KNOWLEDGE MANAGEMENT TOOLS AND THE PRODUCTION OF ASBESTOS-FREE ALTERNATIVE BUILDING MATERIAL PRODUCTS IN NIGERIA

[1]C. W. Adegoke, PhD, [2]S. R. Akinola, PhD & [3]M. B. Gasu, PhD
[1]Faculty of Engineering &Director,
Centre For Alternative Energy Research &
Rural Environmental Technologies (CAERRET)
[2]Faculty of Environmental Sciences,
[3]Department of Urban & Regional Planning
[1,2&3] Osun State University, Osogbo, Osun State, Nigeria

Abstract
This paper uses the Institutional Analysis and Development (IAD) framework in tandem with Knowledge Management (KM) tools to demonstrate how the process of transforming polyethylene packaged "pure-water" sachets waste to asbestos-free alternative building material products through a newly-innovated conversion technology/process can have major socio-economic impacts on the economy and environmental well-being of Nigeria and the West African sub-region. This is important because most of the widely used asbestos-based building material products currently in the African built environment are carcinogenic and hazardous to societal health due to the presence of asbestos. Asbestos is a naturally occurring fibrous geologic material which is known to be carcinogenic and its use in countries like the USA and Canada has been totally discontinued and deliberate efforts are always made to get rid of this material from the built environment through demolition of previously existing asbestos-containing material (ACM) products. On the other hand, "pure-water" or packaged water sachets are made from hydro-carbon based polyethylene material which is inert and also non-biodegradable. The newly innovated technology (Polycrete Technology) converts the polyethylene waste into poly-fiber granules by grinding/milling as a replacement material component to asbestos fibers. When poly-fiber is combined with Portland cement, paper and water in an optimal economic mix ratio and left to cure, a new composite material –POLYCRETE – is formed. Polycrete material is viable for use both as Decorative Ceiling Boards and partitioning wall panels required in "Dry Construction" building technology which can aid accelerated mass housing delivery and in bridging the housing deficit in Nigeria presently estimated at about 16 million housing units. The material is environmentally-friendly, weather-proof, water-retardant, durable and cost-effective. The Nigerian Patent for Polycrete is Pending at the Abuja Patent Office under Application No. NG/P/2011/148. In order to make the benefits of this newly-innovated technology to have far-reaching socio-economic impacts on the society, a concerted/synergetic effort needs to be made by all relevant stakeholders in education, research and policy-governmental sectors to take it from the research/pilot demonstration stage (cabinet shelve) to a commercialized level where the products are taken to the man on the streets. A wide-spread adoption and commercialization of this new technology is desirable and requires the application of Institutional Analysis Development (IAD) and Knowledge Management (KM) tools. KM recognizes that scientific knowledge is the key driver in transforming of local raw materials into useful alternative building material products through some developed process technologies for wealth creation, employment opportunities and poverty reduction. This paper establishes that application of KM tools and IAD concepts are needed to take such home-grown technologies from the experimental/pilot stages to commercialization stages for maximal socio-economic impacts and benefits in Nigeria and Africa.

Keywords: *Knowledge Management, Asbestos-Free, Building Materials, Dry Construction, Mass Housing Delivery*

Background to the Study

The widely used asbestos-cement products as building materials contain asbestos, which is known to be carcinogenic and hazardous to human health. The socio-economic cost of disposal of asbestos into the air, soil and water is enormous on governments, industrial workers, users of buildings constructed with asbestos-containing materials (ACM) and residents within industrial belts of asbestos-cement factories. Thus sustainable development requires a search for asbestos-free alternative building material products and its wide-spread adoption in the society through application of Knowledge Management (KM) tools. KM recognizes that scientific knowledge is the key factor in transformation of local raw materials through innovative production technological processes into useful alternative building materials for job creation, employment opportunities, poverty reduction, and wealth creation.

One of the three factors that is important in understanding how a society functions, as identified by Tocqueville (1966), is "the peculiar and accidental situation, which providence" naturally places people. This could refer to the environmental and material conditions that are available to people in their immediate natural environment in fashioning their lives. The type of resources within an environment, to a large extent, other things being equal, determines the fortunes of the people in that environment. The second is "the laws" or institutional arrangements, while the third factor is the "manners and customs of the people". In the context of this discussion, the first factor deals with the relationship between construction sector and development. In sustainable development discourse, there is a consensus among scholars, practitioners and policy makers on the critical role that locally-sourced construction materials play in environmental-friendly development. This, however, requires the application of knowledge to utilize available raw materials, especially wastes to reduce production cost and to enhance environmental health and sustainability.

Knowledge and its application are acknowledged as key sources of growth and development in a knowledge-driven global economy, especially if they are adapted to specific circumstances to be effectively utilized to generate significant opportunities for reducing poverty and promoting sustainable development. Nonetheless, lack of adequate attention to institutional mechanism to effectively adapt knowledge to address societal needs such as in the construction industry, has engendered persistent gaps between theories/research findings and practical realities in Nigeria. Studies have shown that asbestos fiber causes lung function impairment, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis and carcinoma of the lungs, stomach and colon. (Akinola 2008q:56; Akinola and Adegoke 2012). This present paper demonstrates the process of converting polyethylene packaged water sachets waste to useful asbestos-free alternative building material products and examines how this technology can be taken from the research shelve to a commercialized level using Knowledge Management (KM) and Institutional Analysis Development (IAD) principles to impact wide-spread socio-economic benefits to the society.

The paper posits that knowledge on every available waste material should be applied for processing the materials into building materials. The central argument is that: it is what people are doing at home that should form the basis of development in the built environment. It is not enough to learn from abroad; development cannot be imposed from above or from outside. This requires a rethink on the current methods, approaches and strategies of operation in the research institutes such as the universities and the built environment.

The paper designs institutional mechanisms to bridge the gaps between professionals, public officials, scholars, private sector, people-centered institutions, researchers on construction materials and development on the one hand, and between the citizenry on the other hand. The paper charts a course of action that Nigeria needs to take in order to achieve rapid development, specifying the roles of governments, scholars, the private sector and the citizenry in converting resources such as wastes to wealth. This new working relations requires that these actors adopt alternative development strategy that is inward-looking, community-based, people-centered and Afro-centered.

Nigerian Universities, Knowledge Management Regime and the Problematic Development in the Construction Sector

The construction industry requires KM tools to be able to tailor locally available resources to the needs of the country. Otherwise, resources will be exploited to the advantage of external investors and economies. This has led to the persistent exploitation and expropriation of Nigerian resources – human, natural, intellectual – within the last five decades – a situation that has engendered techno-political and socio-economic crises.

Examining the role of knowledge in economic development, the World Bank created a Knowledge Economy Index (KEI) which benchmarks countries' performance on four pillars of the knowledge economy – the favourability for knowledge development within the economic incentive and institutional regime; education and training; innovation and technological adoption; and information and communications technology. KEI (2007, 2009) confirms that African governments do not put enough priority on knowledge application to real life situations that concern the welfare of their citizens and development of their societies. For example, Nigeria scores 115th among 140 countries that were ranked (World Bank, 2009).Many scientific ideas with many potential societal benefits are lying fallow in many of Nigerian higher institutions waiting for implementation. It has also been discovered that some aspects of the curriculum needed to transform the design ideas to marketable products to create employment for youths are missing in tertiary institutions curricula (Fagbohun, 2005). Innovations without implementation, invariably, result into manufacturing bankruptcy. That probably explains reasons for the decline in productivity and low growth rate in manufacturing sector in Nigeria and Ghana (Adejuyigbe, 2005).

Adaptive education requires critical attention on, for example, how to resolve challenges in the construction sector and the built environment. In essence, leaders and scholars as well as governments and universities should find a way in their operations to allow the "meeting of Town and Gown" so that their weaknesses and threats can be converted to opportunities. However, since it seems that governments are not interested in how to harness knowledge, potentials and skills towards socio-economic and political development, it is the contention of this paper that scholars should be prepared to go the extra mile in taking knowledge to the streets and fashion out the possible ways of achieving this.

The argument is that universities and scholars should identify, record and study how to utilize every available material within their environment. The outcome of such exercise can then be used to design home-grown models of resources processing and utilization, which can then be passed on to government functionaries. It is government's responsibility to take knowledge, test them and turn them into tangible actions. Continuous reliance on government in this direction, however, may not lead to fruition. Unlike in Europe and Asia, where Knowledge Management (KM) tools and techniques have been deployed to

distribute essential information and know-how in public and private sectors for efficiency, productivity and information technology (DBSA 2006:ix), Nigerian government has not fully realized the potentials and capabilities of application of KM in fostering endogenous knowledge and management.

For example, the Israelis, though in the desert, used their culture and habits of hearts in causing agricultural revolution and now has become one of the outstanding agricultural innovationists across the globe. Similarly, it is well-known that a country like Malaysia took palm fruits from Nigeria in the 1960's and now has become one of the leading exporters of palm oil/palm oil technology in the world, while Nigeria now is importing palm oil. Industrial wastes from rice and timber productions have been noted for production of building materials in countries such as Thailand, Malaysia and India (Columa 1970 cited in Okereke 2006:15). Whereas studies by Nigerian scholars also show that waste materials can be recycled for the use of construction industry (Okereke and Obeng 1985; Okereke 1988; Edeh et. al., 2012a; Edeh, et. al., 2012b). These materials are usually burnt away in Nigeria only to cause air pollution. This confirms that Nigeria is not applying knowledge generated by its scholars to solve problems of daily existence. This, in the words of the authors, is synonymous to "knowledge-implementation bankruptcy".

For example, Nigeria in the past 50 years has stifled the initiatives of some of its brightest minds, thus halting development in the areas of science and technology (Adeyemi 2011:22). The late Professor Ayodele Awojobi of the Department of Mechanical Engineering, University of Lagos, envisioned and designed the automobile novelty known as Autonov 1 in the 1970s. Professor Cornelius Ademosu of Department of Agricultural Engineering, Federal University of Technology, Akure also suffered the same fate with the design of water hyacinth harvester and subsequently fabricated it at FUTA in early 1990s (Adeyemi 2011:22-24).

Other examples of creative innovations from Nigeria that can be practically implemented to enhance socio-economic development abound:
I). A group of scholars at the Department of Civil Engineering, Universities of Ibadan and Lagos, Nigeria have come up with series of innovative works on: (1). The use of Palm Kernel Shell, Sawdust and Rice Husk Ash as partial/full replacement for gravel sand and cement in concrete (Olutoge, 1995, 1999, 2000, 2009, 2010); (2). Also structural characteristics of Bamboo (Bambusa Vulgaris) as reinforcement in concrete slabs (Alade & Olutoge, 2004; Alade, Olutoge & Alade, 2004; Olutoge, 2006; Olutoge, 2009; Alade, & Olutoge 2002; Alade & Olutoge, 2004; Alade, Olutoge & Alade, 2004); (3) were studied. The Production of concrete using Rice Husk Ash as a partial substitute for cement (Olutoge, 2009, 2010); (4). The Production of concrete using palm kernel shell and sawdust as partial/full substitute for fine and coarse aggregates (Olutoge, 2000, 2010); (5). Bonding characteristics of oil palm stem in concrete matrix (Alade & Olutoge, 2002) and the structural characteristics of oil palm stem as reinforcement in concrete slabs and beams (Olutoge, 2009).

ii). Scholars in the Department of Civil Engineering, Ahmadu Bello University, Zaria and University of Agriculture, Makurdi, Nigeria evaluated the characteristics of palm kernel shell ash (PKSA) to stabilize reclaimed asphalt pavement (RAP) and found that 90%RAP/10%PKSA mix can be used as base/sub-base materials in flexible pavements. This saves cost as recycling of asphalt pavements is a beneficial approach from technical, environmental and economical perspectives. The use of stabilized RAP as sub base and base materials of pavement leads not only to economic solution but also offers a potential use of the RAP treated with cemented materials like sawdust ash, thus reducing the amount of waste materials requiring disposal

and providing construction materials with significant savings over new materials (Edeh et. al., 2012a; Edeh, et. al., 2012b) – Resource Recovery.

iii). Scholars in the Department of Civil Engineering, Ahmadu Bello University, Zaria investigatated into the strength and durability of soil blocks when mixed with Makuba (extract from Locust Beans Tree) and bitumen. They established that Bitumen-Makuba stabilized soil blocks are strong and durable and are more economical than the conventional sandcrete hollow blocks (Salisu and Jibrin, 2011).

iv). When rice husk is properly burnt, the resultant ash (RHA) can be used as a pozzolan to stabilize laterite soil (Okereke and Obeng 1985; Okereke 1988). Tests results on bricks produced from resultant ash (RHA) – cement stabilized soil bricks were quite satisfactory in terms of compressive strength and rate of water absorption (Okereke 1988, 2006:15).

v). Also, scholars in the Department of Civil Engineering in Obafemi Awolowo University had designed machine that converts palm kernel wastes to activated carbon for water treatment to de-colourise, and de-odourise water as well as remove taste, chlorine and heavy metals such as lead, cromium, cadmium and arsenic that are carcinogenic. This machine can be used for industrial water treatment and liquid refining (Ogedengbe et. al. 1985; Adewumi et. al. 2005).

vi). Adopting the principle of 'turning waste to wealth', some scholars in the University of Lagos used palm kernel shells as raw materials in a laboratory scale downdraft biomass gasifier, designed to deliver a mechanical power of 4KW and thermal power of about 15KW (Ojolo and Orisaleye 2010).

All these cases have ended up on the cabinet shelves after they must have been used for promotion. But the case this paper is presenting has gone beyond the shelves to the streets thus impacting positively on the society and serves as eye-opener and lessons for Nigerian Governments. In this era of problem-solving knowledge regime, the onus rests on scholars to fashion new ways to add value to their disciplines or fields to solve specific problems in the society – for example - the construction industry. It is on this note that this paper demonstrates how waste "pure-water" sachets are transformed into building materials for the utilization in the construction industry in Osun State, Nigeria.

Research Methodology

Motivated by the dual need of developing alternative building material products from local raw materials and the need for sustainable solid waste management of polyethylene packaged water sachets waste (which is presently a source of environmental nuisance), an asbestos-free composite material, polycrete, viable for use as ceiling and partitioning boards in buildings was developed. The technical viability of forming a durable composite material from polyethylene fibers (shredded/granulated polyethylene sachets- poly-fibers), Portland cement and waste paper, in optimal economic mix ratio of 1:3 by volume (i.e. one part of cement with 3 parts of fiber) was established with test specimens cast in plastic moulds as presented at RETAV 2009, Obafemi Awolowo University, Ile-Ife, Nigeria.

In order to meet workability requirements (for easy penetration of nails), some amount of paper was also added to introduce some ductility to the mix. Building on the success of initial trials with model specimens, prototype ceiling boards, 600mm x 600mm in size are now being produced. Replicating the mix ratios as established for the model specimens in the prototype production, final product weight of 4.4kg per piece was achieved. It was considered desirable to reduce the weight per product to about 3.5kg so as to be

comparable with light-weight ceiling products made from gypsum (POP). Various combination weights of portland cement, poly-fibers, waste paper, and water were varied with the objective function of producing a 600mm x 600mm prototype with a net product weight not exceeding 3.5kg. This paper presents results of the trials and establishes a minimum weight of 2.5kg cement, 0.5kg poly-fiber, 0.1kg paper and 2.25kg of water to produce a 600mm x 600mm by 5.0mm thick ceiling board with a product weight of 3.25kg. Production process was replicated several times with durable prototypes being formed each time. A comparable Nigerite Asbestos ceiling sheet, 1.2m x 1.2m x 3.5mm thick in dimension (four times the surface area of polycrete product) weighs 8.0kg. In addition to the asbestos-free attribute of polycrete, other obvious advantage of polycrete ceiling board over the Nigerite product is the architectural pattern design embossed on it, making it artistically more pleasing to home owners than the plain version of Nigerite product.

Polycrete material is viable for use as ceiling and partitioning boards in buildings; – it is environmentally-friendly, durable and cost-effective as building construction material and can help in alleviating housing deficit/ poverty in Nigeria.

Materials and Methods

Materials used in this study include:
Packaged Water Polyethylene Sachets Waste
Printers' Off-cut Paper
A Hammer Mill for shredding polyethylene
Portland Cement
600mm x 600mm Patterned Moulds
Water, trowel, Straight Edge and Range
Weighing Balance

Hammer Mill Design Features

In the initial model trials of this product development, it was observed that the fibrous type of poly-fiber bonded better than the granulated type due to more interlocking potential possessed by the former. Therefore, ability to produce more of the fibrous type of poly-fibers instead of the granulated type was identified as a major requirement of the study [1]. The author therefore collaborated with other researchers at the Department of Mechanical Engineering , Obafemi Awolowo University (Koya O.A. & Adegoke, 2009) so as to apply mathematical modeling techniques to determine the optimal machine components (such as, type of hammers, screen aperture size and shape, shaft speed etc.) to produce the right type of hammer mill for producing the fibrous poly-fibers.

Certain design features of a hammer mill as mentioned above, influence the type of poly-fiber particles that are produced. Therefore the aperture size and shape of the screen slots were varied (i.e. round holes versus slits) to find out the shape that produces more of thread-like particles rather than granules. The larger the size of the slots, the faster ground materials will be output. The longer materials stay in the grinding chamber, the greater the tendency for the polyethylene materials to melt thus forming more of granules rather than the fibrous type. An optimal size/shape of screen slots which produced the desired type of poly-fibers was thus obtained and used for the shredding/granulation.

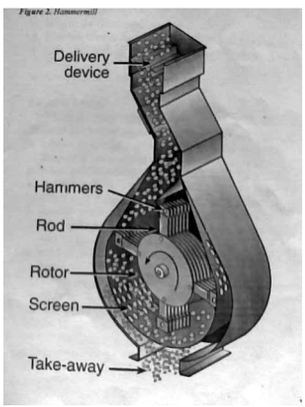


Fig.1 Main Components of Hammer Mill [2]

(Plate 1a)

(Plate 1b)

(Plate 1c)

(Plate 1d)

Plate 1: Processing stages in the casting of polycrete model specimens:
1a-produced strands 1b-cement and strands before mixing; 1c forming of polycrete; 1d-finished product

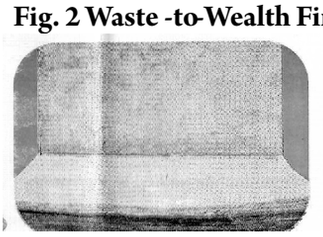
Results and Discussions

Table I: Summary of Prototype Production Trials

Product Components	P1	P2	P3	P4	P5	P6	**P7**	P8
Portland Cement (kg)	3.5	3.0	3.0	3.0	3.0	2.75	**2.5**	2.25
Poly-fiber (kg)	1.0	0.6	0.6	0.5	0.5	0.5	**0.5**	0.5
Paper (kg)	0	0.18	0.15	0.15	0.1	0.1	**0.1**	0.1
Water (kg)	4.0	3.75	3.0	3.0	2.62	2.25	**2.25**	2.25
Product Weight w_P (kg)	4.4	3.95	3.95	3.7	3.7	3.4	**3.35**	2.95
Product Thickness t_p (mm)	10.0	9.0	8.0	7.0	7.0	6.0	**5.0**	4.5
Product Quality	O.K. But too bulky	O.K. But too bulky	O.K. But But too bulky	O.K.	O.K.	O.K.	**O.K.**	Not O.K.– Broke up into pieces; inadequate Bonding

Source: (Adegoke et al 2009)

Fig. 2 Waste -to-Wealth Finished POLYCRETE Products



Installed Polycrete Decorative Ceiling Boards Polycrete Partitioning Wall Panels (Poly-Boards)
(Alternative to Plywood/Gypsum Board)

Referring to Table I and Fig. 2 above, the results of this study have shown that:
A process technology was successfully innovated to produce polycrete material in the manufacturing of prototype ceiling boards of 600mm x 600mm size. Component material weights for Portland cement, poly-fiber, waste paper and water were varied to produce different weights and thicknesses of products. Using 3.5kg to 2.75kg cement yielded products ranging from 10.00mm to 7.0mm thickness with product weights of 4.4 to 3.4kg respectively. The formed products were stable but considered too bulky for ceiling board applications. They may however become relevant in partitioning board applications.

On account of the high "surface area-to-weight ratio" of paper, it was considered desirable to add some paper to enhance ductility/workability of product. Cement content of 2.5kg, 0.5kg of poly-fiber, 0.1kg of paper and 2.25kg of water produced a stable prototype of 3.35kg with a moderate thickness of 5.0mm which compares favorably with competing technologies of asbestos cement and gypsum ceiling products.
600mm x 600mm x 5.0mm polycrete ceiling boards has moderate weight of 3.35kg and a unit weight of 1860.0kg/m3 compared with 1587.0kg/m3 for Nigerite asbestos cement sheet and 2,400.0kg/m3 for standard 1:2:4 concrete respectively.

In addition to the asbestos-free attribute of polycrete, other obvious advantage of polycrete ceiling board over the Nigerite product is the various architectural patterned designs embossed on it, making it artistically more pleasing to home owners than the plain version of Nigerite product.

Typical field installation of Polycrete Decorative Ceiling Boards and Partitioning Wall
Panels (Poly-Boards) are as shown in Fig. 1 above.

The results of this study confirm that Nigerian scholars are capable of generating problem-solving knowledge and ideas that are capable of addressing Nigerian challenges. The required thing is that Nigerian universities should develop these ideas for the consumption of the larger community in Nigeria on a pilot scale, which can be regarded as experiments. The result of such experiments can then be used to develop Technology Demonstrations (DEMO) and models which can be incorporated into teaching modules that can be integrated into Nigerian school teaching curricula as entrepreneurial training. For example, much of socio-economic development in Germany is attributed to the development path undertaken by the country's universities:

The German Democratic Republic has become one of the leading industrial nations in the world. Its success is due, in no small part, to its ability to produce a large, highly trained technical elite through a sophisticated education system closely tailored to the needs of the society (Giles 1978).

It has been found that "socialization" of the university (relating their work more closely to the requirements of the state) or the doctrine of social adaptation of university education is a pre-condition for the technological survival of nations. No modern university can exist in isolation from the society on which it thrives (Aderinto 1985). Given this caveat, the impact of Nigerian universities must be measured by their abilities to improve the well-being of the society and offer practical solutions to contemporary problems of the society such as in the construction development sector.

Addressing the Challenges of Development in the Construction Sector through Polycentric Planning and Problem-Solving Scholarship

Taking the tangible deliverable outcomes of this present research work as an example, and in order to address the challenges of development in the construction sector in Nigeria, it is hereby advocated that the African Development Institutional Mechanism (ADIM) be adopted (see Akinola 2007f, 2008p). ADIM provides enabling environment for the key stakeholders in development – universities, governments, industries, professionals and community institutions to operate in synergy. This model suggests that scholars should view Nigerian realities with intellectual lenses through exogenous variables by factoring the variables into their study, otherwise, such studies will be repeating the error of the past – illusion. Similarly, scholars should generate knowledge through relevant applied research and analysis of existing scholarship focused on overcoming Nigeria's contemporary problems such as in the construction sector. Then they should pass the knowledge on to the political sector (public officials). At the same time, public officials, along with scholars, should implement policies to addressing challenges that are associated with the processing of local resources into building/construction materials.

Linking the work of the university to the needs and requirements of the society is viewed by some analysts as a pre-condition for the technological breakthrough and socio-economic survival of nations. This will serve as an alternative means of using knowledge-based economy to initiate Nigerian socio-economic and technological rebirth and renewal for development. It is in the light of the above that this paper charts a possible course of action that can be taken at reforming higher education system, making it organic, problem-solving and solution-seeking. In this wise, adoption of the African Education Reform Model (AERM) is suggested.

African Education Reform Model (AERM)

African Education Reform Model (AERM) (Akinola, 2010i, 2011l) (Fig. 1a) should be adopted for reforming higher education system and making it organic, problem-solving and solution-seeking (innovative) in the construction sector. This becomes necessary in the light of attendant effects of colonial intellectual syndrome with its consequence of intellectual bankruptcy. The problematics call for a rethink and paradigm shift in the orientations of both the king and the philosopher. It is in the light of this exigency that African Education Reform Mechanism is designed for deliberation and deliberateness/action. The model (as shown in a chart below) suggests that political leaders and scholars should work together when there is a problem to resolve rather than apportion blame when things have gone wrong. In essence, leaders and scholars as well as governments and universities should find a mix of their operations so that their weaknesses and threats can be converted into opportunities.

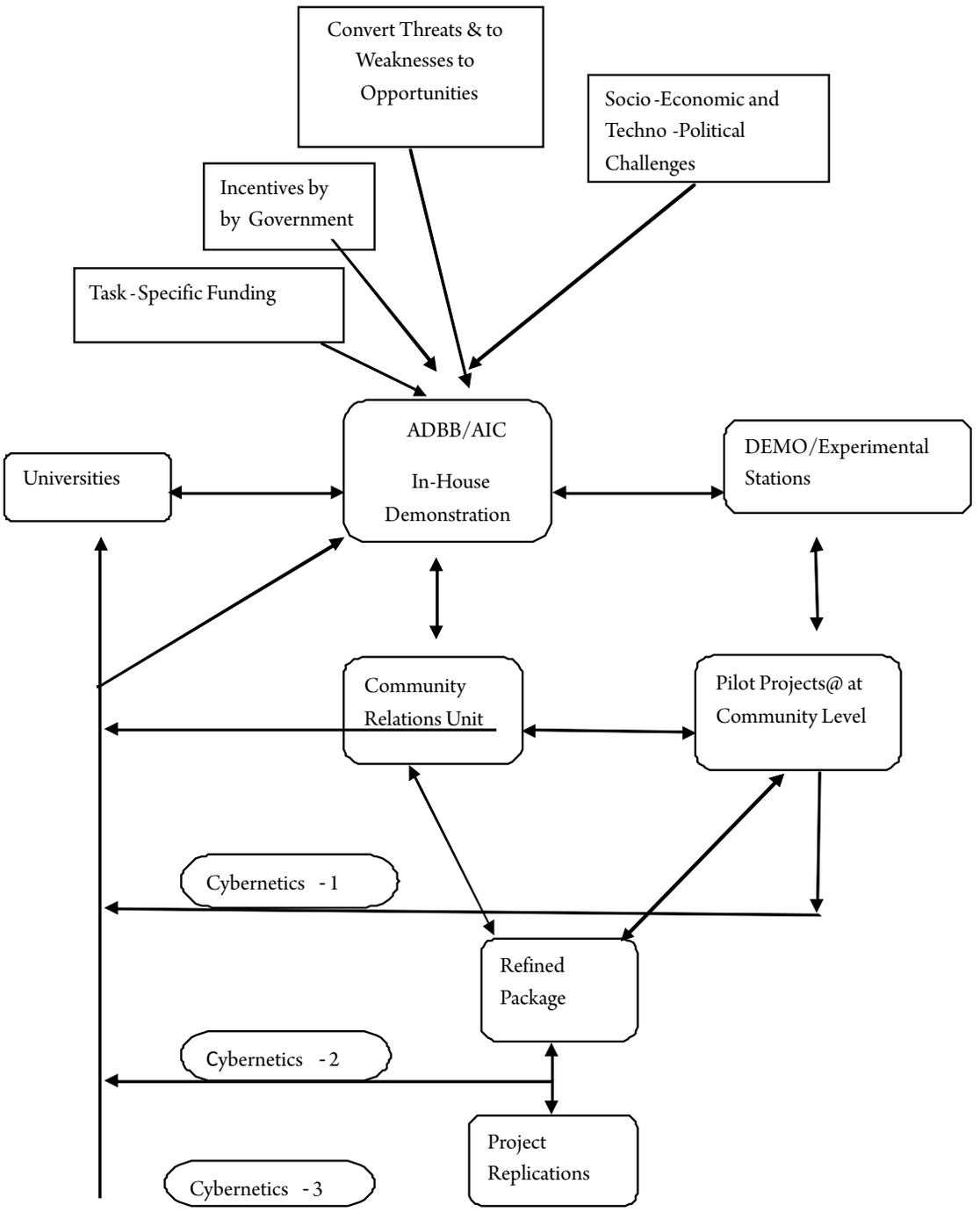


Fig. 2: African Education Reform Model (AERM): Showing the Illustration of the Mechanism of ADBB/AIC in taking theories to the Streets - Source: Adapted from Akinola (2008p:187, 2010i:51, 2011l).

It is the contention of this model that if African scholars want to make their intellectual efforts relevant to African peoples, they must through deliberations and deliberateness, break the old-fashioned limits and set targets, take actions and apply knowledge to solving problems around them. Any effort that is less than this will amount to repeating the error of the past – i.e. illusion and intellectual bankruptcy. Scholars should take the lead by showing the way forward.

In this vein, African Education Reform Mechanism and institutional arrangements that are capable of bridging the gap between the two groups can be achieved through African Development Institutional Mechanism (ADIM) that provides enabling environment for the key stakeholders in development – governments and universities (for details on ADIM, see Akinola 2007f, 2008p, 2009b). ADIM ensures that both public officials and scholars develop smooth working relations. With innovations coming from research scholars who collaborate with robust institutional arrangements, it will be easier for government to increase its presence and relevance at the community level. Training programmes in ministries of science and technology, commerce and industry, works, education, etc., should be executed in the field, in conjunction with working associations on the ground. The trainees should identify specific sites of interests where trainers will demonstrate new ideas to them. Civil servants should spend less time in offices so that their presence can be felt in communities where they are connected with the people. Experiences on recycling of wastes for production of alternative building/construction materials garnered through these contacts with academics should be shared with the community members. Invariably, the locals can be able to generate money from wastes – thus leading to a win-win situation for all stakeholders as both environmental sustainability and economic advancements are enhanced. ADIM will enable scholars and public officials to operate in synergy (as demonstrated in 5 steps – Akinola 2007f, 2010i).

Adopting concepts of African Development Brain-Box (ADBB) (Akinola 2008p:186-187; 2010i) and African Innovation Center (AIC), which plays moderating influence for knowledge transformation and utilization (Fig. 2) will enable knowledge to be adapted to reality through experimental stations and pilot/demonstration projects for example in the construction sector. The Innovation Center will have strong connection with the Raw Materials Research and Development Council (RMRDC) while AIC will have strong community relations such that any innovation coming to it will be quickly translated to practical projects which are demand-driven by the relevant communities where the ideas are needed and can be demonstrated/implemented.

In order to implement these ideas, the first thing that Nigeria and most African governments should do is to increase funding of education. Apart from the general funding that covers salaries and emoluments, and capital projects, task-specific funding in forms of incentives should be directed at scholars who are assigned specific milestone-oriented tasks to find solutions to specific problems in the society such as in the construction sector. For African universities to be organic, they have to learn how to be problem-solving and solution-seeking; constantly operating in synergy with public authorities as well as the people at community levels. This will find practical expression through the establishment of a proposed AIC where ADBB could be operationalized (Akinola 2008p). The findings and experiences gathered from these exercises would, invariably, be useful to reform and transform the educational curricula. At the university and tertiary education levels, constant revision of curricula will have to be dynamically pursued/evolved to reflect the entrepreneurial requirements addressing contemporary specific needs of society and especially of rural and under-served communities.

Conclusion

This paper concludes that the neglect of KM tools in transforming scientific knowledge of locally available raw materials in Nigerian and African communities into practically usable construction/building materials has led to a form of dependency syndrome wherein imported materials abound at the expense of locally produced materials. This is as a result of a high level of dis-articulation between governments, universities, industries and the people, thus culminating into under-development. Unlike in Europe and Asia, where Knowledge Management (KM) tools and techniques have been deployed to generate national wealth and development, Nigerian government has not only neglected the potentials and capabilities of KM but has also relegated to the background the imperatives of endogenous knowledge to development. Instead of applying KM and IAD tools/principles to bridge the gaps between research outcomes such as Polycrete innovation and national development, Nigerian and most African governments have always embraced foreign economic theories, reforms, strategies, models and development programmes such as SAP, IMF etc which were implemented towards national growth over the years, but which have failed woefully to resolve African developmental challenges.

It is the contention of this paper that if Nigerian scholars want to make their intellectual efforts relevant to the society, they must through deliberations and deliberateness, break the old-fashioned limits/set targets and to take actions and apply knowledge to problem-solving in all facets of human challenges and development in order to evolve knowledge-based economies in Nigeria and throughout the West African sub-region. It is on this note that this paper argues that Nigerian leaders have the responsibility of investing knowledge-based intellectual resources in providing enabling environment for their citizens, especially in the application of endogenous and indigenous knowledge to solve contemporary society's problems as well as providing job creation, employment generation and poverty reduction. Apart from the general funding that covers salaries and emolument, and capital projects, task-specific funding in forms of incentives should be directed at scholars/researchers who should be assigned specific milestone –oriented tasks to find solutions to specific challenges in development and in improvement of the quality of life of the society. Consequently, the paper suggests the adoption of African Education Reform Model (AERM) for reforming higher education system in Nigeria and Africa in order to achieve these desirable goals.

The realization of endogenous development such as in the construction sector depends on robust institutional arrangements that can be operationalized in Nigerian/African Innovation Center (NAIC) through African Development Brain-Box (ADBB) concepts for enhancing the utilization of endogenous knowledge in turning knowledge to reality. The findings and experiences gathered from these exercises would invariably, be useful to the reform of educational curriculum which will be focused on both knowledge and national developments. Revised curriculum will enable universities to take appropriate decisions on their programmes, especially on how to use local resources for the benefit of the society and other entrepreneurial endeavors.

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