt the approaches that large international organizations take to solve development challenges is limited, and sometimes recycle the same idea many times without yielding very much result. In addition, Scott White, Kopernik's business development specialist elaborates the need for having a converging place or a community for appropriate technology, as well as for better communication, strategies and funding opportunities. Scott also adds this is an interesting time for social ventures from an entrepreneurial standpoint, because of the evolving opportunities to make and have different types of business models, especially through the world wide web. As such, Kopernik acts as a technology marketplace by linking technology seekers with donors and technology providers. Their focus is on a sustainable dissemination combining the capital and the local organizations creative pricing and marketing schemes. Currently their AT criteria is pretty broad and they let markets and users decide on dominant technologies. When it comes to further barriers better marketing and communication are still the key to let NGOs and communities what technologies are available. Open source is a growing theme among the player in the field, and Kopernik plans to build an interactive section of Q&A and a DIY Service Line to provide scope for interaction and open source and appropriate technology. According to Toshi, another key barrier to keep in mind is how to reach the people in the last mile of the development. As it involves offline work, no matter how good internet databases get, the impact of online information will have a limit.

Governmental Input

A researcher from International Development Research Center Canada (ICT and science and technology sector) confirmed the increase in open source use especially in the field of micro-management and health and information systems. The open-source standards cut operational costs and allow for synching of data, continuity and compatibility with other agencies in the field. The researcher also noted there needs to be more discussion and demonstration of how open source fits in development to help countries innovate and build products and support that can lead to markets. As mentioned previously trust is a major barrier as people constantly need to be re-assured that the software is dependable and works as well as proprietary software. Governments and policy makers must play a larger role in this issue as does the global community. Poor information dissemination, lack of communication, people working in silos are problems. Questions to ponder are: what is role of the research universities, how do we collect and share data, and how can it be more rewarding and relevant to the communities in which they exist.

Entrepreneurial Voices

Zubaida Bai, a TED India fellow and a founder of AYZH uses open source technologies on purpose. If the goal is to provide high-quality low-cost solutions then intellectual property would impede on that vision. In addition, if the market demand for products was higher than Ayzh could deliver, open source would allow other providers to step in. As for problems of trust, profit margins in her enterprise are so low that she does not see much of the threat, and in her experience even when the specs are provided, NGOs still approach them to manufacture and ship the products. When it comes to barriers to appropriate technologies Zubaida agrees with the common misconception where people do not even consider AT a technology, or recognize that even simple things can be a life saving technology. In addition the social enterprise sector is growing and even simple things can make a profit - they don't have to be given away. But the business challenges facing social enterprises are the same as for everyone else: NGOs, non-profits, profits. It takes time and money for R&D as well as advertising your products. She agrees tat there needs to be more inclusion of businesses and private sector in the AT development. “Just because one thinks and works about social good doesn't mean one should live in poverty. One should be able to rise one's own livelihood and raise livelihood of others.”

Apruva Joshi from Digital Green works to provide educational technological videos for local NGOs. He agrees that people and partners they work with are responding well to open source because it is much cheaper than proprietary solutions and allows them to use the reporting system offline and online. While technologies are entering rural areas, food, land and security are still the biggest and main challenges for a lot of people. He agrees that technology cannot be forced upon people – they must see the benefits and feel the need for it. While people are generally very open to technology (TVs and cell-phones are very popular), it is still very slowly entering villages. Farmers looking to make the ends meet are concerned with only what works and easy solutions. Other barriers he points out are the lack of funding, lack of cooperation between NGOs and people working in the field and finding local people interested in working in the development field with NGOs.

Activists and critics

David Eaves – Open access and data activist agrees that cultural barriers of trust are they key to a wider application of OS and open access principles. Governments and people in general are used to paying large amount of money for proprietary software and services that they cannot equate free with quality or trustworthiness. In addition, governments and agencies do not recognize the potential open sourcing data can make – they only see possible risks of public scrutiny, nor do they even collect data for half of the things they should. But David reminds that the data does not belong to the Governments but actually to the citizens who employ those governments. Furthermore by not employing more open access principles and making the data public the governments are actually hamstringing themselves as they are actually the biggest users of data . Having a better mechanism where public servants can access and sharing the information with their fellow departments could lead some interesting efficiencies. Not to mention the possibilities if that data was provided to the rest of the public. David cites an example where his friend exposed fraudulent charities between 2005 – 2007, worth 3.2 billion dollars, by accessing Canada Revenue Agency details. The friend had to go through a lengthy process of accessing the data related to top charity numbers, and had this information been more accessible or posted on the CRA's website, perhaps these activities could have been either prevented or caught sooner.

Vinay Gupta, an activist and a development proponent whose projects include the Hexayurt and Soft Development Paths is quick to identify the number one barrier to appropriate technology: no money. The second barrier is the lack of transparency, accountability and collaboration between aid agencies and NGOs working in the field of development. At worst, some of these agencies are inefficient, secretive and competitive when they should be cooperative and accountable to the people they are supposed to represent. In addition, Vinay estimates how appropriate technology has the potential to save about 1/4 to 1/3 of all human deaths, and yet very few agencies even employ such technologies. The biggest reason is the fact that appropriate technology does not have the same visual appeal as other methods of raising money, especially if that technology happens to be something like a functioning toilet. According to Vinay this problem is insoluble in the current situation were the donors who do not take the time to know give money to agencies that don't want to be accountable. As he says: “It is a perfect marriage: one side does not want to know and the other side does not want to tell”. Further problems holding development back are the arrogance and colonial mindset of imposing technologies, and more especially not providing culturally robust technologies. In addition, he asks “are we donor driven or solving problems for the people on the ground driven?” In regards to open source and open access for better knowledge and technology exchange Vinay is in full support, but again emphasizes the danger of competing databases and need to find the way to confederate the knowledge and databases together into one stream.