African Journal of Science, Technology, Innovation and Development

ISSN: 2042-1338 (Print) 2042-1346 (Online) Journal homepage: http://www.tandfonline.com/loi/rajs20

Indigenous knowledge systems – a rich appropriate technology resource

John Tharakan

To cite this article: John Tharakan (2015) Indigenous knowledge systems – a rich appropriate technology resource, African Journal of Science, Technology, Innovation and Development, 7:1, 52-57, DOI: 10.1080/20421338.2014.987987

To link to this article: http://dx.doi.org/10.1080/20421338.2014.987987

African Journal of Science, Technology, Innovation and Development, 2015
Vol. 7, No. 1, 52–57, http://dx.doi.org/10.1080/20421338.2014.987987

Routledge
Taylor & Francis Group

Indigenous knowledge systems – a rich appropriate technology resource[1]

John Tharakan

Department of Chemical Engineering, Howard University, Washington, DC, United States of America
Email: jtharakan@howard.edu

Indigenous knowledge systems (IKS) comprise knowledge systems that have developed within various societies' independent of, and prior to, the advent of the modern scientific knowledge system. IKS from various cultures evolved into broad and comprehensive knowledge systems, such as those from ancient India, China and Africa, that addressed societal and traditional knowledge issues in various fields important to human survival and the quality of life, including agriculture, health and water, amongst others. In this paper, the IKS of India and China, with particular focus on agriculture and health, are examined for methodologies and received understanding, within the context of identifying and evaluating appropriate technologies for development. Although much work on the cataloguing and documenting of IKS has been completed in these two countries, there is a paucity of attention that has been paid to the scientific rationale and technological content and methodologies of these indigenous knowledge systems. In our work, we examine more closely the scientific and engineering rationale of selected indigenous technologies for agriculture and health that demonstrate a holistic approach to development for their societies. The evaluation reveals that many technologies classified as 'appropriate' for developing communities to address basic needs of water, sanitation and agriculture have their roots in indigenous knowledge systems that have survived in some form, albeit at a much diminished level. We demonstrate that these studies potentially provide valuable resources for appropriate technology development. The extensive history of IKS and practices in India and China provide a rich resource and a history of engagement, success and failure that could beneficially inform communities in their search for improved quality of life. The paper concludes with a preliminary evaluation of certain African knowledge systems in agriculture, water and health, and suggests an approach to conservation of these IKS to better inform development for social justice, especially on the African continent.

Keywords: Indigenous knowledge, appropriate technology, indigenous knowledge systems, technology resource; Africa

JEL classification: O18, O30, O31, O32, O55

Introduction: indigenous knowledge systems

Indigenous knowledge (IK) and indigenous knowledge systems (IKS) refer to knowledge and knowledge systems that are unique to a given culture or society (Ellen and Harris 1996). IK and IKS are seen as separate and different from the 'international knowledge system', which includes knowledge generated by universities, research institutions and private firms. International knowledge is knowledge created from modern scientific systems research and development, which are all part of the global scientific and technological enterprise of human civilisation. This knowledge is acquired through formal education and 'book learning' and enhanced by advanced study, internships, training and mentoring that essentially ensure that the extant avenues and processes for scientific knowledge creation, affirmation and dissemination are maintained and continued.

Indigenous knowledge is also recognised as reservoirs of knowledge pertaining to specific geo-cultural contexts. The breadth of indigenous knowledge and what populations' given systems encompass can span the scale from small, indigenous communities to national systems such as Ayurveda[2] (NCCAM 2013) and Unani[3] (NIUM 2013, IIM 2013) and some IKS have extended beyond their local origins to gain worldwide acceptance, such as acupuncture, all in the area of indigenous medical knowledge systems. At the basic level, IKS are the basis for local-level decision-making and include information, knowledge, practices and rituals pertaining to agriculture, health care, food preparation, education and natural resource management within indigenous communities and cultures.

However, IK and IKS are hard to define and categorise because they are politically 'loaded' terms. Defining what and who is 'indigenous' can be a delicate exercise in minimising the diversity of people that would be offended or antagonised by either being referred to as indigenous or not being included in the indigenous category or grouping. Questions raised in the context of claims to indigenousness can include whether somebody was a prior occupant of the land or what length of time a community and its forebears occupied particular regions. As the mix of peoples of different backgrounds and ethnicities becomes greater, the situation becomes more complex and the discourse has to dissect whether only communities that are native, aboriginal or tribal should be included or focused on. Characterising and defining what IKS encompasses, various appellations for this broad well of knowledge have been recognised, proposed and articulated (Warren

1991). These include indigenous technical knowledge (ITK), ethno-ecology, local knowledge, folk knowledge, traditional knowledge, traditional environmental (or ecological) knowledge (TEK) as well as people's science.

Given the diversity of definitions for IKS, there is, nevertheless, a commonly accepted understanding and appreciation of IKS that is based on a shared understanding as well as an epistemic community focused on the same semantic space around the theme of traditional knowledge in various contexts. It is easier to articulate characteristics of IK and IKS and in so doing attempt to operationally define IKS in context. First and foremost, IKS are always local – based in and rooted to a particular place and set of experiences, and generated by the people living in those places. IK is often transmitted orally, or through imitation and demonstration. IK results from practical engagement in everyday life, and is constantly reinforced by trial and error. More importantly, IKS do not often have substantial grounding in explicit theoretical knowledge. Most importantly, IK is empirical knowledge based on practice and has results that are beneficial to the community.

Furthermore, IK is characterised by repetition, aiding in retention and reinforcement of ideas. IK also tends to be constantly changing, being produced and reproduced, discovered as well as lost, as a culture or community prevails and flourishes. IK is *not* static, unlike pre-conceived notions formal academia tends to hold over IKS. IKS also tends to be focused on the broader public community and hence IK is shared to a much greater degree than other forms of knowledge, especially global science with its current focus on intellectual property – hence the coinage of the term 'people's science'. Given that IKS are deeply rooted in local culture, tradition and ritual, IK distribution tends to be socially segmented and clustered, usually asymmetrically within a population. The clustering and segmentation may be age based, gender based or even based in a particular segment of the community that is engaged in that particular effort and activity.

The preservation and survival of IKS is usually through the memories of 'special' individuals – specialists and acknowledged IK knowledge bearers of a given community through experience, ritual or political authority. IK does not exist in any one place or individual – it is mostly devolved from the practices and interactions of people in a community. The organisation of IKS is essentially functional. Most importantly, IK is situated within broader cultural traditions – hence one cannot easily separate technical from non-technical, or rational from non-rational knowledge and practices (Flavier et al. 1995).

The use of IKS in local level decision-making is exemplified in the *panchayathi raj* system of India (Mahesh 2011) that is characterised by the grass root unit of local self-government based with authority in the village council. *Panchayati raj* is identified as an institutional expression of democratic decentralisation in India. Decentralisation of power to the *panchayats* is seen as a means of empowering people and involving them in all decision-making processes. The councils in the *panchayath raj* include elders and locally elected representatives who would be familiar with IKS, especially in connection with land use, agricultural practices and developments to improve local quality of life.

In summary, indigenous knowledge systems are local and community based, providing the socio-cultural information necessary for community survival and flourishing within the community's local environmental, geographical and cultural context. IKS facilitates communication and decision-making within a community. Most importantly, IKS is dynamic, continually influenced by internal creativity within a community, and experimentation by the community in response to their environmental, social, and public health and safety stressors. IKS are also informed through contact with the external, broader world, which provides additional information and inputs into existing processes and practices within a community and allows for the growth and development of IKS.

There is a critical and important linkage between IKS and capacity building for development. IKS address critical quality-of-life and standard-of-living issues. The predominant domains of IK and IKS are focused on 'appropriate technologies', the critical vision of which is empowerment of people to take control of their human, natural and technological resources, aimed at efficient utilisation to improve the quality of their lives. Boon and Henz (2007) have catalogued indigenous knowledge that has relevance for sustainable development in Africa, showing, for instance, that modern intellectual property laws do not adequately protect indigenous knowledge and innovation of traditional healers and traditional medical practitioners in Africa (Mgbeoji 2007, DeWalt 1994).

Appropriate technology

The widespread use of the term 'appropriate technologies' requires a discussion and articulation of what exactly it means for a technology to be deemed 'appropriate'. Indeed, appropriate technology (AT) has always been difficult to define. AT's development and implementation have been a source of debate for some time (Rybcynzki 1991). Nevertheless, over the course of the decades of discourse and discussion about AT and what exactly it constitutes, there has developed some general received knowledge about AT, including that it should emphasise the use of local materials and resources and build skills and capacity within a community. In general, the implementation of AT's tend to be small-scale, relatively labour intensive and usually require only small amounts of capital. This does not exclude large-scale, capital-intensive projects from being considered appropriate, such as for instance, when large-scale technological interventions are implemented through state-sponsored national or regional development projects that are community focused, engage the community in project conception, development

and implementation, and which result in the empowerment of the community. A major tenet of the philosophy of AT grounds it within specific and individual communities – thus AT must be comprehensible, controllable and maintainable without the otherwise high levels of education or training that might be required for the maintenance and operation of more capital intensive, complicated and imported technologies.

Further, true adherence to the ethic of AT requires that local communities must be included at all stages, from technology conceptualisation and innovation to development and implementation. Any technology that claims the mantle of 'appropriate' should also be adaptable and flexible, while eliminating – or at least minimising – adverse environmental impacts (Darrow and Saxenian 1986). An earlier paper (Tharakan 2004) provided a broad overview of appropriate technologies available for water collection, treatment and storage in the context of land reform and more recent versions have focused on appropriate water technologies in the context of public health (Tharakan 2006) and the environment (Tharakan 2010).

Indigenous knowledge systems and appropriate technology

IK and IKS provide communities with ***local*** knowledge, experience and expertise – the received wisdom and 'common sense' – as they pertain to community survival and flourishing in the local environmental and resource context. IKS focus on appropriate technologies that need to be developed and implemented to enable communities to respond positively to their environmental and resource challenges, and to develop and promote processes and practices that ensure sustainable survival. IKS are based in the diverse and widespread human creativity in thinking about communities' environment and about addressing human and social needs. Creativity and innovation was rooted in the capacity of human intelligence to rationally solve problems at the local level with local ingenuity. This diverse human creativity (Goonatilake 1984) was hindered and dominated by the juggernaut of large-capital funded science and technology development that focused not on meeting human needs but instead on producing a product that would maximise profit. The modern scientific knowledge system, tied closely to large capital and colonisation, easily displaced IKS across the globe as rapid industrialisation in the West required more and more resources and raw materials. There was usually no directive on assessment or evaluation of the actual impact of large-capital socio-technological interventions on addressing unmet social needs.

Basic community needs, including appropriate shelter, clothing, water, food, energy, healthcare, education and information and communication technologies, form the complex of modern civilisation's necessities that must be sourced and provided for any community to survive, prevail, flourish and endure. Appropriate technologies have been, and will continue to be developed by communities to address these needs. The measure of a technology's appropriateness is tied to how well and how sustainably that particular technological intervention and practice is implemented to address the targeted community need.

It is useful to examine a range of appropriate technologies that address these fundamental needs and investigate how these can be incorporated into technologies that the community is interested in and committed to engaging with to promote principles and practices that enhance sustainability for local communities.

There are plentiful examples of appropriate technologies that exist and are being utilised and applied that stem from indigenous knowledge. An excellent example is the application of the neem tree in various aspects of rural life, ranging from health to agriculture (National Research Council 1992). Another example is the use of turmeric in its numerous applications from health to animal husbandry (NCCAM 2012). These examples of IK have larger connections and have been observed in multiple communities and regions, and can also be seen as more local in level. On a more expansive social scale, the belief in and use of alternative medical systems provides pertinent examples, including Ayurveda, acupuncture, and Unani (CIKS 2011).

The ancient knowledge system of *vrikshaturveda,* which advocates agriculture with only natural inputs, frowns on the use of pesticides and inorganic fertilisers, which have numerous adverse consequences (Natarajan 2003). Instead, in *vrikshaturveda*, agricultural inputs are created by manipulating traditional agricultural products and outputs. Thus a plant foliar spray as well as an insecticide and pesticide are produced from a concoction consisting of cows' urine and dung mixed with yogurt, milk and *ghee* (clarified butter). IKS does not only apply to health and agriculture. It is also pertinent to the management of resources within communities. Thus, the water harvesting systems that have been developed recently have their origins in age-old and well established practices for the collection and storage of water, as demonstrated by the various water harvesting and storage systems of southern India, including the *Ery* (tank) systems of Tamil Nadu, the *Kere* systems in Karnataka, and the *Cheruva* system of tanks in Andhra Pradesh (Mukundan 2005).

Turmeric provides an excellent example of an indigenous knowledge/practice being undergirded and supported with scientific and clinical investigations that seek to understand the efficacy of turmeric use in traditional medicine with the aim of understanding mechanisms and efficacy of indigenous knowledge/technology practices. Turmeric has widespread uses in both Ayurvedic and Chinese medicine as an anti-inflammatory, to treat digestive and liver problems, skin diseases, and wounds. Some of this efficacy is a result of the powerful antioxidant properties of curcumin, the main component of turmeric, which has also a demonstrated ability to lower enzyme levels in blood to reduce inflammation and platelet

clumping to form blood clots. The vast trove of indigenous knowledge about turmeric and its uses in indigenous medical practice have led to investigation of the use of turmeric for the treatment of a number of medical conditions including indigestion/dyspepsia, ulcerative colitis, stomach ulcers and osteoarthritic pain. Turmeric has also been suggested as a preventative for atherosclerosis, an anti-cancer agent, and as an anti-viral and antibacterial agent (Agarwal et al. 2007). The vast amount of research on turmeric is provoking new interest in this spice's medicinal properties and re-energising appropriate and local medical technologies to address health issues of relevance.

Traditional Chinese medicine (TCM) is an example of an IKS that has been preserved and sustained over the past several thousand years (Hartzell 2005). Nevertheless, TCM as an IKS can be productively analysed and there is an urgent need to develop an understanding of TCM, as it is widely practiced but insufficiently understood from a modern biomedical context (Hsu 1996). Given the pervasiveness of TCM in China and its wide use within communities, it is a rich resource that can be exploited to develop and further public health. Governmental support and endorsement of acupuncture as an effective medical practice has been amply forthcoming from the Chinese government, and that support has been extended in other countries where the scientific and medical rationale behind acupuncture's effectiveness has now been widely accepted as an acceptable component of effective treatment strategies to address diseased states as well as chronic conditions including obesity, addiction and pain (Hsu 1996).

African indigenous knowledge systems (AIKS) have emerged into the academic mainstream over the past decade and begun to occupy a justifiably more prominent place in development discourse on the continent (JAIKS 2002). AIKS have been deemed worthy of investigation and study for their potential to contribute to education for all (EFA) in Zambia. For instance, Benda (2008) has argued formal schooling education, in its current form may not be the right vehicle to deliver EFA goals. Proposed hybridisation of alternative forms of knowledge with formal schooling could address challenges identified; curriculum and pedagogy reforms can enhance achievement of EFA goals, although hybridising AIKS with formal schooling will only become significant if an economic value is added to the AIKS, such as practical skills embedded in AIKS to foster career building, entrepreneurship and apprenticeship.

As Mbeoji (2007) demonstrated, intellectual property law development needs to recognise and address IKS and take into account the contribution of AIKS and other IKS to modern scientific research and the 'intellectual property' that ensues from the technology development that is either a straight copy of extant indigenous knowledge or that relies heavily on the information and knowledge content of AIKS and IKS. For example, the traditional knowledge or medical use of plants (TKMP) is a very large component of AIKS as well as IKS from China (acupuncture), India (Ayurveda, Unani) and other countries, cultures and indigenous peoples the world over. To protect AIKS and IKS from intellectual property theft, it is necessary to grant legal effect to the existing indigenous protocols for the protection of the knowledge possessed by innovative native healers. It is insufficient to simply tinker with the dominant regimes of intellectual property, which perpetuate the colonial mind-set that indigenous peoples did not have autochthonous and effective legal regimes for the propagation, transfer, sharing, and alienation of knowledge. It is not too late in the day to accord native healers the legal cover for autochthonous and familiar protocols by which they have protected, transmitted, and improved upon their knowledge for thousands of years (Boon and Henz 2007).

Gopalakrishnan (2009) examined the significance of India's ancient knowledge systems in contemporary life, drawing on India's rich tradition of intellectual inquiry, and a textual heritage that goes back to several hundreds of years. In an attempt to probe how India's knowledge systems may become the foundation for future research, she shows that there is solid government support for this through the National Mission for Manuscripts, India from 2003 to 2008. The paper also probes issues relating to the access, documentation of manuscripts and how sharing and dissemination of information can be facilitated through the appropriate use of digital technology (Balasubramanian 1987).

IKS systems have a holistic approach that is very different from the compartmentalisation models with the separate 'silo mentality' and 'breaking things down' approach of modern scientific and technological knowledge systems. Indigenous knowledge systems offer a rich source of local know-how and built capacity that can provide the information and knowledge capability to address community resource and survival issues in various contexts. This is especially so within the context of a developing country economy that has not sought expertise from indigenous talent.

As Goonatilake (1984) has so clearly documented in his comprehensive work on 'third world' science, creative and sophisticated solutions were implemented using indigenous know-how and technology for various problems, ranging from agriculture to health and from energy to the environment. In order to preserve these IKS and enable them to have meaning, impact and sustainability for developing communities, knowledge management (KM) programmes at the national level need to be established that can serve numerous functions. These KM programmes can first provide an IKS resource development function by providing a clearing house where IK on agriculture, natural resources management, food systems, traditional medicine and health systems, and arts and crafts can be collected, compiled, documented and disseminated in focused and pertinent ways to assist communities in need.

Nations should endeavour to develop institutes, departments, and programmes that are enabled and empowered to conduct inter-disciplinary research on indigenous knowledge systems, specifically focused on those knowledge systems which would have the most meaning and impact within national, local and community contexts. Indigenous communities should be included in education and research efforts from the very beginning in these IKS preservation, research and development activities. Interdisciplinary research and partnerships must also engender efforts, perhaps in synergy with state-sponsored programmes or multi-lateral agency-funded programmes, to transfer indigenous knowledge systems to communities that need them; these should be seen as the initial steps in a committed long-term effort to promote the sharing and exchange of such knowledge within countries and the broader global community.

Academic efforts must link education, research and practice by facilitating outreach and collaboration between researchers and practitioners of indigenous knowledge systems, and in the process work to establish district, regional and community level indigenous knowledge centres wherever under-served communities exist across the globe. These community-based centres would work to popularise and spread the use of indigenous knowledge through print and electronic publications and workshops and community demonstrations. These efforts should be paralleled at national and international levels through seminars, workshops, and conferences. As these efforts are initiated and developed, IKS can become integrated into national development knowledge resources and eventually IK may become the reflexive resource that communities first seek out for a tool chest for problem solving.

Conclusion

In conclusion, it is clear that 'western' scientific knowledge and technology development and implementation have been receiving increasing criticism for the inability of the socio-technological system developed to address basic needs such as water, sanitation and energy broadly and equitably across the globe. Although many examples have been presented of the failure of large-scale projects, a specific case in point in Africa that deserves mention is the Bakolori Dam in Nigeria (Mohamed 2002), a large-scale state intervention that sought to bring 'development' to the Sokoko State in north-west Nigeria back in 1978. Unfortunately, the impact 35 years later has not been promising, and is one more 'white elephant' of development that did not bring the stated and hoped for benefits to the large swathe of communities it was supposed to assist. While large infrastructure development projects are clearly needed and have a place, indigenous knowledge, local technology and experience must be given an opportunity to address issues at appropriate scales. At the same time, it is also clear that indigenous knowledge systems are often over-optimistically presented as complete, independent and viable alternatives to conventional capital intensive, multilateral agency prescribed infrastructural development. Following Balasubramaniam (1987), IKS are neither simple nor primitive and can be sophisticated and appropriate for the context, and should not be ignored or devalued as a resource.

Given the global water and sanitation situation and the miserable state of community development and poverty eradication, there is a clear need for fresh approaches. This might include a more effective and creative interaction and interchange between indigenous knowledge systems and modern international scientific knowledge systems. We must critically examine, assess and evaluate the strengths and weaknesses of both scientific and indigenous knowledge systems, focusing on a comprehensive documentation and assessment of indigenous knowledge-based technologies that have the potential for significant impact in development. This comprehensive documentation effort should also include categorisation activities that will identify those technologies that are appropriate and relevant to local communities. These documentation and assessment efforts will lead to outcomes that will provide researchers and practitioners of appropriate technology guidance and ideas from the indigenous knowledge systems being studied. A substantive and critical component of appropriate technology and socially relevant computing should be to make sure that mainstream scientists and people with local knowledge work together to improve agricultural and natural resource management systems and sustainability.

The incorporation of IKS into the database of resources relevant to the initiation and implementation of appropriate technologies for sustainable development should be a critical focus of government knowledge creation and management efforts. Engagement in this process of documentation, evaluation, assessment and adaptation of IK and IKS into nationwide and community efforts would be a natural outgrowth of governmental emphasis on sustainability and community uplift while contributing substantially to capacity building in the country.

Notes

1. A version of this paper was presented at the 5th Int'l Conference on Appropriate Technology, Pretoria, South Africa, 20–24 November 2012.
2. Ayurveda ('the complete knowledge for long life') or Ayurvedic medicine is a system of traditional medicine native to India and a form of alternative medicine.
3. Unani-tibb or Unani medicine also spelled Yunani medicine (*Yūnānī* in Arabic, Hindi-Urdu and Persian) means 'Greek medicine', and is a form of traditional medicine widely practiced in South Asia.

References

Aggarwal B.B., Sundaram C., Malani N. and Ichikawa H. (2007). Curcumin: the Indian solid gold. *Advances in Experimental Medicine and Biology* 595: 1–75.

AIKS (2002), *African Journal of Indigenous Knowledge Systems* 1(1).

Balasubramanian, A.V. (1987). Is indigenous technology simple? *Patriotic and People Oriented Science and Technology Bulletin* 11: 45–57.

Benda, D. (2008). Education for all (Efa) and the 'African indigenous knowledge systems (AIKS)': the case of the Chewa people of Zambia. PhD Dissertation, University of Nottingham.

Boon, E.K. and Hens, L. (eds.) (2007), *Indigenous knowledge systems and sustainable development: relevance for Africa.* Delhi, India: Kamla-Raj Enterprises.

Center for Indigenous Knowledge Systems (2011), Available at http://www.cfiks.org/ [Accessed 23 September 2011].

Darrow, K. and Saxenian, M. (1986), *Appropriate technology sourcebook.* Stanford, CA: Volunteers in Asia.

DeWalt, B.R. (1994), Using indigenous knowledge to improve agriculture and natural resource management. *Human Organization* 53(2): 123–131.

Ellen, R. and Harris, H. (1996), Concepts of indigenous environmental knowledge in scientific and development studies literature: a critical assessment. East-West Environmental Linkages Network Workshop 3, Canterbury, 8–10 May 1996.

Flavier, J.M., Jesus, A. de, Navarro, C.S. and Warren, D.M. (1995), The regional program for the promotion of indigenous knowledge in Asia. In Warren, D.M., Slikkerveer, L.J. and Brokensha, D. (eds) *The cultural dimension of development: indigenous knowledge systems*. pp. 479–487. London: Intermediate Technology Publications.

Goonatilake, S. (1984), Aborted discovery – science and creativity in the Third World. London: Zed Press.

Gopalakrishnan, S. (2009), Manuscripts and Indian knowledge systems: the past contextualising the future. 3rd International UNUESCO Conference.

Hartzell, M. (2005), Making sense of indigenous knowledge systems: the case of traditional Chinese medicine. *Southern African Linguistics and Applied Language Studies* 23(2): 55–175.

Hsu, DT. (1996), Acupuncture – a review. *Regional Anesthesia* 21(4): 361–370.

Mahesh, A. (2011), Panchayathi Raj system: a historical persepective. Available at http://shodhganga.inflibnet.ac.in/bitstream/10603/2392/11/11_chapter%203.pdf [Accessed 10 September 2012].

IIM (2013), Institute of Indigenous Medicine, University of Colombo; http://iim.cmb.ac.lk/unani [Accessed 4 January 2014].

Mgbeoji, I. (2007), African indigenous knowledge systems and patents: is the patent system relevant to the native healers of southern Nigeria? In Boon, E.K. and Hens, L. (eds.), *Tribes and Tribals, Special Volume* 1: 77–92. Delhi, India: Kamla-Raj Enterprises.

Mohammed K.Y. (2002), Development and challenges of Bakolori Irrigation Project in Sokoto State, Nigeria. *Nordic Journal of African Studies* 11(3): 411–430.

Mukundan, T.M. (2005), *The* Ery *systems of south India – traditional water harvesting.* Chennai: Akash Ganga Trust.

Natarajan, K. (2003), *Panchagavya – a manual.* Goa: Other India Press.

National Research Council (1992), *Neem: a tree for solving global problems*. Washington, DC: National Academy Press.

NCCAM (2013), National Center for Complementary and Alternative Medicine, National Institute of Health, Washington, DC; http://nccam.nih.gov/health/ayurveda/introduction.htm [Accessed 14 January 2014].

NCCAM (2012), National Center for Complementary and Alternative Medicine, National Institute of Health, Washington, DC; http://www.nccam.nih.gov/health/turmeric/ataglance.htm [Accessed January 2014].

NIUM (2013), National Institute of Unani Medicine, Government of India, Bangalore, India; http://www.nium.in [Accessed 14 January 2014].

Rybcynzski, W. (1991), *Paper heroes; appropriate technology: panacea or pipedream*. New York: Penguin.

Tharakan, J., (2004), Appropriate technology and water availability and use: impact on and implications for land reform. In Trimble, J. and Mhlanga, S. (eds), *Proceedings of the 1st International Conference on Appropriate Technology, 15–17 July 2004*. pp. 97–104. Bulawayo: National University of Science and Technology Press.

Tharakan, J. (2006), Appropriate technologies for water use and conservation in public health. In Muchabayiwa, B., Trimble, J. and Dube, S. (eds.), *Proceedings of the 2nd International Conference on Appropriate Technology, 12–15 July 2006.* pp. 87–92. Bulawayo: National University of Science and Technology Press.

Tharakan, J. (2010), Appropriate technologies for water and sanitation,' in Dzidzeniyo, V., Hansen, E. Fortunak, J. Tharakan, J. and Trimble, J. (eds.), *Proceedings of the 4th International Conference on Appropriate Technology, 24–27 November 2010.* pp. 5–12, University of Ghana, Accra, Ghana.

Warren, D.M. (1991), The role of indigenous knowledge in facilitating the agricultural extension process. Paper presented at International Workshop on Agricultural Knowledge Systems and the Role of Extension. Bad Boll, Germany, 21–24 May 1991.