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Innovative construction technology for affordable mass housing in Tanzania, East Africa

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Building affordable housing with adequate structural safety is very important in the developing world. New technology, specifically the Terra Block Fabricator, has the advantage of using local soil and labour to create high quality building blocks. An interesting country in which to examine the potential of this technology is Tanzania because it has had a fascinating history of evolving democratically from socialism to a market economy.

Using environmentally appropriate technology can energize local sustainable economic growth by stimulating market demand for improved housing and raising the standard of living in low-income countries.

Keywords: housing, Africa, construction

Introduction

The Least Developed Countries (LDC's) are experiencing dramatic change. The transformation is both political and economic involving a shift in ideology from government-controlled societies to more reliance on market forces. Tanzania, in particular, has been viewed as a success story in navigating change while maintaining political stability.

Historical Overview – 1950 to 1985

Modern Tanzanian politics began under British rule when the colonial administration encouraged a formal political party system allowing the formation of the Tanganyika African National Union (TANU). Under the leadership of Dr Julius Nyerere, independence for the mainland territory of Tanganyika was achieved in 1961. In 1964, the island nation of Zanzibar united with Tanganyika to form the new country, 'Tanzania'.

While Socialism was the official ideology, politics in Tanzania became a combination of Marxism, Democracy and Socialism with a little bit of tradition and culture mixed in. There was no rigidly defined 'ism', and this has led the country up a unique path to both major successes and failures. A few years after the creation of the Republic, a vision of nationalism and self-reliance was promoted under the auspices of the Arusha Declaration. The Arusha Declaration's core philosophy was to nationalize all areas of agriculture and manufacturing to ensure equal income distribution among the population (Kanaan, 2000). While the ideology was promoted and executed, there was no incentive structure in place to drive economic growth. Furthermore, manufacturing plants and agricultural areas of the economy that were run by effective management during the colonial period were managed by inadequately trained managers who either did not know the particular trade or did not have a vision or goal.

The Declaration's effectiveness in eradicating poverty and disease and improving the standard of living of the citizens began to weaken. This was attributed to ineffective economic management, governance and implementation of policy. Furthermore, the morale of the population eroded due to a lack of education, inadequate production incentives within the state-owned industries and more importantly a 'donor dependency' syndrome due to years of aid from the Soviet Union, Asia and western countries that resulted in crippling foreign debt.

This eventually led to the reduction of unnecessary trade barriers, removal of restrictions on foreign exchange transactions and reform of the banking sector.

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Market policies were established through the Tanzania Investment Act of 1997. This Act was a radical change from the past and allowed a more relaxed investment climate. Furthermore, the Act guaranteed that the 'Government does not have a right to nationalize or expropriate any business'. This is the type of language and legal guarantee that investors looked for, especially after the Arusha Declaration in which all assets belong to the government overnight.

While the economic ideologies advocated from 1961–1985 can be questioned today, it must be noted that the political evolution in Tanzania has led to one of the most peaceful, united and harmonious nations in the developing world.

Urbanization and housing

Almost every developing country has experienced a mass rural to urban migration. With urbanization come issues of housing shortages, inadequate infrastructure and societal friction. While there are many causes for the urban migration in Africa, two stand out. First, the levels of poverty in rural areas resulting from low agricultural yields due to famine and other natural disasters in sub-Saharan countries has forced many to move into cities (Global Coalition for Africa, 2000). Second, rural regions are woefully under-serviced, particularly in basic medical and schooling facilities because much of the government resources are targeted for urban areas. Furthermore, inappropriate government policies of land allocation and farming incentives often force farmers to move to urban areas (Policy Forum Report, 2000).

The informal economy

The heavy influx of rural people coming into the cities in search of jobs has also caused an imbalance between job hunters and job creators. In Sub-Saharan Africa, the modern formal economy provides jobs for only 10% of the work force. The remainder of the work force is usually involved in casual labour, street vending and other forms of enterprise. Productivity in the informal sector is low and rather erratic, posing a dilemma for the national government when it comes to revenue projections and budget allocation. Much of the revenue generated by the informal economy is never shown on the books (if they even exist); hence the government is strictly dependent on the formal sector for collections that are woefully short of their projections. While most municipalities recognize that the informal sector is the only means of livelihood for the poor, they have also shown concern for the social issues that come with poverty such as increased slum development, diminishing health services and lack of schooling.

Housing development and services

One of the dilemmas that developing countries and their metropolitan areas are facing is the haphazard way that urban dwellers have developed their infrastructure. The lack of municipal planning for development is mainly to blame for this. It is not uncommon to see construction of homes next to factories and other industrial sites, creating serious health and safety hazards. Much of the development occurs near industrial facilities because infrastructure amenities such as power, water and sanitation are easily available there. And because industrial facilities are typically located in metropolitan centres where infrastructure is available, rural inhabitants are forced to move to urban areas. Slums emerge where hundreds and thousands of people live in appalling conditions without access to basic health and human services, paved roads and utilities (Policy Forum Report, 2002). Central governments in Africa have failed to recognize the sociological truth that the basic way to retain a population in rural and small communities is to provide economic incentives to keep them there. In Tanzania with a population of 35 million, only three cities provide the majority of the industrial capacity – Arusha (north), Mwanza (North-Central) and Dar-Es-Salaam (east coast) – the latter being the largest and most developed.

Most African countries face a tremendous challenge in addressing current problems while at the same time creating a new policy environment that will help their cities to be more effective centres of growth and progress. Cities have to be made more governable and livable as well as economically viable for growth. This includes a proactive and integrated policy-making process involving all aspects of local and national governments structuring a common development strategy. But for planners, urbanization also has to be looked at in the context of *overall* development of the nation and not simply in the area that is the most fiscally rewarding.

Democratic development strategies

Several African nations have begun to embrace democratization as a way of governing. While still in their early stages, multi-party agendas are blossoming. Politics is slowly becoming decentralized and decision-making assumed at a local and regional level. It is hoped that the initial stages of the decentralization of power will slow down the growth of capital cities, and that resources will be transferred instead to the smaller towns that are

in dire need of development. Concurrently, it creates a mechanism whereby financial outflows occur to facilitate rural development and strengthen secondary cities that can sustain industries and curb unnecessary economic migration.

Housing and urban development

The need to build affordable housing and other infrastructure is paramount in Tanzania. While the elite has the means to live adequately, the low-income population suffers the most. The high cost of construction and the lack of financing have left large pockets of metropolitan areas inhabited largely by dense and often impenetrable slums built of wood, sheet metal and cardboard. Local governing bodies are struggling to alleviate their problems with the help of NGOs such as Habitat for Humanity. However, such institutions only make a small dent in the larger problem that the continent faces, making the need for a massive development strategy ever more essential.

The 2002 Household Budget Survey (HBS) and the 2002 Census, conducted by the Tanzania National Bureau of Statistics (NBS), analysed the housing conditions in 20 regions of the country. The census not only counted the civilian population of the country, but also collected information about household incomes, gender roles, living conditions and quality of infrastructure.

The data in Table 1 clearly indicates that inferior material is used mainly in rural areas of the country. Referring to Chart 2 in Appendix A, the majority of the rural population lives in dwellings made of pressed mud. Only 3% of the population lives in dwellings of concrete or stone and only

Twenty-three per cent use mud brick. Regionally, the use of modern material is highest in Dar-Es-Salaam and Kilimanjaro and lowest in Lindi, Singida and Tabora. The use of modern housing material has increased in all areas since the last Housing Budget Survey in 1991 (Appendix A, Chart 2). In general, there has been an increase in baked brick walls mainly in the rural areas and a leap in the use of metal sheet roofing in urban areas such as the Kagera, Arusha and Kilimanjaro regions. As it is the wealthier households that are able to afford modern materials, this suggests an increase in incomes.

According to 2001 housing figures published by the Tanzanian Ministry of Lands and Habitat Development, there is a demand for 600 000 housing units in the major urban areas, with Dar-Es-Salaam carrying 50% of that burden. This amount continues to rise with the daily influx of new migrants from smaller towns and villages. Peripheral issues such as financing further exacerbate the lack of structured land development policy. Since the collapse of the Tanzania Housing Bank (THB) in 1993, there has been no formal method by which one can borrow money to build a home. Instead, most construction in the country has been financed through personal funding, an expensive and unreachable option for a low-level civil service employee making no more than $2000–$3000 annually. Thus, individuals get priced out of the housing ownership

Table 1 Percentage of households living in dwellings with modern[4] materials (NBS, 2002)

	Dodoma	Arusha	Kilimanjaro	Tanga	Morogoro	Pwani	Dar-Es-Salaam	Lindi	Mtwara	Ruvuma	Iringa	Mbeya	Singida	Tabora	Rukwa	Kigoma	Shinyanga	Kagera	Mwanza	Mara	Tanzania Mainland
Modern floor (%)																					
Urban	70	66	67	70	65	51	n/a	37	54	66	79	66	52	60	52	39	64	65	54	66	71
Rural	7	11	38	12	7	10	n/a	7	8	25	15	19	7	5	3	4	9	15	13	20	13
Total	16	23	42	17	21	18	92	12	17	32	20	33	11	14	10	9	15	18	22	27	25
Modern walls (%)																					
Urban	54	43	57	44	61	26	n/a	20	40	76	62	20	26	24	38	27	41	54	25	47	54
Rural	18	11	36	3	18	1	n/a	1	5	65	26	37	5	3	31	41	2	10	6	19	17
Total	23	18	39	6	28	6	88	4	11	67	28	32	7	6	32	39	6	13	10	23	25
Modern roof (%)																					
Urban	89	96	93	86	88	70	n/a	56	75	81	88	90	84	85	64	73	75	89	79	89	88
Rural	24	41	84	36	31	24	n/a	8	17	34	44	37	15	11	8	13	18	51	31	34	31
Total	33	53	85	41	45	33	98	16	28	42	48	53	21	24	16	21	24	53	42	43	44

market; yet, they still have to pay a large portion of their monthly salaries for rent.

The most immediate response of the government has been to utilize the National Social Security Fund (NSSF) as a mechanism to build affordable housing in some of the more impoverished areas of Dar-Es-Salaam. Using the funds from social security contributions, this pilot project includes the planned construction of 146 homes complete with infrastructure (roads, running water, drainage and electricity) by 2004 (Mwamunyange, 2003). The homes will be built of concrete block walls and clay tile roofs and sold for approximately $9000 to $12 000, depending on their size. While the intent is good, it does not meet the minimum demand nor make it affordable for an average family of four to six people.

Ecological awareness

Environmental sensitivity is often a low priority in developing countries, and the need to make ends meet is primary for the majority of Tanzanians. For example, in order to find both cheaper material *and* much needed structural strength, roadside 'brick factories' have been set up without approval or any quality-control. These small-scale producers, using shovels, pack brick-sized moulds with a sand and clay mix under uncontrolled conditions and then either sun-dry them or fire them in home-made wood-fired kilns. While this is a tried and tested method, consumers fail to see the negative environmental impact caused by the use of firewood to fuel the kilns.

Furthermore, there is another psychological and sociological issue that needs to be emphasized. The very idea of a middle-income earner living in a 'mud dwelling' goes against the grain of their status in the community. Instead, the extensive and expensive use of foreign materials symbolizes success and position in the community. This is a trend that should be reversed through the introduction of creative design and construction sophistication that emphasizes locally available products and labour.

The construction sector in Tanzania

A lack of statistical data makes it extremely difficult to gauge the health of the construction sector in Tanzania. The biggest hurdle is accounting for the unregulated and informal housing sector that includes squatter camps and shanty towns. A 1992 Swedish International Development Agency (SIDA) evaluation reports '95% of the rural homes and 85% of all urban houses are built by self-help' (Bjork and Klingberg, 1992). This amounts to 3.49 million residential homes built by the non-regulated sector, a phenomenal amount when considering revenue potential from property taxes.

There are several developmental pitfalls that have been a detriment to the sector, creating a void and preventing it from growth and development in areas of research and innovative engineering (Bjork and Klingberg, 1992):

- There is a high degree of 'stop-go'. While the industry is seasonal (most construction occurs in the dry period), work often stops because of the lack of adequate technology, material shortages or bureaucratic hurdles.
- Managing a transient construction workforce is logistically difficult, due to a limited highway network.
- The economic turbulence used to be a major hurdle for contractors, and in order to overcome losses, they often inflated their price quotes. This was primarily to cover unforeseen costs including sudden shift in policy and currency devaluation. While that problem has diminished today, it was the most common threat 15 years ago.
- Laws and regulations covering industry standards exist but are often overlooked due to insufficient monitoring and lack of resources.

Overcoming the housing shortfall using innovative technology

The underlying struggle that most developing nations face when it comes to housing is how to make it not only affordable, but more importantly sustainable over time. The economics of affordable housing calls for a dwelling having minimal maintenance requirements, and being affordable to the lowest wage earner paying a mortgage that does not exceed 10 years. Fortunately, innovative technologies are being introduced to help reduce some of the financial, economic and engineering pitfalls. Innovative technology, or alternative technology, is by definition, technology that has been creatively re-designed to produce a similar, but better product. Typically, the re-design is done to reduce costs, be more environmentally sensitive and technologically improved for efficient use. More importantly, the technology is tailored for *local* use under *local* conditions. In the case of East Africa, the use of mud and thatch as a building material is a common sight particularly in rural and other outlying regions.

The potential to improve this traditional approach has been shown in India that also uses mud as a primary building tool in rural development. Research institutes such as Auroville, India have been promoting the use of

manual block machines that create structurally sounder building blocks. The manual hand crank process including the hydraulic system of producing clay blocks for construction is certainly not a unique concept, and in fact there are several functioning designs available.

Mechanized hydraulically compressed block machine

Going beyond manual labour, an inexpensive diesel-fuelled hydraulic machine can take a semi-dry mix of local clay and sand and create better building blocks with consistency and quality control equivalent to that achieved in a factory setting. There are several designs available.

The hydraulic functions of these machines have several advantages particularly in large-scale development programmes such as affordable mass housing. The 'Terra Block Fabricator (TBF)' (see Figure 1) models were used as a case study for this research paper. Using gravity feed, the TBF self-loads the compression chamber. Once loaded, a powerful ram compresses the soil at a consistent rate ensuring the necessary quality controls. The sizes of the blocks vary according to the model used. After compression, the block is automatically ejected and the chamber is cleared to receive the next batch of soil for compression.

This approach has several advantages:

Cost effectiveness

The use of indigenous material, namely soil compared to the use of cement blocks provides substantial savings. Soil can also be found on the building site, eliminating unnecessary transportation costs that comes with ready-made materials, such as cement block and fired brick. Furthermore, the press uses diesel fuel that is widely used and is the preferred choice of fuel in Tanzania.[1]

Labour effectiveness

Most developing countries face a shortage of skilled labour. The only skilled person required for the press is a mechanic who understands the basics of operating hydraulic technology and who can carry out preventive maintenance.

Table 2 Regional cost comparisons

Material	U.S.A.	Tanzania
Compressed block	$0.80*	$0.04
Concrete block	$6.80	$2.00
Press built house construction cost range	$10–$80	$6.00–$50

*All figures are based on "installed" per square foot.
Source: National Construction Council (Tanzania), AECT (San Antonio, TX).

Figure 1 TBF205: Mulanja

Environmental impact

Not only does the hydraulic press eliminate the use of firewood for firing the block, it also has a positive environmental impact in terms of energy efficiency. In Tanzania, ventilation is of paramount importance in order to keep the habitat cool. Mud is one of the best insulators and has a great cooling effect. The use of adobe walls can result in a 40–50% savings[2] in energy bills (air conditioning) over a 12-month period.

Speed and efficiency

Several hydraulic press models that were analysed could produce up to 900 blocks in one hour, while the smallest produced up to 240 per hour.[3] While these are key statistics, what is important is the fact that because the blocks only contain up to 8% moisture, they can be put in place immediately without having to dry them. This results in substantial savings in storage, time and fuel.

Quality control

Quality Control: Construction storage facilities in Tanzania often do not meet high quality standards. The storage of building materials over a period of time may result in deterioration due to water seepage and bad handling. Furthermore, to transport building blocks from warehouses is detrimental to the quality of the product. Because the TBF manufactures the building block on-site, quality can be maintained at all times by the building crew rather than depending on independent suppliers who could be making bricks in wood fired kilns under questionable quality standards.

Low maintenance

While the hydraulic press is sophisticated, it requires minimal maintenance, much of which involves periodic inspections of the mechanism by a skilled mechanic. Parts are easily replaceable and can be found in any hardware store or can be ordered. Furthermore, the components of the machine are non-proprietary, which lowers the overall maintenance costs.

Ease of transportation

The typical hydraulic press is extremely mobile and built for rugged conditions. It is designed to be towed behind a truck or can be placed on a flatbed vehicle, allowing it to be moved from one job site to the next as needed. This is particularly advantageous in developing countries such as Tanzania where road conditions are sub-par, and the very fact that the hydraulic press can be brought *to* the source of raw material as well as the site can produce a level of efficiency that is often lacking.

Job creation and 'mobile' education

In Tanzania, the inadequacy of reliable overland transportation often curbs the movement of potentially talented people. The mobility of the press is advantageous, because it brings the technology to the people, in essence establishing an equivalent of a 'mobile classroom'.

The hydraulically pressed block (HPB) produced by the TBF has a load-bearing strength of 1000 pds/in^2 (concrete masonry unit: 1500 pds/in^2). Reinforced concrete columns are not necessary for a typical single story structure because an HPB wall derives its strength from its monolithic nature when complete. In fact, an HPB wall can withstand earthquakes up to 7.5 on the Richter scale if made and used appropriately. This feature is particularly important considering the horrific damage caused by the 2004 earthquake in Bam, Iran that measured 6.5 on the Richter Scale. Cement mortar is not used; instead watery mud slurry is painted between the blocks, causing the layers of blocks to bond directly to each other. This vastly increases the shearing strength of a block wall compared to concrete or fired-brick blocks, which bond to the inter-layer of mortar – not to each other.

Market and customer

The hydraulic press has been designed for continuous, large-scale and voluminous construction, and identifying the right market to ensure some level of success is critical. Accordingly, a niche market has been identified and exists in two forms as described below:

Non-governmental Organizations (NGO)

In sub-Saharan Africa, NGOs and non-profit organizations have provided humanitarian services, food distribution, medical services, education and infrastructure development for decades. An NGO also tends to be a likely partner in promoting such locally based technologies, as their role is often to promote rural development, education and self-sufficiency.

Central and regional governments

Currently, all policy making, financing and strategic planning is made at the central government level and then funding is distributed to regional bodies for execution and coordination. In Tanzania, the process is rapidly becoming more decentralized, giving additional authority to regional governments in all areas of development, including schools, health facilities, road expansion and more importantly, the collection of revenue that can be solely used for that particular region. Aside

from the housing need, Tanzania has a severe shortage of school buildings, clinics and agricultural storage facilities. The hydraulic press is an ideal candidate for sale to government agencies that have established development programmes. In Tanzania, these would include the ministries of health, education, housing and urban development and agriculture.

Private developers/builders

Tanzania enjoys the presence of small and medium-sized enterprises (SME) providing a full range of services. There are several large-scale developers who are involved in urban planning and development. Marketing the press for some of their projects can help reduce overall operational costs that can then be transferred to the customers for overall economic benefit.

Cost analysis

The cost estimate (Table 3) shows a comparison between using hydraulically pressed block and standard concrete masonry units. The estimate was for the construction of a single-family, single-storey home. Several assumptions were also made in order to portray a 'worst-case scenario' of construction costs in Tanzania. These include soil that has to be trucked in from

Table 3 Sample cost breakdown using compressed mud block

	Cost estimate[5]: 1350 ft single storey basic home						
	Using hydraulically pressed block						Using concrete block
Description	Unit cost	Quantity	Units	Quantity 2	Total cost	Comments	Total cost
Concrete Floor	$2.00	1350	SF		$2,700.00	50' × 27' footprint	$2,700.00
Walls (exterior and interior)	$0.05	9240	per block		$323.40	6" ×12" block	$2,635.20
#5 Steel rebar (for bond beam)	$1.00	300	LF		$300.00	for bond beam	$600.00
Grout/mortar	$0.00	0	0	0	$0.00		$3,150.00
Wall finishes (slurry/ plaster)	$0.04	2000	SF		$80.00		$200.00
Metal roof (4'x8' sheets)	$0.20	1350	SF		$270.00		$269.00
Roof trusses	$1.00	1350	SF		$1,350.00		$1,345.00
Windows	$35.00	6	Units		$210.00		$210.00
Doors	$35.00	3	Units		$105.00		$105.00
Utilities	Fixed	Fixed	allowance		$120.00		$120.00
Total material cost:					$5,597.00		$11334.00
Operating costs:							
Material/equip. transport	$10.00	7	trips		$70.00	Soil material transportation depending on site conditions. Soil may be available on-site eliminating transport needs	$100.00
Storage	$0.00	2	days		$0.00	Use of shipping container the press came in.	$70.00
Material wastage/breakage		0%			$0.00		$131.76
Other costs							
Diesel fuel	$2.00	7	gallon	2	$28.00	4 days of brick production	
Maintenance	Fixed	Fixed	Allowance		$10.00		
Labour (machine ops, construction)	$3.50	5	per labourer	12	$210.00		$525.00
Daily operating/OH cost	$15.00	12	days		$180.00	on-site office, telephone,	$315.00
Total operating cost					$498.00	electric/ water	$1,141.76
Total cost:					$5,956.40		$12,025.96
Profit		15%			$893.46		$1,783.64
Total cost to customer:					$7009.25		$14259.60

another location if the site conditions are not adequate. If the clay and sand conditions are adequate, then the costs are less.

The use of concrete masonry units (CMU) requires multiple transportation of the product from a factory. Furthermore, the inadequate roads in Tanzania often hinder delivery of the material and are the main reason why a proportion of the goods are damaged at delivery. The use of concrete masonry units also requires structural additives that result in higher cost. Block masons are considered skilled and require quite a lot of experience prior to taking on complex projects. Furthermore, they are paid almost twice as much as unskilled persons and in reality a four-person team can only lay up to 500 blocks per day, as opposed to 2000 per day in the case of hydraulically pressed block that requires a minimal effort to shape and prepare for construction.

Financing and credit facilities

The banking system in Tanzania has matured tremendously since banking policies were amended to allow private banks to serve the population. Furthermore, the government ceased to operate banks and sold the majority of its holdings to private investors. Tanzania now boasts several commercial lending banks, both local and international, such as the National Bank of Commerce Ltd (NBC), Citibank, Standard Charter, Kenya Commercial Bank and Stanbic SA. With this infrastructure, the business community has access to capital and credit facilities for investment, business loans and financial transactions. Therefore, financing becomes an important element in purchasing the press, even though lending rates run as high as 19% annually (Bank of Tanzania, 2003).

2

The cost of the smallest TBF is approximately US$22 000 – an unaffordable amount to a small builder. However, it must be noted that the TBF is most effective in *high volume construction* to get the maximum return such as mass housing development and therefore larger construction firms are most likely to benefit the most from this technology. Based on field observation, the return on capital investment must be made within three years or approximately 30–40 small homes.

There are however, several negative aspects to the Tanzanian lending laws that need to be emphasized. As in most developing countries, particularly in the sub-Saharan region, the acute lack of records on asset ownership (land and property as collateral) combined with past fiscal policies has resulted in difficulty to obtain financing. The alternative for the small businessperson is to pursue micro-lending, but the amounts are extremely small and require some sort of backing. For the medium to large company, the constraints of borrowing are magnified. Per e-mail correspondence in March 2003 with the Head of the Commercial Division of the National Bank of Commerce (Tanzania), the lending policy of Tanzanian commercial banks requires collateral of at least 125% of the borrowed amount before a loan can be made.

Table 4 Material sources

Material	Imported	Local
Block/brick		〈
Paint	〈	
Roof panels		〈
Doors		〈
Windows		〈
Piping		〈
Plumbing fixtures	〈	
Wiring		〈
Elect. Fixtures	〈	
Cement		〈
Appliances	〈	

Material availability

As mentioned earlier, construction in Tanzania is often hampered by a lack of the steady availability of building material, including concrete blocks, and the situation is worse in outlying areas. The reason is not because of the lack of manufacturing facilities, but inadequate and inefficient distribution channels. Bureaucratic hurdles at warehouses, customs and ports often cause significant delays in delivering material. Innovative technology thus becomes the driving force in an effort to remove many of these frustrations. Because of the unreliable quality of building blocks, contractors in Tanzania often make their own concrete block on the site to ensure quality control. However, the dependence on cement is tremendous, leaving them at the mercy of the suppliers and often resulting in stalled construction. By using the hydraulic press, dependence on the single most significant material item is removed.

The information above indicates that when the hydraulic press is used, most of the basic building material is manufactured locally, thus avoiding some of the bureaucratic and cost burdens associated with importing therefore ensuring a reliable supply of basic building material.

Conclusion

Increasing the quality of life in developing countries requires the optimal utilization of resources. Reliance on local natural resources and labour skills instead of imported construction materials increases the potential

affordability of decent housing for workers and the middle class. The political and economic evolution of Tanzania has given its government the opportunity to promote quality housing for its people, but a major challenge is to overcome the negative perception of 'mud' in the status consciousness of the people. Since mud is viewed as a poor man's material, pilot programmes and training facilities will have to be set up to show the creative and cost effective ways compressed mud blocks can be used. Government efforts should be reinforced by multilateral organizations and NGOs. In Africa, these institutions have begun to take prominent roles as liaisons between central governments and the local populations. Their involvement also reduces bureaucracy and keeps the government out of the day-to-day running of the program, putting the responsibility in the hands of the people.

Government policy, NGOs and the private sector need to work together to promote cost-effective sustainable housing which can lead to an improved standard of living and economic growth. If this can be achieved in Tanzania, it could be a positive example for the rest of Africa.

Notes

1. Field verified by authors.
2. Advanced Earth & Construction Technology, Inc. (AECT), San Antonio, TX.
3. Source: Global Pressed Block LLC (New York).
4. Note: Modern floor material include cement, tiles etc and exclude earth floor; modern walls include baked/ burnt bricks and concrete/ cement/ stone; modern roof materials include metals sheets, tiles, concrete.
5. Statistical information sources: AECT (San Antonio, TX), Drishti Planners LTD (Tanzania), National Construction Council (Tanzania).

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Appendix A

Chart 1 Tanzania population statistics

Region	2002 Popn.	Households	Avg. Household size	Popn density (per km2)	Growth rate (percentage)	
					1978–88	1988–2002
Total Tanzania	34 569 232	6 996 036	4.9	39	2.8	2.9
Total Mainland	33 584 607	6 811 087	4.9	38	2.8	2.9
Total Zanzibar	1 003 794	184 949	5.3	400	3.0	3.1
Dodoma	1 698 996	376 530	4.5	41	2.4	2.3
Arusha	1 292 973	286 579	4.5	35	3.8+	4.0
Kilimanjaro	1 381 149	297 439	4.6	104	2.1	1.6
Tanga	1 642 015	356 993	4.6	61	2.1	1.8
Morogoro	1 759 809	385 260	4.6	25	2.6	2.6
Pwani	889 154	200 919	4.4	27	2.1	2.4
Dar-Es-Salaam	2 497 940	596 264	4.2	1793	4.8	4.3
Lindi	791 306	190 761	4.1	12	2.0	1.4
Mtwara	1 128 523	293 908	3.8	68	1.4	1.7
Ruvuma	1 117 166	232 340	4.8	18	3.4	2.5
Iringa	1 495 333	346 815	4.3	26	2.7	1.5
Mbeya	2 070 046	491 929	4.2	34	3.1	2.4
Singida	1 090 758	217 572	5	22	2.5	2.3
Tabora	1 717 908	291 369	5.9	23	2.4	3.6
Rukwa	1 141 743	222 868	5.1	17	4.3	3.6
Kigoma	1 679 109	242 533	6.9	45	2.8	4.8
Shinyanga	2 805 580	445 020	6.3	55	2.9	3.3
Kagera	2 033 888	394 128	5.2	72	2.7	3.1
Mwanza	2 942 148	495 400	5.9	150	2.6	3.2
Mara	1 368 602	246 600	5.5	70	2.9	2.5
Manyara	1 040 461	199 860	5.2	23	n/a	3.8

Chart 2 Percentage distribution of households by construction materials

	Dar Es Salaam		Other urban areas		Rural areas		Mainland Tanzania	
	91/92	00/01	91/92	00/01	91/92	00/01	91/92	00/01
House foundations:								
No foundation	16.1	7.8	31.1	24.9	72.5	61.9	62.9	52.7
Stones in mud-mortar	11.3	6.8	27.7	22.9	11.2	12.9	13.6	14
Stones loosely laid	7.4	2.5	2.9	4.2	0.6	0.9	1.4	1.5
Concrete	64.8	82.8	33.2	44	13.9	20	20	27.8
Others	0.4	0.1	5.1	4	1.8	4.3	2.2	4
Total	100	100	100	100	100	100	100	100
House Floor:								
Earth	14.5	6.7	44.6	38.3	90.8	86.6	79.2	74
Cement, tiles, etc.	84.3	92.4	54.2	61.1	8	12.5	19.6	25.2
Other	1.2	0.9	1.2	0.5	1.2	0.9	1.2	0.8
Total	100	100	100	100	100	100	100	100
House Walls:								
Poles, branches, grass	3.4	0.9	5.7	5.3	23.7	19.3	19.8	16
Mud and poles/stones	15.1	5.2	16.3	13.1	27.7	21.8	25.3	19.4
Mud only	2	2.2	11.1	12.1	14.6	18.1	13.3	16.1
Mud bricks	12	3.2	37.6	30.8	24.2	23.5	25.4	23.3
Baked/burnt bricks	4.8	1.3	11.9	15.9	8.1	13.7	8.5	13.2
Concrete, cement, stone	62.1	87.2	17.1	22.4	1.5	3	7.6	11.5
Other	0.7	0	0.2	0.4	0.1	0.6	0.2	0.5
Total	100	100	100	100	100	100	100	100
House roof:								
Grass, leaves, bamboo	1.1	1.1	21.7	14.3	63.1	55.7	53.1	45.8
Mud and grass	0.2	0.7	1.7	1.5	12.8	12.5	10.4	10.1
Concrete, cement	3.4	3.6	0.7	0.5	0.1	0	0.4	0.3
Galvanized metal sheets	91.5	91.7	74.2	81.9	23.8	31.1	35.4	42.8
Asbestos sheets	0.1	0.5	0	0.3	0.1	0	0.1	0.1
Tiles	3.8	2.4	0.5	1	0	0.1	0.3	0.4
Other	0	0	1.3	0.5	0.1	0.5	0.3	0.5
Total	100	100	100	100	100	100	100	100

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