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Chapter 7

Indigenous Knowledge Systems for Appropriate Technology Development

John Tharakan

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Abstract

Indigenous knowledge systems (IKS) comprises knowledge developed within indigenous societies, independent of, and prior to, the advent of the modern scientific knowledge system (MSKS). Examples of IKS such as Ayurveda from India and Acupuncture from China are well known. IK covers diverse areas of importance for society, spanning issues concerned with the quality of life - from agriculture and water to health. The IK resident in India and China have high relevance to rural life, especially given the level of engagement with agricultural and health technologies. The goal is to establish a heuristic whereby IK can be reviewed and evaluated within particular contexts to determine if the IKS can lead to the development of appropriate technology (AT) addressing that need sustainably. Although much work on cataloguing and documenting IKS has been completed in these two countries, a paucity of attention has been paid to the scientific rationale and technological content of these IKS. Evaluation of many indigenous technologies reveal that many of these technologies can be classified as 'appropriate', focused on basic needs of water, sanitation and agriculture, and many have origins in IKS that survived. Thus, IKS must be validated, exploited and integrated into AT innovation and development.

Keywords: indigenous knowledge systems, modern scientific knowledge, appropriate technology, sustainable development

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1. Introduction to indigenous knowledge and systems

Indigenous knowledge (IK) and indigenous knowledge systems (IKS) refer to knowledge and knowledge systems that are unique to a given culture [1]. Indigenous knowledge can be differentiated from the modern scientific knowledge system (MSKS) and international knowledge systems. The roots of MSKS rest on scientific research conducted and generated in institutions of higher learning such as universities and research institutions. MSKS can be seen as a component of society, part of the scientific and technological advancements of humanity; this knowledge cannot be orally garnered or obtained through anything but rigourous academic study. It is propagated through advanced study's institutes, graduate research and education, including internships and training workshops and modules. What should be understood most clearly about the MSKS is that it is self-perpetuating, where the models for training and development and career advancement all involve the reinforcement of existing systems of research and knowledge propagation and development. Nevertheless, there are examples of indigenous knowledge systems that have survived and even thrived despite the challenges brought up through the MSKS such as *Ayurveda* [2] and *Unani* [3] and even acupuncture, which is basically an indigenous Chinese medical knowledge system. The strength of IKS can be seen in how these three systems have gained acceptance in various contexts, including the National Institute of Health establishing centres of research and study for both acupuncture and *Ayurveda* in the United States, as well as various governmental research centres that have been established by the Indian government, for example, to research *Unani*.

At its most elemental level, IKS can be considered the foundation upon which local communities make determinations about local issues. These decisions pertain to various areas of endeavour, including water and other resource use, conservation and management, agriculture, health care issues, as well as providing information and public outreach and education within a local community.

The major problem with indigenous knowledge and indigenous knowledge systems reside in the difficulty encountered in establishing what constitutes 'indigenous' in particular social, geographical and cultural contexts. The difficulty for a society to come to agreement on what and who is indigenous can be quite high, especially because of establishing a socially and culturally accepted identification of what constitutes the indigenous groupings within a given country or region. The conflict can range from groups that desire to be recognized as indigenous to groups that find paternalistic offense in that identification. Global transcontinental migration drives the mix of peoples of different backgrounds and ethnicities towards greater complexity and the discourse has to dissect whether only communities that are native, aboriginal or tribal should be included or the scope expanded to include other types of residents or migrants. The process of classifying and providing tangible examples of indigenous knowledge systems, researchers, educators and practitioners have developed a plethora of terms that can be linked closely to IKS [4]. These include such labels as traditional knowledge (TK), indigenous technical knowledge (ITK), folk and local knowledge, environmental or ecological knowledge (EK), and sometimes it has also been called people's science.

Despite the multitude of terms used to identify IKS, there are generally accepted and received notions of what IKS comprise, specifically around the space of traditional knowledge in

diverse cultural surroundings and geographical spaces. Thus, what is helpful is developing operational and characterizing ideas of what IK is, how it is developed, and how it grows as a knowledge system within a particular cultural space.

The main characterizing feature of an IKS is that it is locally based, grounded in a particular culture and geography. The oral tradition is strong in IKS, most of the knowledge being passed on orally, and through mimicry and practical application. In general, IK can be considered the cultural and technological product, or knowledge product, from a society or culture's interaction and engagement with daily living. Theoretical grounding is not IKS's hallmark—that is, the foundation of the MSKS. On the other hand, IKS is developed through daily engagement and through trial and error to see what meets a particular community's needs.

The notion of the static nature of IK has been disproved through numerous examples showing how IK can be changing continuously, especially as a culture or a community develops and grows, and is subject to changing environmental, cultural, physical and economic stressors. Because of its oral traditions, IKS tend to be more transparent and openly accessible to communities. Intellectual property is not a strong point in the IKS ecosystem—knowledge is supposed to be shared for the benefit of the community and not for private gain. As described earlier, IKS are grounded in a specific local culture and as such tend to be distributed through a given community according to different bases; IK can be quite asymmetrical dispersed in a given community. The bases can be age, seniority, gender, or sometimes based within a particular community sub-group or segment that focuses on the particular activity the IKS is integral to—such as, for example, river keepers and water masters clustered around rapine communities focused on water treatment and conservation.

IKS is often maintained and propagated through community members who are experts recognized and accepted as such by the community. This standing may obtain from political authority, particular ritualistic standing an individual may possess, or simply from being the most respected authority with the most experience and acknowledged as such within a particular community. In terms of knowledge organization and management, indigenous knowledge is broadly seen as based in its function, which may include both technical and non-technical aspects within a particular field of application [5].

An excellent illustrative example of IKS being employed in decision-making at the local level is the *panchayathi raj* form of local government that involves all stakeholders at the grass roots level in governance decisions at the village level [6].

To summarize, indigenous knowledge and indigenous knowledge systems are based in communities at the very grass roots level; this knowledge provides the critical socio-cultural capital that is essential for communities to not only survive but also to go beyond and flourish within the given contexts of that community's geography, environment, culture and economy. At the same time, IKS is not static—it changes as is required and in response to the various stressors that a community faces, including environmental, social, public health and safety; IKS is also informed through external interchanges and interactions that any community undergoes through trade, exchange and other cross-boundary type interactions.

Given the importance of IKS to a community's survival and flourishing, these knowledge bases and systems are critically important for capacity building within a community. This

capacity building takes the form of development of appropriate technologies (ATs) to sustainably address the challenges that a community may be faced with [7-9].

2. Appropriate technology

Before being able to relate indigenous knowledge and IKS to appropriate technology (AT), it is important to clearly define what an 'appropriate' technology is, something that has been quite difficult to do and has been the source of much controversy [10]. There is some consensus that has emerged from the various discourses, however, on the operations and manifestations of technologies that have been deemed appropriate, despite many accepted notions of AT being brought into question [11]. Perhaps most important for AT is the underlying philosophy and ethic that focuses on empowerment of communities at the grassroots through the development and implementation of appropriate technologies that address basic needs of clean air, water, shelter, safe and nutritious food, relevant education, and pertinent information and communication technologies among other needs. Some of the tenets generally applicable to ATs include: require little capital, utilize local materials and resources, be relatively labour intensive, be small scale and be affordable. Nevertheless, there has recently emerged the notion of micro-AT and macro-AT, challenging some of the previously mentioned tenets of AT. It is clear that many long held presumptions about AT are now being debated and questioned. AT philosophy does emphasize grounding in specific communities, implementation within the constraints of local community-specific socio-cultural and geographical contexts. Perhaps most important, the end result of development and implementation of ATs within communities must result in building community capacity and empowering the community at the local grass roots level [12–14].

The most critical feature of the appropriate technology ethic speaks to the holistic inclusion of the local targeted community in the entire development process. This has to begin with the actual technology conceptualization stage, going on right through to technology innovation, development, implementation and execution, followed by monitoring and evaluation. Any technology that claims the mantle of 'appropriate' should also be adaptable and flexible, while eliminating adverse environmental impacts [12, 13]. An earlier paper [13] provided a broad over view of appropriate technologies available for water collection, treatment and storage in the context of land reform and a more recent version [14] updated appropriate water technologies in the context of public health.

3. Indigenous knowledge and appropriate technology

For a community to survive and flourish, elementary community necessities for survival such as clean water and air, safe and healthy food, renewable energy, accessible and affordable healthcare, relevant and topical education as well as information and technology needs, must be satisfactorily met. The focus of appropriate technologies being developed across the

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planet is the development of sustainable technologies to satisfy these fundamental needs. Communities focus on the development of the technologies appropriate to the satisfaction of these community needs. Often, it is the indigenous knowledge of these communities that was the basis for the community's technological development.

A launching point for the analysis of how indigenous knowledge and IKS might contribute to the development of appropriate technologies would be to address these identified needs. More importantly, after identifying relevant and applicable needs, IKS that include appropriate technologies for these targeted efforts must be identified through engagement of the local community. A broad and diverse spectrum of appropriate technologies can be called upon as a resource base, allowing communities to self-select and focus on those areas that are of critical immediate need for the community. This drawing from IKS for the development of ATs will promote and enhance sustainability practices and principles within the community.

Numerous and diverse examples exist of appropriate technologies that are being implemented and practiced that originate in indigenous knowledge. The application of the prolific and multifaceted neem tree in a broad array of rural sustainability practices such as health and agriculture is an excellent and pertinent example [15]. The spice turmeric has been utilized for centuries by indigenous communities in agriculture, animal husbandry and in health and medicinal applications [16]. Turmeric is also widely employed in the Ayurvedic medical practices, as well; indeed, medical systems for health management such as acupuncture and Unani [17] are examples of IKS on a much larger and deeper social milieu.

Among the rich resources that emanate from IKS, agricultural knowledge and management systems also abound. An example that has particular relevance in the age of synthetic fertilizers and large-scale pesticide inputs into industrial scale agriculture and the various problems that ensue is *vrikshaturveda*. This is an old IKS that focuses on agricultural practices that only call for organic and natural interventions into the farming process and cycle. Thus, in *vrikshaturveda*, traditional agricultural outputs such as cow dung and biomass waste are manipulated to create sustainable and naturally and organically renewable input. Thus, a spray for plants is created out of cow urine, yogurt, milk and *ghee* (clarified butter), and this can displace synthetic pesticide and foliar sprays that might have large negative impacts on the environment [18].

Alongside food and agriculture, water is a critical natural resource that needs to be managed sustainably for the community. Various indigenous knowledge systems have developed water sourcing, conservation, storage and treatment techniques and practices that are sustainable in the context of that local community. As part of the natural hydrological cycle and the seasonal variations in rainfall, indigenous knowledge systems developed such as the various water tank systems of India [19], including the *ery, kere and cheruva* water tank systems of Tamil Nadu, Karnataka and Andhra Pradesh, respectively.

Indigenous knowledge systems are being supported by some governments such as those of India (*Ayurveda and Unani*) and China (*Accupuncture*), with the aim of undergirding the IKS with scientific backing and support. Turmeric, as utilized and implemented in indigenous knowledge practices, lends itself to more fundamental scientific and clinical study in

order to be able to develop an understanding of the mechanisms and processes by which turmeric might be affecting various health outcomes. As something that has widespread use in *Ayurvedic* practices as well as in traditional Chinese medicine (TCM) for numerous ailments. Turmeric has been indicated for use to treat wounds, skin diseases and liver problems. It has also been used extensively as an anti-inflammatory agent, not just in human medicine but in animal husbandry as well. Turmeric's anti-bacterial properties are well known; nevertheless, it is also being investigated for beneficial therapeutic effects in the treatment of atherosclerosis, stomach ulcers, ulcerative colitis and cancer. It has also been employed as an anti-viral agent [20]. The tremendous breadth of research that is now on-going and being initiated to explore the diverse therapeutic potential of turmeric is what can drive the engagement of appropriate technologists with local medical technologies to develop sustainable solutions to public health issues.

Acupuncture is perhaps the most widely known traditional Chinese medical practice that is being reflective of a tradition of indigenous knowledge that has a history of over thousands of years [21]. Although there is broad awareness of TCM, the need to develop a more fundamental understanding of what happens in TCM from a biomedical perspective is great [22]. This need has been addressed by the Chinese government, which has thrown a great deal of resources behind establishment of institutes devoted to the systematic and scientific study of these traditional medical practices. In the west, government research institutes such as the National Institute of Health, have established departments and centres for the study of acupuncture and other non-traditional or non-conventional medical practices. The realization that these traditional medical practices have led to positive health outcomes for diseased individuals who have been so treated underscores the great need for thorough scientific investigation and understanding of indigenous medical practices, ranging from Ayurveda to acupuncture [22].

Although much of the world's attention has been focused on Asia, many African Indigenous Knowledge systems (AIKS) are now being documented and described and are becoming the focus of study, especially as these indigenous practices pertain to development in the African context [23]. Indigenous knowledge from Africa can be a central vehicle by which education for all (EFA) target and goals can be met. It has been argued [24] that formal schooling and regular school education may not be the appropriate vehicle for delivery of the outcomes that are being visualized in the EFA context [24]. Formal schooling, with more traditional educational practices, may need to be integrated with and into these practices to enhance their impact and expand their reach.

Another critical area that needs to be paid attention to is the issue of 'intellectual property (IP)', as it impacts the articulation, development and implementation of indigenous knowledge system-based technologies. It is important to be able to protect the IKS as well as the knowledge bearers and practitioners. To do this, it may be critical to grant legal effect to existing indigenous protocols for the preservation, as well as protection, of indigenous knowledge possessed by native healers. A good first step is to identify indigenous knowledge and to ensure that indigenous knowledge practices must be researched and given due credit when reviewing and considering IP and patents that have their origins in that indigenous understanding [8].

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It is clear that support for indigenous knowledge and systems must emanate from the state. This has been the case in both India and China, and is also emerging as a model that is being employed in other countries such as Ghana, Sudan and Guyana. In India, for instance, there is the National Mission for Manuscripts that seeks to document and catalogue a rich trove of indigenous knowledge that spans the diverse country [25]. The issues that need to be addressed by such institutions include access, documentation and sharing and the incorporation of appropriate digital technologies for the knowledge management, sharing and dissemination [26].

The underlying philosophical approach that most indigenous knowledge systems take is a holistic one. The 'disciplinary' approach, which seeks to break everything down to some elemental constitutive components and study these individually, is the opposite of the indigenous approach, which takes a systemic perspective in its approach to developing solutions to particular problems. The developing world does not lack for this creativity, as Goonatilake [27, 28] has so clearly described: in fact, creative and innovative solutions that were sophisticated in their complexity, integration and effectiveness have been implemented across the centuries in various areas of human endeavour and need, from agriculture and food to health and the environment.

4. Institutionalizing IKS for appropriate technology development

A number of earlier papers investigated the resource-potential of IKS to serve as a repertoire of appropriate technologies [29] as well as the ability to integrate IKS into the conceptualization, research and development of appropriate technologies [30, 31]. These papers provided lessons that will facilitate the integration of best practices for appropriate technology conceptualization, research, development and implementation such as sets of integrated strategies for the management of various resources such as water. The practices are more subject to failure when the civil institutions that may be the vehicle for a technologies development and implementation do not reflect the needs of all stakeholders equitably. Thus, focusing on only agriculture and farmers as the primary water extractors, while not paying attention to water-heavy users such as commerce and industry, would contribute to failure. Nevertheless, the major reason for failure in the development sector is because of the lack of attention that would have been paid to the indigenous knowledge that may have been resident in the community and that could easily have been harnessed to address the problem.

In order for indigenous knowledge systems to be successfully integrated into the development of appropriate technologies, many questions need to be asked and various issues need to be raised and addressed. Has the problem been tackled before? What are the existing institutions that have been addressing this problem before? What are the technologies that are available to address the problems? Are there indigenous knowledge systems of practices that have any relevance to the situation? Is it necessary to bring in an outside-community expert? What are the equity and justice issues that need to be addressed? Will the IKS be able to handle this? Is outside mediation necessary? Who will be benefiting from the technology development and implementation? Who will be bearing the burden? Of cost? Of resources?

These and other questions underscore the importance of a thorough understanding of, and appreciation for indigenous knowledge and indigenous knowledge systems, and how these can contribute holistically and sustainably to the development of communities in a participatory, just, equitable and environmentally non-impactful manner.

5. Conclusion

Modern scientific knowledge is a part of the top-down model of development that is the hallmark of multilateral development agencies that promote MSKS as the only solution to development problems. These agencies' claims for success in terms of improvement of the quality of life across the planet are risible, given the state of human civilization today, where, in most of the developing world, basic community needs remain unmet, despite more than half a century of 'development' engagement on the part of the multilateral agencies, including the World Bank, the International Monetary Fund and United Nations Development Program. This is especially true of rural areas and in the bulk of the overburdened and degraded urban centres. Slums and informal settlements are the urban habitat of rural folk who have been displaced from their environments and thrown into the city. These displacements occur because of infrastructural development projects that are usually state-sponsored, of a large-scale and focused on resource extraction, energy production, transportation and communication. Very little of the infrastructural development is focused locally and hence local needs remain unmet.

This is especially true in the need areas that are critical for survival and flourishing. Clean air and water, adequate clothing and shelter, safe and healthy food, renewable energy, accessible and affordable healthcare, accessible, affordable and quality education, as well as information and communication technologies are the minimum that need to be provided to a society in order for that society to not just survive, but to prevail and flourish. The fact that adequately meeting these needs remains a pipe dream for most developing country inhabitants, especially those in rural areas and congested urban cores, is reflective of the failure of traditional development paradigms and models.

The AT movement from its start, going as far back to the colonial era when Gandhi was in the midst of his non-violent struggle for Indian independence, and continuing on through ATs actual articulation in the 1970s with Shumaker and *Small is Beautiful* has as a rationale for its existence the failures of the traditional development models.

The importance of IKS in this context becomes even more critical and significant. IKS provide tremendous knowledge and technology resource bases that tend to be sustainable, and which also focus on addressing needs in appropriate cultural contexts. IKS already have a head start in terms of sustainability. This recognition has led to proposals for the establishment of Institutes for Indigenous Science and Technology (IIKS, 2012 [17]), and work on the fusion and integration of MSKS with IKS. Anamuah-Mensah and Asabere-Ameyaw [31] promulgate the notion of fusing indigenous knowledge systems education with the regular school curriculum. They have convincingly argued for indigenous knowledge systems and the study

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of IKS, demonstrating how various impacts and outcomes of such engagement. Outcomes include the engagement of teachers, who are community members, in curriculum development that does not devalue indigenous knowledge but focuses on integrating these into the curricula. Using indigenous knowledge can have tremendous benefits in terms of the being able to link disparate disciplines with its intrinsic multi-disciplinarity and interdisciplinary approach. The potential to deal with linkages with the environment, with culture and how these engage with development objectives is there and should be taken advantage of. In this way, IKS and the modern scientific knowledge system are also brought closer together, further strengthening the thematic and disciplinary linkages between IKS and appropriate technology development. This also enables the articulation of the complementarity of IKS and MSKS, even while employing MSKS to validate IKS; the balance between the informal of IKS and the rigour and formality of MSKS is not envisioned as contradictory.

An approach to the integration of indigenous knowledge into the development paradigm, which has been suggested in other forms before [30], is diagrammed in **Figure 1**.

Alongside the use of MSKS to validate IKS, developing country governments serious about sustainable development must engage their institutional and academic scientists and researchers with informal science practitioners. Academic administrators, as well as educational curriculum and program developers have to buy into a new vision, which elevates indigenous knowledge to a position and level where it becomes part of the knowledge resource base available to the field. Building an effective interface between modern scientific knowledge and indigenous knowledge will substantively enhance capacity building capabilities and potential for successful and sustainable appropriate technology development and deployment.

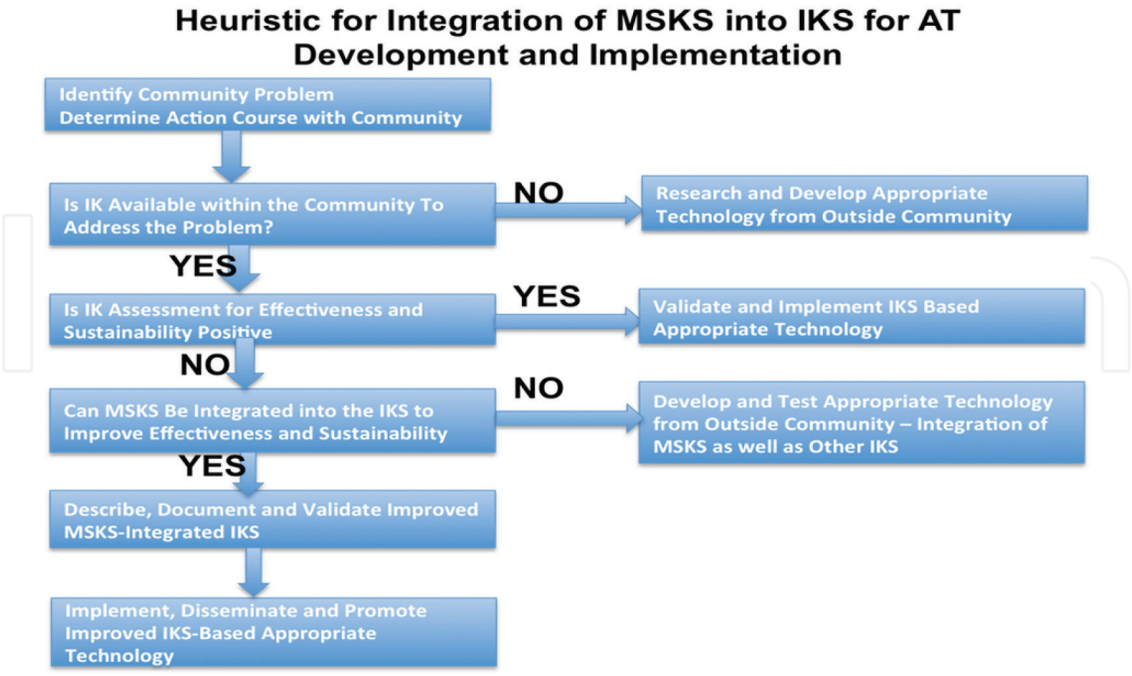

Figure 1. Heuristic for integration of MSKS into IKS for AT development and implementation. (Adapted from Aluma [32].)

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