

**OVERCOMING LANGUAGE CHALLENGES OF OPEN SOURCE APPROPRIATE
TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT IN AFRICA**

By: Joshua M. Pearce and Eleanor E. ter Horst

ABSTRACT

Despite enormous efforts over the course of several decades, sustainable development on the African continent remains incompletely realized. Top-down methodologies have largely failed and many sustainable development organizations now support small-scale direct approaches, which provide the tools and knowledge necessary for people to help themselves. The new approach to sustainable development of open source appropriate technology (OSAT) builds on these successes. OSAT is a development method for traditional appropriate technologies (following Schumacher). The fundamental concept behind OSAT is that anyone can learn how to make and use AT free of intellectual property concerns, and can simultaneously add to the collective open source knowledge base by contributing ideas, observations, and experimental data. This approach to drive sustainable development is promising because the continuous peer review should result in better quality, higher reliability, more flexibility and of course less expensive (free) AT than conventional design/patenting. As OSAT is being developed largely in English, Africa's many languages present a fundamental challenge to OSAT's use for sustainable development on this continent. This paper provides potential solutions to this challenge by reviewing i) the ongoing merger between Appropedia (English) and Ekopedia (French), ii) systematic translations at the NGO Catalytic Communities, and iii) virtual service learning in languages.

Despite enormous efforts over the course of several decades, sustainable development on the African continent remains incompletely realized. Top-down methodologies have largely failed and many sustainable development organizations now support small-scale direct approaches, which provide the

tools and knowledge necessary for people to help themselves. The new approach to sustainable development of open source appropriate technology (OSAT) builds on these successes. OSAT is a development method for traditional appropriate technologies (following Schumacher). The fundamental concept behind OSAT is that anyone can learn how to make and use AT free of intellectual property concerns, and can simultaneously add to the collective open source knowledge base by contributing ideas, observations, and experimental data. This approach to drive sustainable development is promising because the continuous peer review should result in better quality, higher reliability, more flexibility and of course less expensive (free) AT than conventional design/patenting. As OSAT is being developed largely in English, Africa's many languages present a fundamental challenge to OSAT's use for sustainable development on this continent. This paper provides potential solutions to this challenge by reviewing i) the ongoing merger between Appropedia (English) and Ekopedia (French), ii) systematic translations at the NGO Catalytic Communities, and iii) virtual service learning in languages.

Keywords: Appropriate technology, language, sustainability, sustainable development, service learning, open source, open design, community, language education, Africa, translation

INTRODUCTION

The need for just sustainable development in Africa is well established. The goal of just sustainable development is "to ensure a better quality of life for all, now and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems" (Agyeman, et al., 2003:5). One method to assist in just sustainable development in Africa is the advancement of appropriate technologies (ATs) following Schumacher (1973). Although there is considerable debate about exactly what type of technology is appropriate (Morrison, 1983), here we will follow Schumacher's concept of ATs, which are defined as technologies that can be easily and economically implemented by local communities in the developing world, using readily available resources (Pearce, 2007a; 2009). ATs work within the limits set by the local community's environmental, cultural, economic, and educational resource constraints (Pearce, 2007a, 2007b; Reyes, et al., 1978).

The term appropriate technology originally gained a following in the 1970's as a potential response to the enormous inequities of wealth distribution and poverty in the world, particularly in the non-industrialized countries, and the failures of development (Pursell, 1993). Many projects meant to address

sustainable development then and even today were based on large-scale industrial development, which creates technology dependent on foreign aid, foreign expertise, and foreign perceptions. As an example, consider the failure of large dams to encourage development. This fact is well documented by critics of international aid agencies, who point out that 60% of the world's major rivers have had flows altered by dams and that millions of indigenous peoples have been relocated from their lands, only to see the dams fail when they are not subsidized by the state or private enterprise (IRN, 2006). So-called 'client communities' often have no capacity to support these large-scale development efforts and so the projects fail if external aid is withdrawn, thereby forcing these communities to be dependent on aid. Often the terms of this dependence are so egregious that some academics have come to see this type of development as a new form of colonialism (Escobar, 1995). Observing the dismal failures of large-scale industrial development, Schumacher started to call for more context-aware and small-scale development involving appropriate technologies (1973). Other academics and activists followed. They believed that smaller, locally produced, and more “mundane” technology could tackle many of the problems of the 'developing countries' that external aid had not solved. For example, they argued that simple decentralized point-of-use water sanitation systems requiring minute amounts of human and capital investment would be a more sustainable form of development than a centrally placed municipal sanitation system that would require enormous capital and human investments (Mintz, et al., 2001; Hashmi and Pearce, 2009). Backed by academics in the new appropriate technology school, NGOs and nonprofits started to use appropriate technology for sustainable development, since the technologies were low-tech, locally made, low-cost and contextually relevant for the client communities. DubBose *et al* argue that the concept of appropriate technology was a necessary precursor to the idea of sustainable development, which has gained such popularity (1995).

Although some limited research has been done on a number of appropriate technologies, see for example the Appropriate Technology Library (Village Earth, 2009), the diffusion of these innovations has greatly lagged behind the demand for such technologies in the developing world. The use of open source appropriate technology (OSAT) has been proposed (Pearce, 2009) to overcome this lack of diffusion. OSAT refers to technologies that are designed in the same fashion as free and open-source software such as Linux. Open source is a development method for appropriate technology that harnesses the power of distributed peer review and transparency of process. Appropedia.org is an excellent example of open source appropriate technology. The website is an appropriate technology wiki featuring detailed

instructions for a wide variety of projects and processes that contribute to poverty reduction, sustainability and international development. At the Appropedia site, anyone can learn how to make and use AT free of patent concerns, and users can also contribute their own work to the global community. The site is structured so that any user can write or post an article on a relevant topic, and anyone can revise and update existing articles. In this way, all users can add to the collective open source knowledge base by contributing ideas, observations, experimental data, deployment logs, etc.

The potential for OSAT to drive applied sustainability is clearly large as witnessed by the success of the open source software movement. The primary example of success in the open source software movement is the use of Linux, an open source operating system initially created by Linus Torvalds in 1991. This UNIX-based operating system has since consistently grown in the number of users, and its annual growth rate has recently accelerated with an increase from 15% in 2001 to 40% in 2004 (NetApplications, 2009). Linux was developed by thousands of users/developers who volunteered their time because they were frustrated with the proprietary nature and inferior performance of Microsoft software (Kogut and Metiu, 2001). There are many other examples of open source software projects developed by volunteers competing against software products developed by large multinational corporations, including Apache, a popular web server software accounting for almost 50% of its market according the Netcraft Survey (2009), and Mozilla, a free web browser, which has more than 20% of the global browser market (Taylor, 2008). One of the primary reasons that open source software is so remarkably popular is that there is a massive continuous peer review.

When open source methodologies are applied to appropriate technology, the same built-in continuous peer review should result in better quality, higher reliability, and more flexibility than conventional design/patenting of technologies (Raymond, 1999). The free nature of the knowledge also provides lower costs, particularly for those technologies that do not benefit to a large degree from scale of manufacture. Finally, OSAT puts an end to predatory intellectual property lock-in. This is particularly important in the context of technology focused on relieving suffering and saving lives in the developing world. The “open source” model can act as a driver of sustainable development in Africa. There are (at least) three good reasons for its potential (Cascio, 2006): i) it enables production as well as consumption; ii) it enables localization for communities that do not have the resources to tempt commercial developers to provide local versions of their products; iii) it can be free as in "gratis" (free

of charge) as well as free as in "libre" (available to everyone) -- an important consideration for developing communities.

THE LANGUAGE CHALLENGE IN AFRICA

As OSAT is being developed largely in English, Africa's many languages present a fundamental challenge to OSAT's use for sustainable development on this continent. Although the demand for English is very high in Africa because of the revolution in information and communication technology (Bgoya, 2001), over 2,000 languages are spoken in Africa (Grimes, 2000). This represents more than a third of the world's languages and an enormous amount of localized knowledge on sustainable survival. The number of languages, however, is fluctuating significantly as some continue to be 'discovered' similarly to how Columbus 'discovered' the Americas, while many others continue to disappear or become extinct (Crystal, 2000; Nettle and Romaine, 2002).

Although the official languages of African countries are often English or French, many people in Africa still do not speak one of the westernized dialects. It should be noted here that some contemporary critics make it clear that the historically colonial languages continue to impose the will of the powerful on Africa's people. For example, Bgoya argues "English is the language of this globalization and English serves fundamentally the interests of those for whom it is both an export commodity and a language of conquest and domination" (2001: 286). While imposing OSAT advancement only in English presents cultural challenges, Africa's native languages possess two key benefits for the development of OSAT: i) they are spoken by those living in rural areas now - when the information is needed and ii) many of the keys to sustainable living in the bio-regions of the continent are preserved within these languages. Ideally OSAT development would occur in a parallel fashion with all available languages, and this should be the goal. Practically this is difficult because there is not a critical mass of speakers with the information technology and communication equipment needed to support OSAT in all Africa's languages (IWS, 2009). In addition, there appears to be a clear trajectory of language dominance seen in Africa and thus, logistically, a smaller number of languages should be targeted first for OSAT translation including: Arabic, Malagasy, Afrikaans, English, French, Spanish and Portuguese. Then, as critical mass grows for OSAT developers in Africa, work should be extended to the continent's many other languages.

POTENTIAL SOLUTIONS

A possible solution to the communicative challenges of OSAT is the development of a universal language. This has been proposed many times before – most notably with Esperanto (Forster, 1982; Janton, et. al., 1993). Esperanto, unfortunately has had relatively modest levels of adoption with only 2 million people speaking it in the entire world (Gordon, 2005). Similarly, English has become the de facto universal language for both business and science. In most regions of the world it is taught as a second language for the well-educated university class. As the world's populations increase their education level, it will become increasingly easy to communicate with them in English. These proposed solutions, however, do not address the immediate need in Africa, where an extremely small fraction of the population knows either Esperanto or English, and where English is still associated with the culture and history of colonization.

The second possible solution is technical in scope. It would be possible to inform non-English speakers about the many open source technologies by developing them pictorially and in videos. There is significant notable work on this front, both at appropedia.org and at instructables.com. This solution has the advantage that it can transmit knowledge even to those who cannot read any language. Users could download short video clips discussing various ATs to their cell phones. This would be an extremely effective way of communicating many aspects of AT. The disadvantage is that showing videos takes up enormous bandwidth as compared to text. In rural Africa, both the cost and the availability of high speed internet and bandwidth again make this solution impractical in the short term.

The third possible solution is automated (computer) translation. This service might serve as a stop-gap measure when entries are first input to provide rudimentary details, but computer translations of such material are notably inaccurate and contain many errors, often to the point of being incomprehensible to a native speaker of the target language. Currently, human translators are needed to correct and refine the automated translations.

Taking into account the limitations of these proposed solutions, we believe that three techniques for handling multiple languages in OSAT offer the best potential to promote sustainable development in Africa: i) co-site development of OSAT, ii) systematic translations, iii) and virtual service learning in the languages.

Coupled Co-site Development - The Open Sustainability Network Approach

Coupled co-site development involves creating an independent website and separate content for each language. Unfortunately, this approach results in redundancy and squanders resources because the content must be researched, tracked and written for every language (Désilets, et al., 2006). This redundancy is unacceptable due to the life-saving potential of OSAT and the urgency of the need. To overcome this problem, the primary goal of the Open Sustainability Network (OSN) is to build a unified collection of relevant online tools and practices to help stakeholders accelerate just sustainable development (Pearce, *et al.*, 2008). The OSN is being synthesized from a number of existing online tools and methods of partnerships between the stakeholders using predominantly online tools. To see how the growth and collaboration of the OSN can assist in solving the language challenge in Africa for OSAT, the recent collaboration between Appropedia and Ekopedia is instructive. Appropedia and Ekopedia are both wiki-based websites like Wikipedia. Appropedia is the primary site in English for collaborative solutions in sustainability, poverty reduction and international development, and Ekopedia fulfills a similar role in French. Both sites offer a lesser volume of OSAT information in other languages currently including Indonesian, Czech, English, Spanish, Esperanto, German, French, Italian, Dutch, Polish, and Portuguese. These sites have enormous potential to assist in sustainable development because they simplify the process of collaboratively organizing information, project examples, best practices and 'how to's. Appropedia, for example, has already become the venue of choice for organizations like Engineers without Borders – Australia and Demotech, and is set to expand rapidly as other organizations use its information transfer and collaboration capabilities (Pearce, et al., 2008).

In 2008, Ekopedia and Appropedia began to adopt a deep and adaptable partnership (Beckman, *et al.*, 2009). The two organizations share the vision of a positive collaboration that could lead to a merger of the projects. First the two sites will develop compatible licensing (like CC-BY-SA-3.0 + FAL). Then they will begin content sharing and translation (French pages on Appropedia are ported to Ekopedia, English pages on Ekopedia are ported to Appropedia, French pages on Ekopedia are translated to English pages at Appropedia, and English pages on Appropedia are translated to French pages at Ekopedia). Next the two sites will begin creating links and developing a common method for organizing and categorizing articles. Links between versions of the same article in various languages will be established between the wikis, in both directions. Finally, the projects will merge.

This method is extremely functional and is viable with any OSAT site creation in the many languages of Africa. The primary challenge is the independent creation of an OSAT site in each of the languages used over the entire continent. The potential and limitations of this method for a specific language can be gauged by the availability of the language in the much larger-scope encyclopedia, Wikipedia. Methods for recruiting people to develop content in various languages are described below (3.3 Virtual Service Learning).

Systematic Translations – The Catalytic Communities Approach

Catalytic Communities (CatComm) uses technology to link grassroots community groups so they can learn from each other's successes, and support one another's work. When community organizations tackle local problems, their work would be easier if they knew about successful programs in similar neighborhoods around the world. CatComm realizes that people solve crises in their communities every day, and the Internet is the perfect tool to replicate these successes. CatComm collects and posts how-to examples in their Community Solutions Database. These real-life stories address a wide range of issues, from HIV prevention to spurring economic growth or providing effective care for children and the elderly. The majority of existing projects (>130) are concentrated on social solutions, although OSAT projects are possible. The goal is to inspire people to make a difference around the world. Historically CatComm has collected community solutions through a standard template and then arranged for volunteers to translate them into Spanish, English and Portuguese (see <http://www.catcomm.org/>). This process not only provides more access to a greater population, but it also motivates community members when they see their work spread into other languages.

CatComm is near to releasing a new multilingual platform with the capability of adding any number of languages and a number of templates (Maranda, 2009). Upon switchover to the new platform it will also have a ReSTful API, which means that anyone can pull CatComm content for replication elsewhere either by widgets, xml/json code or potentially with a data partner/back-end. Their next phase of development is the evolution of a 'Virtual Casa' in homage to the Casa that CatComm once maintained in Rio de Janeiro, Brazil. The original Casa brought local community leaders together to exchange ideas; the Virtual Casa will offer an online version of the face-to-face activities of the Casa, so that people working to solve local problems can connect with others, in their communities and around the

world, who might be dealing with similar issues. The Virtual Casa will feature tools for collaboration and will embody some degree of process sensitive project management in support of the documentation, refinement and replication of solutions (Miranda, 2009).

Using the CatComm database offers enormous promise to deploy OSAT into a number of languages. The CatComm system relies on a network of volunteers and foreign language students to translate the material developed in one language into multiple languages. As each native language entry is input to the database, through a portal, the entry is delegated out to a network of translators. This method not only reduces the redundant effort, but also offers potential as a teaching tool, through service learning, for language courses. There is an enormous amount of valuable work to be performed in order to maintain the OSAT information in multiple languages, considering the fast and ever-changing nature of the development of appropriate technology all over the world.

The primary challenge of this method is to obtain enough volunteers to do systematic translations into the many languages used in Africa. When dealing with a small number of community solutions, CatComm was able to coordinate translation with emails. When a greater number of OSAT sites, more languages and more content are added, this methodology demands both automation of task assignment and enormous numbers of translators. One method of recruiting those able to do translations is through the use of service learning.

Virtual Service Learning

Service learning is “a teaching method, which combines community service with academic instruction as it focuses on critical, reflective thinking and civic responsibility. Service-learning programs involve students in organized community service that addresses local needs, while developing their academic skills, sense of civic responsibility, and commitment to the community” (Campus Compact, 2000: 17). Recent experiments with virtual service learning, where the community member is an organization contacted through the internet, have proven extremely effective (ter Horst and Pearce, 2008; Pearce and ter Horst, 2008; Pearce, 2009). Students have contributed content to organizations such as Appropedia and Ekopedia through structured course assignments, through independent study and through internships. Appropedia, for example, had very little content in languages other than English until a group of students, through a collaborative project, began to expand the German-language content. At the

time this project began, Appropedia contained only a single German-language article that had been poorly translated, and there were no German language content guidelines. In order to establish the foundation within Appropedia for students and others to begin adding German-language content, a small group of students undertook a one-credit independent study in Spring 2008. These students, including a native speaker of German and advanced American students of German, established the front end of the German area—including the welcome page, help pages and main categories—and translated numerous content articles to create a foundation for German speakers to use Appropedia (ter Horst and Pearce, 2008).

In the same semester, a unit on Appropedia was incorporated into an upper-level German course, German Conversation and Composition. This unit involved a preparatory phase with an introduction to environmental issues in German-speaking countries and discussion of key environmental concepts, such as “sustainable development,” “poverty reduction,” “international development,” “appropriate technology,” and other vocabulary related to these issues. The students then chose an article featuring appropriate technology to translate from English into German, engaged in peer editing of their translations via the Appropedia website, then gave an oral presentation and wrote a paper on aspects of the project that contributed to poverty reduction, sustainability, and the development of appropriate technology (ter Horst and Pearce, 2008). Such a unit can be easily adapted to other types of courses and to languages other than German. In fact, the development of the German content section on Appropedia spurred the addition of other languages, including French, Italian and Portuguese.

Incorporating translation work with OSAT organizations into academic course work allows students to collaborate with classmates on translations of individual articles and possibly, to develop a number of translated articles around a common theme. For students who are able to work more independently, internships in translation are also available at many OSAT organizations and can provide a way for students to gain valuable work experience while making a difference in the global community. With the merger of Appropedia and Ekopedia, discussed earlier, student interns are involved in the work of moving articles from one site to another and translating articles from English into French and from French into English. Exchange students from countries where French is spoken, including northern Africa, have been an important resource for this project.

These various types of service-learning projects provide many benefits to students. The academic benefits are significant: students involved in the classroom project and in the independent study discussed above increased their linguistic proficiency and used more complex grammatical structures in speech and writing when they were working on the Appropedia assignment. At the same time, the students appreciated the opportunity to communicate about an important topic and to connect with other speakers of the target language (ter Horst and Pearce, 2008). Virtual service learning assignments such as this one provide a unique opportunity for students to connect with the global community of speakers of the target language. In many cases, opportunities for students to work with local linguistic communities are limited because, aside from Spanish and, in some areas of the country, French, very few of the languages taught in the United States have significant communities of native speakers, even in urban areas. In rural areas, the problem is more acute; even access to a Hispanic community might be out of the question. Contact with linguistic communities outside the university setting helps students to deepen their understanding of the target culture and to develop proficiency in the spoken language; virtual service learning allows students' access to a larger, global community of speakers.

Beyond the linguistic and cultural benefits, virtual service learning gives students the opportunity to participate in community service and involve themselves in projects that benefit humanity. Many of the students involved in work with Appropedia had never participated in a service-learning project before, and few felt that their life had benefited humanity in any way before they completed the Appropedia unit. Afterwards, however, many expressed satisfaction that they were able to help spread ideas about appropriate technology to a wider, global audience (ter Horst and Pearce, 2008). One of the most powerful features of virtual service learning is that it enables students to make a positive difference in the world immediately. Although these contributions may be small, they have the advantage of involving students in the global community of people working on appropriate technology. Students involved in this type of project become more aware of the global nature of issues surrounding poverty and the environment.

This type of service-learning project, designed to expand the reach of OSAT on a global scale, benefits not only students but also faculty members and colleges or universities as a whole. Virtual service learning, and the research that accompanies it, makes the work of higher education relevant not only to the local community but worldwide. The connections established with other universities through OSAT

work can also benefit the university's study abroad programs and make the institution more attractive to foreign exchange students, thus increasing its global relevance.

The primary challenge of this method for providing OSAT information for users in Africa is the lack of African language courses offered in North America. In order to spread state-of-the-art OSAT to Africa it is imperative that universities in Africa begin partnering with OSAT sites on language-based service-learning projects. Collaborations between North American and African universities, especially when a student or faculty exchange exists between the institutions, can be useful in bringing experts on African languages and sustainable development in Africa into contact with OSAT organizations. These collaborations will not only spread the content already available in English and French to Africa, but will also provide OSAT advancement created in Africa to the rest of the world.

CONCLUSIONS

Open source appropriate technology has the potential to transform sustainable development in Africa by making available to Africans the projects and processes that are being developed in North America and Europe, and by facilitating the spread of sustainable techniques and technologies, developed in Africa, throughout the world. In order to capitalize on the potential of open source appropriate technology to drive sustainable development in Africa, OSAT, which has been developed primarily in English, must be made available in the continent's many languages. This paper provides potential solutions to this challenge by reviewing the ongoing merger between Appropedia (English) and Ekopedia (French), which provides a model for merging two independent sites in different languages for the benefit of all users; the systematic translations at the Catalytic Communities website, which depends on volunteers to translate content and which has organized the process for delegating the translation of new material through its online "translation network;" and virtual service learning in languages, which permits students to serve local and global communities by translating the content of appropriate technology websites into various languages, thus making available to a greater number of users material that exists only in one language, or in a limited number of languages. These three methods can be used in concert. The OSAT and CatComm sites provide the technical base, a means of organizing information and delegating the translation work that is then completed by students involved in service-learning projects, under the supervision of faculty members. Students making systematic translations between the various sites not only provide a useful service on local and international levels, but also improve their

proficiency in the target language and increase their awareness of global issues and cultures. While service learning is still somewhat neglected at colleges and universities in North America, this pedagogy has been shown to improve student motivation and learning and will, we hope, become more widespread in the future. In order to spread OSAT in Africa, it is imperative that more language programs in North America begin using virtual service learning in the language classroom, and also that universities in Africa begin partnering with OSAT sites on language-based service learning projects. Partnerships and exchange programs between universities in Africa and North America may facilitate and encourage more service-learning projects in language education, and would also assist in linking both African and North American universities with OSAT sites.

ACKNOWLEDGEMENTS

The authors would like to thank all the members of the OSN and in particular, Lonny Grafman, Chris Watkins and Curt Beckman at the Appropedia Foundation; Jean-Luc Henry and Olivier Chaput at the Ekopedia Foundation; and Theresa Williamson and Michael Miranda at Catalytic Communities, for their support and assistance with this work.

This work was supported by a Queen's University Community Service Learning Engagement Grant.

References

- Agyeman, J., Bullard, R. D., and Evans, B. eds. (2003). *Just Sustainabilities: Development in an Unequal World*. Earthscan/MIT Press, London.
- Beckman, C., Watkins, C. Henry, J. and Chaput, O. (2009). "Appropedia:Memorandum of Understanding/Ekopedia." Available:
http://www.appropedia.org/Appropedia:Memorandum_of_Understanding/Ekopedia
- Bgoya, W. (2001). "The Effect of Globalisation in Africa and the Choice of Language in Publishing." *International Review of Education/Internationale Zeitschrift für Erziehungswissenschaft/Revue internationale l'éducation*. 47(3-4): 283-292.
- Campus Compact National Center for Community Colleges. (2000). *Introduction to Service Learning Toolkit*. Brown University Press, Providence, RI.
- Cascio, J. (2006). "Open Source, Development and Design", *World Changing*, January 17, 2006

Available: <http://www.worldchanging.com/archives/004004.html>

Crystal, D. (2000). *Language Death*. Cambridge University Press, Cambridge.

Désilets, A., Gonzalez, L., Paquet, S., & Stojanovic, M. (2006). "Translation the Wiki Way."

2006 *International Symposium on Wikis*, 19. Available:

<http://www.wikisym.org/ws2006/proceedings/p19.pdf>

DuBose, J., Frost, J. D. , Chamaeau, J. A. and J. A. Vanegas (1995). Sustainable development and technology, In *The Environmentally Educated Engineer*, D. Elms and D. Wilkinsin (eds). Center for Advanced Engineering, Canterbury.

Escobar, A. (1995). *Encountering development: the making and unmaking of the third world, 1945-1992*. Princeton University Press, Princeton, NJ.

Forster, P. G. (1982). *The Esperanto Movement*. Mouton de Gruyter, The Hague.

Gordon, R. G. (ed.) (2005). *Ethnologue: Languages of the World, Fifteenth edition*. SIL

International, Dallas, Tex.. Available:

http://www.ethnologue.com/show_language.asp?code=epo

Grimes, B. F. (ed.) (2000). *Ethnologue: Languages of the world*. Summer Institute of Linguistics, Dallas/Texas.

Hashmi, F. and Pearce, J. M. (2009). "Viability of Small-Scale Arsenic-Contaminated Water Purification Technologies for Sustainable Development in Pakistan." In *Sustainable Development*, (in press). Available: <http://dx.doi.org/10.1002/sd.414>

International Rivers Network (IRN) (2006). "Spreading the water wealth: making water infrastructure work for the poor" *Dams, Rivers, & People 2006*. IRN, Berkeley, CA.

Internet World Stats (IWS) (2009). "Internet Usage Statistics for Africa (Africa Internet Usage and Population Stats)." Miniwatts Marketing Group. Available:

<http://www.internetworldstats.com/stats1.htm>

Janton, P., Tonkin, H. and Edwards, J. (1993). *Esperanto: language, literature, and community* (translated by Edwards, J.) . SUNY Press, Albany, NY.

Kogut, B., Metiu, A. (2001). Open-Source Software Development and Distributed Innovation. *Oxford Review of Economic Policy* 17: 248-264.

Maranda, M. (2009). Personal communication February 23, 2009.

Mintz, E. Bartram, J., Lochery, P. and M. Wegelin (2001). "Not just a drop in the bucket: expanding access to point of use water treatment systems." *American Journal of Public Health*, 91(10): 1565-1570.

Morrison, D. E. (1983). "Soft Tech/Hard Tech, Hi Tech/Lo Tech: A Social Movement Analysis of Appropriate Technology." *Sociological Inquiry* 53(2-3): 220-248.

NetApplications (2009). "Operating system market share." Available:
<http://marketshare.hitslink.com/operating-system-market-share.aspx?qprid=8>

Netcraft (2009). "June 2009 Web Server Survey." Available:
http://news.netcraft.com/archives/web_server_survey.html

Nettle, D. and Romaine, S. (2002). *Vanishing Voices: The Extinction of the world's languages*. Oxford University Press, New York.

Pearce, J. M. (2007a). "Teaching Physics Using Appropriate Technology Projects", *The Physics Teacher* 45: 164-167.

Pearce, J. M. (2007b). "Teaching Science by Encouraging Innovation in Appropriate Technologies for Sustainable Development." *Proceedings of the 11th Annual National Collegiate Inventors and Innovators Alliance Conference*:159-167.

Pearce, J. M. (2009). "Appropedia as a Tool for Service Learning in Sustainable Development." *Journal of Education for Sustainable Development*, 3(1): 45-53.

Pearce, J. M., Grafman, L., Colledge, T., Legg, R., (2008). "Leveraging Information Technology, Social Entrepreneurship and Global Collaboration for Just Sustainable Development." *Proceedings of the 12th Annual National Collegiate Inventors and Innovators Alliance Conference*: 201- 210. Available: <http://www.nciia.org/conf08/assets/pub/pearce.pdf>

Pearce, J. M. and ter Horst, E. (2008). "Appropedia and Sustainable Development for Improved Service Learning", *Proceedings of the Association for the Advancement of Sustainability in Higher Education 2008 Conference*. Available:
<http://www2.aashe.org/conf2008/uploads/dl.php?f=36>

Pursell, C. (1993). "The rise and fall of the appropriate technology movement in the United

- States, 1965-1985.” *Technology and Culture*, 34(3): 629-637.
- Raymond, E. (1999). “The Cathedral and the Bazaar.” *Knowledge, Technology & Policy* 12(3): 23-49. Available: <http://www.openia.com/resources/downloads/cathedral-bazaar.pdf>
- Reyes, W., Unakul, S., and Acheson, M. (1978). “Research in the Development of Appropriate Technology for the Improvement of Environmental Health at the Village Level.” 4th Session, *Regional Advisory Committee on Medical Research*. World Health Organization. SEA/RACMR/78.1/5.
- Schumacher, E. F. (1973). *Small Is Beautiful: Economics as if People Mattered*. Perennial, New York.
- Taylor, S. (2008). *Mozilla seeks growth and tie-ups in China market*. Available: <http://www.reuters.com/article/ousiv/idUSSHA1908220080225>
- ter Horst, E. and Pearce, J. M. (2008). “Foreign Languages and the Environment: A Collaborative Instructional Project.” *The Language Educator* (October 2008): 52-56.
- Village Earth (2009). *The Appropriate Technology Library*. Village Earth, Fort Collins.