# CAPACITY BUILDING AND APPROPRIATE TECHNOLOGY:
## Application to Building & Construction in a Developing Economy



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**THEME:**

# A BUILDING MATERIALS POLICY FOR NIGERIA

**SYNOPSIS**

This paper examines the fundamental principles underlying development in terms of building of capacity for production, creation of wealth, and the development of infrastructure as the foundation of sustainable industrialization. Using copious illustrations, it tries to show that Research and Development (R & D) efforts must be geared towards widespread acquisition of technological skills through familiarity with machines (principles and practice – both) as the basis of technological/industrial empowerment and sustainable development. It further argues that, in the construction industry, the perennial search for cheap building materials is misplaced. Emphasis should be placed on the development of high-value, high-performance building components, married with technique-mode building systems and industrial methods for high productivity and cost efficiency.



## INTRODUCTION

The root problem that is ravaging Nigeria is under development. All indications, - poverty, strife, corruption, gross inadequacy of basic services and utilities resulting in stressful living conditions and attendant train of consequences - are merely symptoms.

The problem of underdevelopment can only be solved through continuous and sustained development over time. Any development is sustainable only through the empowerment of the people to produce the goods and services that improves and enhances their

standard of living: in other words, ***the building of capacity for production and creation of wealth.***

Tackling the problem of underdevelopment is undermined by a pervading fallacy in the minds of most Nigerians that their country is wealthy on account of its petroleum resources. All social, political, educational, and economical activities are directed towards the ***distribution of wealth*** with significance on material resource, rather than ***creation of wealth*** with significance of human resource. The most important human resource in the creation of wealth is the resources of the mind: Knowledge, information and skill. The role of R and D is to enhance the transformation of knowledge into know how and information into problem solving skill – i.e ***empowerment to produce***.



**CREATION OF WEALTH**

Creation of wealth has to do with the value that is added in the transformation of material: the value added to cotton in transformation to fabric, value-added to sand (silicone) in transformation to computer hardware; value added to zeros and ones in transformation to computer software. It is the value added to musical notes in transformation to melody. More value is added in the scoring of melody for an orchestral arrangement for a range of musical instruments, more value is added in the orchestral performance of the musical score; more-value is added in the recording of the performance, more value-added in the production, marketing and selling of CDs of the music. The culmination of wealth in all the upstream and downstream musical activities involves several levels of transformation of material: i.e. the wealth

created has to do with the power or capacity for modern musical production and not in the value of musical notes per se.

The point of this illustration is that materials can be abstract or physical, and they have in themselves little value. The evidence in the world today as in all human history is that gold or diamond or petroleum does not make a country wealthy or prosperous. In fact some of the most poverty stricken countries and failed states are those awash in material resources, whereas some of wealthiest countries are whose with a paucity of material resources but with highly developed capacity for production of goods and services.

**PRODUCTIVE CAPACITY**

**While knowledge and information are transferable, capacity can only be acquired. There is therefore no such thing as transfer of technology, for as we shall see, technology and capacity are closely related.** In the production of goods and services different types of skills and several levels of specialties are required. This generally translates into the development of mutually interdependent and complementary capacities.

The basic principles underlying productive capacity can be illustrated with a very simple example as follows:

- Workman at a well with only his bare hands lacks capacity to produce (Water 3meters down in a well has little value).
- Workman empowered with rope and bucket has capacity to produce (Value is added to water brought to ground zero. More value is added to water at altitude 30

meters, which can be distributed over a wide area by gravity).

- Five workmen work the well in relay. Empowered with plastic bucket and rope, two of the workmen are skilled at flipping the bucket such that it hits the surface of the water with an open edge, sinks immediately and is filled with water. The two skilled workmen thus achieve a fairly good man-hour output for their efforts. Three unskilled workmen achieve much smaller output because of the tendency of the plastic bucket to float rather than sink into the water.

***The overall production is thus inefficient and inconsistent (i.e. low productivity) because it is dependent on the varying skills of the workmen. This is "craft-mode" of production***

- A small weight is fixed to the side of the bucket making it to sink as it hits the water. The five workmen deliver a high and consistent output.

***Craft-mode is transformed into "technique-mode" by a method that ensures consistency in production. Technique-mode of production enhances the capacity and productivity of workmen***. Even with the same hardware greater efficiency in productive capacity can be achieved by improvement in methods. Generally, R and D efforts should be directed at the building of capacity by supplanting craft-mode of production with technique-mode.

- A "mallam" down the street mends the rope when as it needs mending, and a handyman goes around the neighborhood mending plastic buckets and utensils.

The production at the well is thus "sustained" by the complement of specialties and interdependent capacities.



- A new management takes over and is applauded at the use of bucket and rope in the 21st century. Directs the replacement of bucket with electric pump.
- Incessant power failure results in considerable disruption of production. Thus the electric pump is grossly underutilized (i.e. low productivity due to low capacity utilization) Management responds by installing a gasoline-powered generator.
- Complete power outage, resulting from a blown transformer in the neighborhood, went on for weeks on end thereby overstretching the capacity of the generator, resulting in frequent breakdown and repairs, resulting in high maintenance costs (in addition to the high capital outlay) resulting in more disruption of production, resulting in less and less productivity.
- A citywide fuel shortage soon escalated into a nation wide fuel crisis. Production spurted along with black market fuel.
- Adulterated gasoline knocked the engine of the generator, production grounded to a halt.

This illustration approximates real life situations in many industries in Nigeria (especially the building and construction

industries). In the particular example, the performance of the pump is not sustainable because the power supply on which it is depended is not sustained. The electric power supply - either through the national grid or the gasoline generator - is not sustained because the complex of industries upon which it is dependent (i.e. industrial infrastructure) is not adequate.

This example illustrates the relationship between productive capacity, interdependent/complementary capacities, sustainability, and productivity.



A complex of interdependent capacities translates in practice into industrial infrastructure (i.e. productive capacity and productivity are sustained and sustainable only upon adequacy of infrastructure). This means that the development of infrastructure is the foundation upon which sustainable capacity is built.

**SUSTAINABILITY AND INFRASTRUCTURE**

A pervading fallacy of popular wisdom in this country holds that we do not have a maintenance culture. But the truth is that in our attempts at modernization, we adopt the "forms" and neglect or misunderstand or misapply the "substance". For example, all over the country, flush toilets are routinely installed in all kinds of buildings, including student hostels. The flush toilet as a hygienic system of waste disposal is premised on sustained running water without which it becomes breeding ground for disease. Which is to say, if you have not acquired the capacity for sustained running water, you have no business with the flush toilet. Attempts to maintain the facilities in working order are bound to fail. The

problem is not one of maintenance but a much more fundamental one of sustainability.

In the 21st century[1] in most parts of the country, capacity for sustained running water is lacking. Does that mean we should do away with flush toilets? Not necessarily. It means that where water from the mains is at premium, it does not make sense to flush toilets with expensive water (i.e. water processed to drinking quality). Wells can be drilled (never dug!) near the toilet facilities, using manually operated drilling auger on tripods. The manually operated pump should always be installed as back up to feed a dedicated water tank for the flushing of toilets.

Some might argue that the manual pump is tiresome as well as tedious. The solution is simple: The bicycle is a perfected and cost efficient technology for harnessing the power in the legs. Couple a bicycle to power the pump, and tedium is thus transformed into adventure.

The digging of wells should actually be banned in this country; the fatality from accidents, both during the digging of the well and usage of well is insupportable. At the other extreme, highly mechanized boring equipment are used for mining underground water at great depths for expensive borehole water supply only a few can afford.

In between the two extremes - the primitive and inefficient; and the capital intensive and unsustainable - there are intermediate systems more appropriate for a wider range of utilities.

## APPROPRIATE TECHNOLOGY

Machines are devices those applications make a task easier by allowing man to do greater work than his capacity by means of mechanical advantage. Widespread familiarity with machinery is fundamental to the productive capacity of a country. In this country most work falls between two extremes – manual labour without enhancement with machines on the one hand, work done with highly mechanized capital-intensive equipment on the other. Which means that most work is done with manual inefficient labour. On the other hand the landscape is littered with abandoned high capital equipment whose value were never recovered. High capital equipment would perform at only a fraction of its capacity where the industrial infrastructure on which its performance is premised is lacking. This burden of wealth destruction is particularly evident in building and construction industries. The widespread use and familiarity with plants and machinery that improve productivity, and methods and techniques that improve workmanship, is the key to the building of capacity for production.

This calls for the development of appropriate and intermediate technology that makes the most efficient utilization of available labour, material and capital. To illustrate these principles, I will use three examples of building and construction practices widespread in Nigeria that demonstrate a vicious cycle of wastefulness, resulting in low productivity and destruction of wealth, resulting in skyrocketing costs of building and construction, resulting in poverty, resulting in unemployment and more poverty . . .

**Wall System:**

Walls are generally constructed using the dry-mix concrete block. The blocks are generally of varying structural strength and textual quality. One reason for this is that even though the blocks are generally produced from mechanized block-making machines, the mixing of water, cement and aggregates is done manually. The diesel engine that powers the machine can actually be used to power a small concrete mixer. The engine is placed between the block-making machine and the mixer where it can alternately power the latter in the intervals between vibrating the concrete. This way, consistency of quality and efficiency of production are achievable without dependence on the varying skills and strength of the laborer for mixing. At the University of Lagos we are presently perfecting a research proposal for simple mixer fabricated from used oil drums.

One of the most significant sources of wealth destruction in the building industry is the waste resulting from construction of blockwall. Due to lack of standardization and modular-coordination of space and structural dimensions, there is much destruction of blocks during construction on site. The 225 mm (9 inch) block does not lend itself to easy standardization of material and dimensions. With the nominal 200mm (8 inch) concrete block, all the spatial dimensions, length, breath and height are denominated in 200 mm. With three types of blocks – stretcher, half and lintel (U) – cutting and patching of blocks can be virtually eliminated on site.

With the use of interlocking blocks, requiring little or no mortar for bonding, the craft-mode of constructing block wall is replaced by technique-mode. The interlocking block is high value added

building component that empowers unskilled labour for better quality blockwall and greatly increased man-hour output.

In order to enhance productivity in the building industry, it is imperative to have a shift of emphasis from development of building materials to the development of high value building components and systems for technique-mode site assembly.

**Suspended Floor System:**

In Nigeria, the suspended floor has for a long time acquired the quality terror for prospective homeowners. The solid r.c. concrete slab system generally adopted for the construction of suspended floors is wasteful from every conceivable standpoint – economy of material, structural efficiency, ease and time of construction. Every student of architecture, engineering, building or quantity surveying is taught the range of alternative lightweight options. But the country, led by its professionals, persists in this wasteful method. A composite system using fired clay pot as fillers in between pre – cast tee joists or instu. r.c. ribs, have simply failed to catch on. One reason is that the clay pot, produced by the large industrial plants are expensive and not readily available – i.e. the system is unsustainable in the Nigerian industrial context. But the problem really has to do with poverty of understanding of first principles and a mental laziness, which despite a profusion of academic qualifications, cannot or would not translate knowledge into problems solving skills.

The concrete block filler is much cheaper and more viable alternative to clay pot filler. Its viability is due to the fact that it can be just another product of the widespread block-making industry. Next door in Benin Republic, block-making industries produce blocks both for wall and floor systems.

At the University of Lagos we had developed and utilized in actual housing projects, a suspended floor system of pre-cast, lightweight, hollow-core r.c. slabs. Embedding bamboo stems during casting produced the hollow-core slabs. The reduction in material and weight of slab resulted in significant reduction in steel reinforcement and cost.

The voided slab was in 600mm pre-cast module, for a 3-meter structural span, weighing about 450 kilograms. The pre-cast slabs were placed on structural walls by a system of handling and stacking equipment that are simple and inexpensive. We have a proposal for an alternative floor system using slender pre-cast r.c. joists (50 x 150mm for up to 6-meter spans at 500mm on centers) grouted composite with pre-cast r.c. planks (50 x 600 x 1000mm). The pre-cast joist and plank weigh about 100kg and 40kg respectively. This makes for easy handling by one or two workmen. An even simpler system of handling and hoisting equipment complement the components as one single harmonized system building. The lightweight composite floor slab is estimated to be cheaper and more convenient than the D.P.C. for construction of the ground floor slab. Apart from the cost efficiency of the system, the labour and material used in back filling are eliminated.

## Handling And Hoisting System

There is nothing that demonstrates the primitive level of our building and construction industries as well as the spectacle of a battalion of laborers precariously negotiating make-shift scaffolding with head pans of concrete, in the casting of suspended slab two stories from the ground. The outright absurdity of the process is better appreciated when analyzed. The concrete in a head pan weighs, 25kg and the labourer weights 75kg. In carrying the concrete up the scaffolding, he is in effect transporting 100kg and traveling 45 meters to deliver 25kg of concrete. ***Empowered with rope and pulley he can transport 25kg load with 25kg effort up 9 meters.***



In fact with a 25kg counterweight and 25kg effort, he can transport 50kg concrete. In addition, the gantry support for the rope and pulley is much simpler, less expensive and much less precarious. With a deferential pulley or chain block, much greater loads (up to 2000kg) can be effortlessly transported, but there arises two problems:

(i) The scaffolding support would have to be much more robust.

(ii) The vertical travel and return time is very slow and tedious.

The travel/return time can be greatly increased by operating the differential pulley with a bicycle. One of our research proposals is for a bicycle-operated differential pulley, mounted on a modular scaffolding tower, for vertical transportation of a whole range of building materials and components on a building site. (See fig. 1 – fig. 3)

## The Culture Co-Efficient Of Productivity

I am requested to deliver a paper on Appropriate Technology for Materials' Production and Utilization. I have chosen instead to emphasis the building of capacity for ***transformation*** of material. This is because, as I have pointed out, the higher the levels of transformation of material, the greater the value added and consequently, the higher the creation of wealth.

Moreover, the theme of the conference is, "A Building Materials Policy for Nigeria". Rather than discuss ***policy***, which has to do with the prerogative government, I will here conclude with a discussion on ***culture***, which has to do with the empowerment of a people.

Culture is a much-misunderstood concept in this country. Culture tends to be promoted in terms of masquerades and young girls presented to dance bare-footed for visiting for foreign dignitaries. I will here discuss culture in its all embarrassing sense as ***"the total pattern of human behaviour and its products embodied in thought, speech, action and artifacts, and dependent upon man's capacity for learning and transmitting knowledge to succeeding generations; culture in the sense of steady improvement in a special line; culture in the sense of the act of developing by education, discipline and social experience".*** (Webster's Dictionary; 1961).

Culture in this sense constitutes the greatest and most powerful tool of learning and creativity given to man (Olusanya, 1993). It has to do with intangibles and subliminal aggregation of knowledge and know how, which, in the participatory interaction of men, jells into

a community of experience. The key element here is **"participation".**

Promotion of appropriate technology should lead to widespread familiarity with machines and linkages between mutually inter-dependent and complimentary industries. The goal is a society that fully participates in its own economy, developing techniques and processes relevant to its own needs.

Archibuild has been successful as a forum for bringing together architects and manufacturers in the building industry. But there is a much more fundamental issue we are not addressing as architects. Architectural conferences in Nigeria are not different from conferences are by engineers or quantity surveyors. Too many architectural seminars and conferences are held where not a single picture or drawing is presented. The academics from the universities come with graphs, the professionals in practice with charts, all accompanied with profusion of words.

Architecture should be the central matter in every important gathering of architects. The annual and bi-annual conferences should be a time for architects to show their works and learn from one another. Talkshops should be replaced by workshops on design to complement exhibition of architectural works. It is the time for awards and recognition; for sharing of ideas and forming consensus as to standards of architectural excellence; for forging of common purpose and common vision. The journal of the Nigerian Institute of Architects should be re-focused as the flagship for showcasing architecture in Nigeria.

The word architect in the original Greek means: **"builder-in-chief"**. It is a more timeless defination than the more common **"master builder"**. And just like the commander-in-chief, the builder-in-chief has overall responsibility for the success of the architectural enterprise. In this matter there is no buck passing. It is therefore important that architects thoroughly understand and be involved in the building process. Architecture has to be understood in terms of several levels of transformation of material - abstract and physical. The building of indigenous capacity for production means that there is greater local addition of value and creation of wealth in real terms.

**References:**


Webster's Third New International Dictionary: London, 1961.

Okunsanya, Olumide: Metaphysics of creativity: In Diversity of Creativity in Nigeria. Ed: B. Campbell et al, Department of Fine Arts, Obafemi Awolowo University, Ile-Ife, 1993. Pp. 317326.