Brazilian Contributions to the Formulation of Agenda 21 on Sustainable Construction in Developing Countries.

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1. The Brazilian Context In The Definition Of Development And Sustainable Construction

Brazil has a landmass of 8.5 million km^2, divided up politically and geographically into five distinct regions: North, Northeast, Southeast, South and Center-West, which together have approximately 169 million inhabitants. The country's great natural wealth is its biodiversity, which is the target of international environmental interest with particular emphasis on the Amazon Rainforest, which occupies around 47% of the national territory and is the Earth's largest forest formation.

Brazil presents high rates of underdevelopment and poverty, and is ranked, according to the United Nations Development Program report – UNDP (Folha De São Paulo, 1999), on the Human Development Index – HDI, in 79th place out of the 174 countries studied. The HDI measures quality of life of the population based on indicators of knowledge (adult literacy and enrolment rates), longevity (life expectancy at birth) and standard of living (GDP per capita). In the ranking, Brazil is behind several other South American countries such as Chile (34th), Argentina (39th) and Uruguay (40th).

With this status, in 1999 Brazil joined the ranks of those countries classified under the Human Poverty Index (HPI). In contrast to the HDI, the higher the position in the ranking, the worse the country's classification. Out of 92 developing countries, Brazil appears in 19th position. According to the report, 15.8% of the Brazilian population – or 26 million people – do not have access to minimum conditions of health, education and basic services.

An interesting piece of information presented by the UNDP's report in 1999 is that economic growth is not necessarily linked to improvement in the quality of life of the population. This means that, although the country has got richer in recent years, it has not managed to transform this wealth into benefits for the population and it continues to hold the title of the nation with the world's worst distribution of income.

This duality between the country's economic growth and its low standard of life quality for its population reflects the absence of an alternative policy to the current one, which gives priority to economic efficiency aimed at the accumulation of capital, but which also generates external factors with a negative effect on the social-environmental ambit. Among the alternatives for development put forward in the 1970's, one of the most important is eco-development, which takes as a basic premise the need for the models of action to be implemented to correspond to the specific features of local contexts.

The concept of eco-development applied to urban areas was developed during the 1980's by the economist Ignacy Sachs, who defined it as "...endogenous development dependent upon its own forces, submitted to the logic of the needs of the population as a whole, aware of its ecological dimension and seeking to establish a harmonious relationship between man and nature" (Sachs, 1986). According to the same author, the definition of this concept is based on three key points: economic efficiency, social justice and ecological prudence. In 1987 the Brundtland Report – Our Common Future (WCED, 1987) - defined the term sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." That definition became the best-known concept of alternative development, utilized by all areas of the knowledge.
At present, the concept of sustainable development for Brazil is still an idea under construction. This is because, despite the fact that in recent years there has been a great advance in the world scenario regarding the definition

of the general premises on which the term is based, and despite the considerable investigation and some experiments carried out by the country, the majority of the population is facing a process of extreme social exclusion and the degradation of the environment has been putting at risk the load capacity of ecosystems. Within this Brazilian context, the most suitable definition of sustainable development and construction for the country should take into account technical and non-technical aspects on which the term in based.

1.1 The Balance between Technical and Non-Technical Aspects

According to Sachs (1997), due to the broad scope on human activities inherent to the idea of sustainability, the approach to any given activity, such as civil construction, can be based on one of the five dimensions upon which eco-development (that author's term) is based. These are: social sustainability, economic sustainability, ecological sustainability, spatial or geographical sustainability, and cultural sustainability.

For many years there was a tendency for the studies that pervaded the question of sustainability to give greater emphasis to the dimensions or aspects denominated as technical – ecological sustainability and geographical sustainability. As a result, this approach often ended up neglecting the social contradictions, making the environmental issue mainly – and in some cases exclusively – a technical one.

The very definition of sustainable development in the Brundtland Report, in citing the current needs of society and also of future generations, makes a simplified generalization of humanity. In analyzing the needs of future generations it is correct to consider them as a unit, since they do not yet exist and are unknown. However, it is impossible to think of the present society as a whole, or to think of one unique and abstract man, and leave aside his internal social differences when it is the intention to ensure, for example, equality among different peoples, which is one of the aspects of social sustainability (Foladori, 1999).

Thus, the pursuit of comprehension of the non-technical aspects, i.e., social, economic and cultural sustainability, as well as the political, which Sachs does not mention, must be encouraged and practiced in countries like Brazil which have the fight against social exclusion as one of their priorities. This change of focus, or increased plurality of approach, should contribute towards helping developing countries to face up in a more productive way to the challenges presented by sustainable development within their reality, given that the social, economic and cultural contradictions are the true cause of their environmental problems.

If the worldwide environmental crisis has been brought about by the economic model that favors the expansion of the structures of mass production and large scale agricultural production in developing countries, among them Brazil, social inequality which involves a scenario of high concentration of wealth and social segregation has only made things worse. Hence, the consequences resulting from these models of production, which establish a predatory relationship with the physical environment, have affected many of the world's nations, albeit with qualitative differences in the transformations that have occurred in developed and developing countries (Singer, 1975).

In Brazil, the transformations brought about by industrialization and the consequent urban expansion have occurred at an intense pace and in a much more decisive way, which has submitted the economic structure to shocks that were much more profound. For this reason, in order to overcome the problems unleashed by this dynamic, the definition of development (and subsequently, sustainable construction) should emphasize the environmental, social, economic and political aspects. In her paper on the definition of indicators of Brazilian urban sustainability, Silva (2000) systematized these aspects and also defined the general strategies for each of them to be achieved.

The environmental aspect requires the keeping of ecological integrity through prevention of the various forms of pollution, prudence in the utilization of natural resources and the preservation of the diversity of life, as well as a respect for the load capacity of ecosystems. In considering the social aspect, greater equality in the distribution of wealth and opportunity needs to be achieved, targeting practices of exclusion, discrimination and reproduction of poverty. As for the economic aspect, we should seek to realize the potential for a growth that gives priority to the distribution of wealth and income, together with a reduction of the social-environmental external factors, with the aim of achieving positive macro-social results. Finally, in order to include the political aspect, mechanisms should

be created that increase social participation in decision-making, recognizing and respecting the rights of all, overcoming the practices and policies of exclusion and permitting the development of active citizenship.

The aforementioned measures are the conceptual basis for structuring the definition of sustainable construction for Brazil. Based upon this definition, government should draw up a plan of local actions with the aim of overcoming, in conjunction with the construction industry and organized society, the challenges represented by the sustainable development of the built environment.

2. Themes And Challenges In The Brazilian Civil Construction Sector

2.1 Economic Growth and the Urbanization Process

The average population growth in developing countries, estimated at 2% per year, compared with 0.3% in developed countries, is a matter of fundamental importance in the debate over sustainable development. This is because the high rates of urbanization in countries such as Brazil represent huge challenges to the environmental, economic, social and political order, due to the precarious and inept way in which the built environment responds to demands for housing and urban infrastructure.

After World War II, a development model was consolidated in the capitalist countries that placed economic growth in a position of hegemony. In Brazil this model was institutionalized during the 1950's, when a policy of state incentives was introduced for industrialization. An integral part of this development project, the process of installing an industrial zone in the Southeast region of the country, involved the recruiting of large numbers of workers to meet the consequent demand.

The new economic model, aimed at the growth of national industry and corresponding urban development, extended beyond the Southeast region in the mid 1960's. This new model of organization of urban society intensified the flow of immigrants between regions, from the north and northeast to the south and southeast, and also from the countryside to the cities. The dual phenomena of accelerated urbanization and demographic growth resulted in the evolution of cities with diverse functional levels and urban population levels well above the world average.

Table 1 shows that in 1940 the rate of urbanization reached 31.24% of the country's total population, and in 1980 this figure rose to 67.59%. That is to say, while the total population of the country grew by 288%, the urban population underwent a growth of 860%. In 1991 Brazil's urban population – 110,875,826 inhabitants – was close to the country's total population in the previous decade – 119,002,706 inhabitants in 1980.

In the early 1990's the urban population rate was up to 75%, and by the end of the same decade it was over 80%. According to estimates from the demographic census carried out in 2000, the urbanization rates for the most industrialized Brazilian states of São Paulo and Rio de Janeiro were 94% and 96% respectively.

In Table 2 we see the importance of the Southeast Region in the industrialization process up to the present, which constantly raised the level of the country's urbanization. Until the 1970's, this was the only region with rates higher than the national average; however, over the last twenty years the Center-West Region has also experienced a rapid rate of urbanization. The similarity between the Southeast Region and the Center-West lies in the fact that their growth was generated by flows of immigration, resulting from the supply of urban employment, mainly in the cities of São Paulo, Rio de Janeiro, and Belo Horizonte, and of agricultural expansion and the emancipation of rural nuclei, respectively.

Table 1 – Brazil's Urban Population

Year	Total Population	Urban Population	Urbanization Rate (%)
1940	41,263,315	12,880,182	31.24
1950	51,944,397	18,782,891	36.16
1960	70,070,457	31,303,034	44.67

1970	93,139,037	52,084,984	55.92
1980	119,002,706	80,436,409	67.59
1991	146,917,459	110,875,826	75.86
2000	169,544,443	137,670,086	81.20

Source: IPEA/ DIPOS/ CEGESP/ Coordenadoria de Estudos Populacional (1998); IBGE (2001).

Table 2 – Rate of Urbanization in Brazil

Region	1940	1950	1960	1970	1980	1991
North	27.75	31.49	37.38	45.13	51.65	57.83
Northeast	23.42	36.40	33.89	41.81	50.46	60.64
Southeast	39.42	47.55	57.00	72.68	82.81	88.01
South	27.73	29.50	37.10	44.27	62.41	74.12
Center-West	21.52	24.38	34.22	48.04	67.79	81.26
Brazil	31.24	36.16	44.67	56.72	67.59	75.47

Source. IBGE - Anuário Estatístico do Brazil

The accelerated growth of the great urban centers prompted the government to create the Metropolitan Regions (Table 3), which have more than a million inhabitants. The government's aim was to unify governmental planning and actions for municipalities whose centers were being, or were about to be absorbed by more dominant cities. Together, the Metropolitan Regions represent approximately 30% of the urban population of Brazil and they share the same problems, resulting from their growth. In these regions, a significant part of the inhabitants have no access to housing and urban infrastructure – facilities offered almost exclusively by the construction industry, whether public or private sector – and these people suffer precarious basic sanitation and living conditions (Bernardes, 2001).

Considering that the Metropolitan Regions concentrate an accentuated incidence of social exclusion compared to medium sized cities and small towns, any urban environmental policy, including strategies for sustainable construction in Brazilian cities, must be linked to a social policy. For, "...the urban-social equation in our cities is closely linked to the issue of social exclusion. This is due to the context of extreme economic, social, and political inequality in which our cities have grown up" (Rolnik, 1997).

Table 3 – Metropolitan Regions in Brazil

Metropolitan Region	Population (inhab.)	Percentage of National total (%)
Belém	1,334,460	0.9
Curitiba	1,975,624	1.3
Fortaleza	2,294,524	1.6
Salvador	2,472,131	1.7
Recife	2,859,469	1.9
Porto Alegre	3,015,960	2.1
Belo Horizonte	3,461,905	2.4
Rio de Janeiro	9,600,528	6.5
São Paulo	15,417,637	10.5

Source: IBGE (1991).

2.2 The Housing Deficit and Urban Segregation

The current state of Brazilian cities, unprepared for the great flow of immigration to which they were subjected from the middle of the 20th century onwards, is due to the non-existence of public or private housing programs capable of financing or promoting the production of housing and urban infra-structure on a large scale. Besides this, the freezing of rents (instituted by the government between 1942 and 1964) destructured the letting market and, in this context, "...a series of expedients were consolidated for the construction of houses on the margins of

the formal market and of the State (...), based on the triad: lot dividing on the periphery of cities, home-owning and self-construction." (Bonduki, 1992)

Self-construction in Brazil is a process of spontaneous housing production in which owners of lots, whether acquired through the formal market or not, build their own residence without public or institutional orientation and control, in their time off from paid employment – holidays and weekends –, using their own resources, and using their families', relatives' and friends' labor as well as hired labor.

On the periphery of cities the supply of cheap lots, a result of private real estate speculation, far from any urban infrastructure but with access by way of precarious public transport, has in practice become the ideal location for people to build their own houses. From these beginnings, this process of housing production has spread across the country's great urban centers and created the "illegal city", originally peripheral and disconnected from the road systems of the urbanized zone, and characterized by the absence of consistent urban and political housing infra-structure, but able to meet the needs of its urban contingent.

The "illegal city" is no longer restricted to the periphery. The occupation of areas unsuitable for building, such as slopes and high-risk areas, or the invasion of public areas, whether centrally located or not, has grown in the last few decades in many Brazilian cities, due to the economic crisis. Thus, the housing deficit today is characterized as one of the biggest problems faced by the population and a major challenge to the private construction industry and for governments in the municipal, state, and federal spheres. The quantification of this deficit is a question that is arousing much interest.

According to the João Pinheiro Foundation – FJP (1995) – the Brazilian housing deficit (Table 4) can be quantified and subdivided into two different concepts: quantitative deficit, the number of dwellings that need to be built to meet the demographic demand; and qualitative deficit, the number of dwellings considered inadequate because of a lack of, or poor, infrastructure and excessive overcrowding.

Given that 55.1% of the Brazilian quantitative housing deficit is concentrated among income groups earning less than twice the national minimum monthly wage (R$ 151.00, or approximately US$ 71.22), it can be said that the poor distribution of income is the main cause of the housing deficit in the country, with the lack of a housing policy for the underprivileged sectors of the population in second place.

Table 4 – Housing Deficit in Brazil – 1995

Quantitative Deficit	
Urban Area	4.0 million
Rural Area	1.6 million
Qualitative Deficit	
Residences without infrastructure	5.6 million
Residences with inadequate infrastructure	5.0 million
Residences inadequate because of overcrowding	4.0 million

Source: João Pinheiro Foundation (1995).

Hence, historically, a large part of the housing deficit has not been combated through traditional programs and much less by way of the formal market. In fact it is the clandestine methods of production, such as the self-constructed shantytowns (*favelas* in Portuguese), which were, and still are, the main source of housing production for the poorest sectors of the population.

According to Almeida's definition (1999), the *favela* is a "...housing settlement, located on private or public land, acquired in an illegal way in relation to the rightful ownership of the land and independently of the number of buildings involved or the type of houses constructed there." By 1993, there were approximately 2 million people living in *favelas* in the municipality of São Paulo, which was at the time equivalent to 19.4% of the city's total population (FIPE, 1994). In 1996 the population of *favelas* in Rio de Janeiro made up 17% of the city's total population (IBGE, 2001).

2.3 New Models in Housing Management

During the last twenty-five years, various housing practices considered to be alternative have shown themselves to be the only programs capable of reaching the poorest sections of the population. Among these is the popular housing cooperative (*mutirão* in Portuguese), an alternative method of production based on the collective and organized efforts of the community, the so-called *mutirantes*, for the construction of housing for this same community (ABIKO, 1996).

In Brazil, the appearance of new forms of management in housing production resulted from the international debate that arose in the 1970's, as well as the World Bank having begun to defend new practices, influenced by the work of the Englishman John Turner, among others. According to Turner, a participative system for housing production would bring benefits for all. On the one hand, the users themselves decide on the planning, administrate the resources efficiently, and guard the built environment against degradation. On the other, the quality of the resulting buildings and the personalization of the product help to reduce instances of default on payments and promote the financial sustainability that the traditional programs had been losing (Turner, 1977).

The setting up of the National Housing Bank (Banco Nacional de Habitação – BNH), in 1964, was part of the military government's national policy to combat the deficit through intensive housing construction by public bodies and private enterprise, and through providing financing for people to buy their own homes. By the mid 1970's the BNH had carried out the construction of 4.5 million homes, though only 5% of these homes were for the sector of the population with an income of less than three times the minimum monthly wage. In an initiative to reach that sector of the population, the BNH launched a "second generation" of programs, which produced 211,000 units in alternative processes (eradication of *favelas*, financing of urbanized lots and housing cooperatives), compared with 1.2 million built by more conventional means. The implantation of alternative programs was interrupted in 1985 when the BNH was abolished.

Since that time, the country has never had a national housing policy. With the demise of the military regime and the democratization of public policy at the beginning of the 1980's, different spheres of society began to organize themselves to promote house-building. In São Paulo, where the housing movements were stronger and better organized, various initiatives sprang up during this period in the form of self-managed popular cooperatives that were not part of any specific program.

Self-management can be considered the most highly evolved model of the popular housing cooperatives' productive process, in that it requires a society organized into community associations, driven by its own representatives to demand their rights from governmental bodies. According to Cardoso (1993), the self-managed popular cooperative is one where the community has financial control of the project, which includes purchasing, hiring, payments, and keeping of accounts. For the development of the building project and its execution, technical consulting services – which do not belong to any public organ – are contracted.

In 1988 the first program of self-managed popular cooperatives with direct financing to the end users was drawn up. Although the program was abolished by the following government, and despite the fact that it carried out only a few experiments, the historical context of the popular movements influenced the later appearance of other types of state and municipal house-building programs by self-managed popular cooperatives. It is important to point out that the popular cooperative programs carried out to date, regardless of the form of management (whether institutional, co-management or self-management), provided an opportunity for access to housing for low and extremely low income segments of the population which had never before benefited from any program directly providing housing to the end user.

Thus, the popular cooperatives were a triumph for the population (which united outside of the formal housing market), insofar as the State has repeatedly and for a wide diversity of reasons, been incapable of financing or promoting housing production on a large scale. This conquest reinforces the challenge faced by governments in formulating less centralized housing policies that take into account the participation channels of organized society. This decentralization by the State in housing issues is also based on the idea of reducing the number of

middlemen in the construction process, which will result in the de-bureaucratization of the process of acquisition, legalization and construction – key factors for the reduction of production costs.

The reduction of costs is the main objective of any agent that promotes housing production, be it public or private. According to Cardoso (1993), the main reason for the reduction in costs for the projects carried out by popular cooperatives is the "…magnitude of the indirect costs in the conventional system: transport, food, central office, financial costs and bonuses." In the popular cooperatives, the total indirect cost is some 45% less than the total cost of conventional construction.

Besides the cost factor, the quality of the constructions produced by popular cooperatives can be higher than that achieved in conventional enterprises. This higher quality of construction can be explained by the low levels of materials wastage and the diversity of the architectural and typological solutions resulting from the participation of the cooperative workers in the planning and execution.

However, social sustainability is a somewhat controversial question hanging over the practice of housing production by popular cooperatives; that is to say, besides working a full week at their jobs, the cooperative workers are obliged to give up their holidays and weekends, and in some cases even their nights, in order to carry out the exhausting work of house-building. Many authors have debated this issue in Brazil since the advent of self-construction, wondering if these workers are not, by building their own homes, being exploited, and selling their labor to the capital system. In counterpoint to this argument, Rolnik & Bonduki (1979) argue that the worker, at the moment of construction, becomes an "individual producer of goods", and the usage value of the building becomes exchange value, as it may be sold at any time, bringing profit to the owner.

It is true to say that, since the beginning of this debate, the experiments in popular cooperative building have evolved greatly and are not the same as they were at the end of the 1980's, when the idea of self-management was incorporated; and it is clear that when the workers undertake housing construction they do not always do so purely for their own use. On this matter, Bonduki (1992) states, "…it is essential that social housing policies encourage housing production by self-managed popular cooperatives." The same author, analyzing another limitation of the popular cooperatives, i.e., their low productivity rate, said that the time taken to complete the construction should be seen as an intrinsic characteristic of the popular cooperatives, and that "…they will never be completed at the same speed as housing construction by private companies." And he concluded that, despite its negative aspects, there is a place and a need for the practice of popular cooperative house-building, in addition to other processes including a variety of alternatives.

Some of the Brazilian experiments with popular cooperative house-building have already shown the viability of the process. In the city of São Paulo, between 1992 and 1995, the FUNAPS-Comunitário was the first big housing program directed at financing for housing construction through popular cooperatives and self-management. This program was made possible through agreements reached between the city council and residents' associations, which financed the purchase of materials, specialized labor, technical consulting, and construction sites. This program enabled the construction of more than 90 building projects, with a total of almost 10,000 units.

Another important program in Brazil, which won an award at the Istanbul HABITAT II, was Mutirão 50, carried out at the end of the 1980's in Fortaleza, in the northeastern state of Ceará. The program was innovative in that it integrated housing construction with capacitating and income-generating activities, setting up community facilities for manufacturing and educational activities, which strengthened the collective organizational aspect. Besides this, the program also provided sanitation facilities for the project and set up environmental preservation and leisure areas.

In such cases, popular participation in housing construction goes beyond the technical benefits, also achieving economic and sociopolitical advantages that are fundamental to Brazilian society. Economically speaking, self-managed popular cooperatives enable the cooperative workers to acquire technical expertise, which equips them with skills to enter the labor market, especially in civil construction. In addition, the forging of social networks within the group favors the emergence of other cooperatives and small businesses, resulting in job creation and added income.

In a social sense, the impact of the self-managed popular cooperatives can be seen in the improved quality of life experienced by the cooperative workers, who find in housing a channel through which they can exercise their citizenship. This is because the democratic referential of political administration in the alternative house-building processes foments self-determination and self-confidence and allows greater social and political integrity. Although the access to housing is a constitutional right of Brazilian citizens, the extreme poverty in which much of the population live prevents them from fighting for decent housing conditions.

The building of a housing project by self-managed popular cooperatives brings together representatives and those represented, and is without doubt a great democratic challenge that facilitates direct participation in political matters. This participation is "…the only way to bridge the abyss separating the State and society, constantly reconstituting the legitimacy of government decisions" (Santos, 1988).

3. Opportunities Offered By Traditional Culture And Practices

The solution to the housing shortage problem in cities, in parallel with the construction of a more sustainable urban environment, requires policies from the Brazilian government which, besides having decentralized productive processes, must be executed by way of economically and technically viable building technology. These "sustainable technologies" must be endogenous in nature, i.e., reflect the cultural, natural, social, and economic traditions of the region in which they are employed.

Conventional building technologies – concrete structures and brick walls – have been exhaustively utilized throughout the country, in all types of construction, from *favelas* to large residential buildings. It is for this reason that the technological development of new construction methods is justified; methods which are not only capable of widening the options for solving the housing shortage, which has reached gigantic and uncontrollable proportions, but also of adapting to a more sustainable reasoning.

According to Habitat Agenda, governments should provide incentives for the construction industry to promote "locally available, appropriate, affordable, safe, efficient and environmentally sound construction methods and technologies in all countries, particularly in the developing countries, at the local, national, regional and sub-regional levels to emphasize optimal use of local human resources and to encourage energy-saving methods that are protective of human health" (UNCHS; 1999).

In the great Brazilian urban centers, the choice of alternative technologies to solve the housing deficit has not always been the best solution from the technical, environmental, and economic viewpoints. Currently, cities like São Paulo and Rio de Janeiro require other approaches to the housing problem, with the need to increase the average coefficient for ground use and avoid peripheral growth, which obliges public authorities to invest in costly infrastructure and services. In this context, for reclaiming small urban vacant areas and buildings in downtown areas (adapting them for housing purposes), or the urbanization of *favelas*, the utilization of conventional technologies is hardly appropriate.
Even so, due to the enormous housing shortage, there is still a lot to be done in terms of construction in the cities, and to that end the planners need to understand and to recognize the existence of a considerable wealth of natural resources and autochthonous technologies. Due to their non-aggressive effects on the environment, those technologies should serve as a reference for the human, technological, and economic development of each region. This approach to construction is one of the bases on which the Economic Commission for Latin America and the Caribbean (ECLAC), in partnership with the World Bank and the United Nations Development Programme (UNDP), have drawn up a document entitled *Nuestra Propia Agenda sobre Desarollo y Medio Ambiente* (Our Own Agenda for Development and the Environment), that served as a reference for the local implantation of Agenda 21 in Latin America.

This is the main challenge for the construction industry in Brazil: to overcome the antagonism of Brazilian urban reality, based on the poor quality of life experienced by a large part of the population, and a huge potential for development that derives from the country's wealth of natural resources. This is because when the non-technical barriers are removed, developing countries such as Brazil possess an enormous unexplored natural potential to

produce biomass under ecologically, socially, and economically sustainable conditions, by taking advantage of local know-how.

There is only a small number of projects that make use of appropriate technology, and this demonstrates the difficulty in finding a solution capable of embracing all of the variables that interfere in the sustainability of the construction process. Both in theory and in practice, experiments that do not conform to the economic model and that develop working strategies capable of contributing to the improvement of living conditions for the underprivileged population are very few. (Mascaró, 1990)

The Argentinean architect Víctor Saúl Pelli states that the central issue of the built environment in Latin America is the housing deficit faced by the ever-increasing poor population. According to this researcher's line of reasoning, although there are other issues to be resolved by the civil construction industry, Brazilian proposals for technological strategies should give priority to the solving of the housing problem, considering the possibilities and limitations of the population and, in some cases, incorporating its manners and its codes (Pelli, 1986).

The author concludes that: “the problem of the deficit of popular housing is so closely tied to unemployment, social and political participation, national economic and productive planning, distribution of wealth, and geographical distribution of the population, among other things, that coming up with technology appropriate to (technically) tackling the problem, without a link to the non-technical aspects, may seem to be inoperative".

3.1 Construction Technologies using Crude Earth and Reforestation Wood

In the search for alternatives which meet the expectations of the population as well as housing and environmental requirements, the technologies which use crude earth and wood from reforestation as raw materials represent a great potential for construction in Brazil. Although there is currently much resistance to the utilization of the construction techniques for these materials, the origins of construction with earth go back to the era of Portuguese colonization (16th Century) and construction with wood goes back to the time of European and Japanese immigration (20th Century).

Some of these techniques are deeply rooted in the culture of different regions of the country, and if they were to be used in a technically correct and economically viable way, it would be possible, through successful experiments, to restore governments’, industry’s, and end users’ confidence in them.

Environmentally speaking, crude earth and reforestation wood can be considered appropriate construction materials, since they conform to some of the principles of sustainable development in its ecological dimension, obtained by the: " …improved use of resources, limiting the use of those which are exhaustible or harmful to the environment; a reduction in waste production and pollution through conservation of energy and resources, recycling and research into more eco-friendly technologies..." (Sachs, 1994).
Crude Earth. Crude earth is one of the oldest and most common building materials known to man, used for the construction of dwellings in various technical and cultural guises on all the world’s continents. In Brazil, the construction techniques involving the utilization of earth – mud brick (adobe), rammed earth (pise) and daubed earth (*taipa de mão* in Portuguese) – were introduced by Portuguese settlers at the beginning of the 16th century. Mud brick, or adobe, is essentially hand-molded bricks of unbaked earth, while the rammed-earth technique consists of the piling up of earth in molds, and the daubed earth technique uses a wooden, cane or wicker trellis to which the earth is applied. (Dethier, 1986).

Following their spread in the colonial period, earth-based construction techniques went into a long period of stagnation and disfavor, mainly due to the technological changes brought on by the Industrial Revolution and the consequent new demands of the consumer market. In recent decades, the study of these techniques has been revived in Brazil by planners and research centers, mainly by those interested in the systematization of informal technologies and in finding solutions for housing provision on a large scale and of better quality than that being produced in a precarious and sporadic way, mainly in the Northeast Region.

The speed and ease of building with earth, especially with the daubed earth technique, has made it common practice among the poor, who can build whole villages in a few days. On the main causes of the lack of durability

of these constructions, which are quite primitive and technically simple, Ferraz Júnior (1995) lists the following problems: " a) fissures caused by retraction and expansion of the material, due to successive cycles of dampening and drying out; b) loss of compression resistance due to rains and floods; c) low mechanical resistance, and, d) low resistance to absorption and impact ".

Although the practice of building with earth has decreased in urban areas, the main advantages offered by its use are well-documented in the literature. These are: a) availability of the material in large quantities; b) low cost of excavation and transport, when the earth is found at the site; c) speed of execution; d) the ease with which construction techniques are learned by unskilled laborers; e) fire resistance; f) good climatic compatibility for most regions of Brazil; g) low demand for electric or fossil-fuel energy for manual processing of non-stabilized soil; h) limitless reutilization of the soil, when not stabilized; i) it does not cause pollution, and, j) earth is the most environmentally friendly material available (Mukeerji & Craterre, 1988; Santos & Rodrigues Filho, 1993; Lopes, 1998).

From a brief study of earth-based construction in Brazil, it is clear just how widespread the use of this material has become, as it occurs in all Brazilian states, in spontaneous self-construction projects or those carried out by construction professionals. Unfortunately, many government initiatives for earth-based housing construction have been limited to the construction of a prototype, which demonstrates the lack of credibility enjoyed by this building material and the conflict of interests among the agents involved in housing production. In spite of this, research carried out in recent years has systematized the data, providing extensive material on existing construction methods in crude earth, which enable its use in a rational and productive way for large-scale housing construction.

Among the experiments in the construction of housing projects, one in particular stands out. It was carried out in 1987, in the towns of João Câmara and Poço Branco, in the Northeastern state of Rio Grande do Norte. Seismic disturbances in the region had destroyed some 1,500 residences and a further 1,241 were damaged. However, some residences, built using the daubed earth technique, withstood the strong earth tremors, a fact which influenced the local administration to use that technology in the reconstruction and repair of the destroyed and damaged housing (Torquato & Machado, 1987).

Thus, using the existing informal local technology, a rationalized and flexible construction system was developed by means of the pre-fabrication of components and utilization of some industrialized materials. The housing, built by institutional popular cooperatives, covered areas of between 26.5m^2 and 78.4m^2, depending on their typology, based on a combination of the three types of modulated panels. Resources for the project were financed by the Caixa Econômica Federal (CEF), a state bank currently responsible for financing of this type throughout the country (CEF, 1987).

Reforestation Wood. Having more limited utilization possibilities than earth (due to availability and geographical distribution), though by no means less appropriate environmentally, reforestation wood is, for some regions of the country, the most viable material for the construction of dwellings, combining local economic and human development.

In Brazil, planted forests are divided into two main groups: Pinus spp and Eucalyptus spp, which belong to different biological categories, with distinct anatomical structures and physical-mechanical properties. The Eucalyptus, a species that originated in Australia and Oceania, was introduced to Brazil in 1904 by the Brazilian forester Edmundo Navarro de Andrade. His records show that eucalyptus wood was already in use for civil construction in Brazil by the 1960's and his work is certainly of great importance in the spread of the species in the State of São Paulo - Andrade (1961).

The introduction of exotic species of conifers, especially of the Pinus species, occurred during the 1940's and early 1950's. The planting of the Pinus species was carried out to counter the scarcity of native conifers, the only viable source of soft, long-fiber wood in the country, as well as to diminish national dependence on the importation of cellulose and resin, typical products of conifers.

A short period of fiscal incentives in the 1960's resulted in the extensive plantation of forest areas, which today total five million hectares. Donelly & Suchek (1997) presented the statistics gathered by the Brazilian Forestation Society (SBS) in 1995, which showed planted forests in Brazil to be made up of 60% Eucalyptus, 35% Pinus, and 5% other species. Table 5 presents the areas reforested with Pinus and Eucalyptus in Brazilian states. Most of these plantations are located in the South and Southeast Regions.

Table 5 – Reforestation in Brazil today

State	Pinus (hectares)	Eucalyptus (hectares)	Total
Rio Grande do Sul	136,800	115,900	252,700
Santa Catarina	318,120	41,550	359,670
Paraná	605,130	67,000	672,130
São Paulo	202,010	574,150	776,160
Minas Gerais	143,410	1,523,750	1,667,160
Bahia	238,390	213,400	451,790
Other States	182,390	431,030	613,420
Total	**1,826,250**	**2,966,780**	**4,793,030**

Source. Tomaselli & Garcia (2000)

After HABITAT II, Ermínia Maricato drew up a Brazilian plan of action that synthesizes proposals with the aim of reverting the dynamics of inequality in the national habitat. The technological proposal addressed "…development of wood resources appropriate to construction of housing and furniture from managed forestry, for which Brazil has a high potential. This proposal is justified by the reduction of costs and waste, in addition to its sustainability" (Maricato, 1997).

Ino & Shimbo (1997) mention that besides being economically viable, the use of reforestation wood in housing production is also viable from the technological point of view and is good for the forests. From the technological standpoint, good housing construction can be achieved if detailed planning of the construction system is carried out, taking into account the characteristics of the forest, the sawn timber, the equipment, tools and labor. As for the forests, considering the extent of reforested areas in the country and the volume that this could represent in sawn timber destined for housing production, one may conclude that this material could very well meet the demand for housing.

Finally, reforestation wood has some advantages over conventional materials. These are as follows: a) it is renewable, and with forestry management large quantities of raw material can be obtained over a short period of time, at low cost; b) it can be produced in a variety of shapes and sizes, which favors structural variation and better architectural results; c) it can be worked using conventional tools, which facilitates jointing and linkage, indispensable for popular cooperative programs; d) it is reusable, which enables, for example, the repetition of tasks during assembly; e) it has good resistance to tension and compression, having low specific mass and high mechanical resistance (Eucalyptus); and f) it has good thermal and acoustic insulation qualities that proportion a sense of well-being and habitability.

Indeed, the utilization of reforestation wood should be encouraged not only for the low production costs when compared to native woods, but for a combination of environmental factors that include the following: the low availability of native wood; the ecological pressure for use of renewable forest resources; the reduced age at which it can be cut down; the favorable climatic conditions in the country and the high productivity of planted forests.

A comparison from an environmental viewpoint of wood and steel structures carried out by the Canadian Wood Council (1996), detailing the environmental impacts throughout their life cycles showed that, overall, the environmental cost for steel structures is four times greater than for wooden structures. The energy cost in housing production, in the physical plane, is the total value in specific energy units, from the material's production to its disposal. The more energy spent, the higher the cost and the greater the harm done to the environment. Besides the zero energy consumption in its formation process and the low consumption in the other stages, the

extraction of wood does not harm the environment, especially if it comes from a well-managed plantation.

Table 6 shows the relative values of energy consumption in the production of conventional construction material compared with sawn timber. The values are given in four types of energy units.

Table 6 –Energy consumption in the production of materials compared with wood

Material	**KWh/Kg**		**KWh/m3**		**Coal (Kg)**		**MegaJ/Kg**	
Sawn timber	0.7	-	350	-	0.8	-	<5	-
Glulam	2.4	>3.4	1200	>3.4	-	-	-	-
Cement	1.4	>2	1750	>5	260	325	-	-
Concrete	0.3	<0.4	700	>2	25	31	-	-
Bricks	0.8	>1.1	1360	>3.8	140	175	-	-
Steel	5.9	>8.4	46000	>131	1000	1250	≅30	>6
PVC Plastic	18.0	>25.7	24700	>70	1800	2250	-	-
Aluminum	52.0	>74	141500	>404	4200	5250	≅120	>24

Source: Mascaró et al (1978) and Oliveira (1998)

Looking at Table 6, we can compare sawn timber with other products widely used in the Brazilian civil construction sector. Baked clay bricks, for example, require 3.8KW per hour more than wood in the production of 1 cubic meter of material; and cement requires 5KW more. The manufacture of these construction materials also gives rise to another problem, more alarming in the short term: the emission of residues. The generation of undesirable residues, as well as their emission into the environment, is not an issue for wood, due to its high degree of biodegradability, its possible reutilization for energy generation, and the manufacture of derived products.

On the other hand, the disadvantages of reforestation wood are: a) its heterogeneity, i.e. the variation in its physical characteristics in different parts of the wood; b) anisotropy - the quality of reacting differently in tangential, radial and longitudinal directions when exposed to one and the same phenomenon; and c) higroscopicity - the quality of absorbing and releasing humidity that results in dimensional alteration and vulnerability to external agents when exposed to the weather. These disadvantages should be seen as inherent features of the material, and recognized by planners, so that housing constructions in wood might serve as good examples and contribute to a greater understanding of the material's potential.

In Brazil, research in the area of social housing built using reforestation wood is still just beginning, and the first utilization of Eucalyptus in housing projects is to be undertaken this year in the state of Rio Grande do Sul. Among the few experiments that have used Pinus wood, one that stands out is the construction of a complex of 90 residences, financed by the Campos de Jordão city council in the southeastern state of São Paulo, in 1983. The Technological Research Institute of the State of São Paulo (IPT) used Pinus wood from forest reserves within the city, with a prefabricated construction system that was accessible to the low-income population, and this became a point of reference in studies of social housing built from reforestation wood (LIMA, 1988). Although contracted labor was used, the basic housing unit of 41m^2 could be enlarged to 65m^2, or even built by the inhabitants themselves in a popular cooperative, due to the ease of self-construction: " ...feature of a construction project, component, or system that enables it to be self-constructed" (Abiko & Concílio, 1996).

Thus, the production of social housing from reforestation wood or crude earth is not an end but a means whereby people in certain regions of the country, which have usable reserves and a tradition of construction using these materials, might escape from the conditions of poverty in which they find themselves. For those regions that have reforestation areas, it would be possible to create a market producing wooden components for housing, and by means of a policy of investment in forest replenishment (the stage of the wooden housing production process that generates most employment), to stimulate the local economy. Research carried out by the Institute for Housing Studies – IHS (1991) and Abiko & Concílio (1996) concluded that " ...the existence of local manufacturing

techniques makes them more easily accepted as a solution, and these should be encouraged since they contribute to the local economy and to the technical and economic development of the community".

4. The Barriers To Sustainable Construction

4.1 Government Limitations.

In Brazil, the few initiatives since the United Nations Conference on Environment and Development (Rio de Janeiro, 1992) undertaken in the urban environment have brought as a benefit the consolidation of the collective environmental conscience, revealed by the recurrent reference to the term "sustainable development" in countless fields of scientific activity and in the implementation of local practical actions. According to Silva (2000), in spite of the " ...unanimity in the opinions concerning certain contemporary problems, such as the need to overcome economic and social inequalities or the importance of preserving biodiversity and natural resources...", there is a consensus in the discourse, but this comes undone in the proposals for concrete measures for dealing with the problem. This divergence between the theoretical and practical spheres is the cause of the obstacles to sustainable construction in Brazil.

In the field of public administration, the difficulty lies in a lack of administrative continuity and the incapacity of governments to prevail over their bureaucratic limitations and corruption. When those limitations are overcome, it will be possible to implement policies that will provide a chain of long-term actions typical of environmental protection strategies. Although sustainability is not something that is acquired in an absolute and permanent way, but rather through a continuous process of change, the "Agenda 21 on Sustainable Construction in Developing Countries" should endeavour to ensure that many projects already underway in the field of housing and urban infra-structure, with proven technical, economic and environmental viability, are put into practice through public policies.

According to Turner (1990), one of the main barriers that needs to be removed by governments regarding the housing issue is "...the habit of thinking in terms of impositional programs and packages, that is to say, standardized sets of goods and services for categories of people, made up of pre-chosen options". This administrative, cultural or merely geographical divergence between those who decide, control, and make projects, on one side and those who need, use, and pay, on the other, has already resulted in many unsuccessful experiments in housing, in economic, technical, aesthetic, environmental and social terms, and obviously in the habitability of the constructions. Even so, the simple assertion that an increase in the power of decision and control by the population is a way to assure social and economic sustainability of housing construction is not enough. Governments should contribute, recognizing and legitimizing channels for the communication of claims and complaints, increasing the access to basic resources and diminishing the direct supply of housing.

4.2 Importation of Technologies.

Another limitation of the Brazilian government in dealing with the issues surrounding the civil construction sector is the lack of a national technological policy, which creates favorable conditions for the faithful reproduction of the technological models adopted in developed countries, models not suited to Brazilian reality. On this idea, Pelli (1990) comments that "...the imported systems of the highly industrialized countries, implanted from Africa to Latin America, have not brought good results. Climatic requirements, as well as the fact that people in each place have their own way of building and of living, have caused grave problems not only in terms of productivity, but also of fruition of the constructed property."

As there is no such thing as apolitical technology, besides the social, economic and cultural causes, technological dependency is reinforced by the harmful effects of globalization, which makes poorer countries subject to an agenda designed to favor the economic and financial aims of large international groups. Technological dependency hinders the autonomous development of dependent countries in developing their own technologies, in an increasingly chronic process of marginalization of large segments of the population.

In this context, it is also important to mention some comments made by Goldemberg (1995), concerning the adaptation of local resources and energy saving in construction, suggesting the use of low energy consumption materials and techniques. According to the author, "developing countries need information that is better adapted to their own natural resources than that which they can obtain from industrialized countries. For example, the production of biomass does not only use a lot of manpower; this is also more readily available than fossil fuels in most tropical countries..."

4.3 Technological Inertia.

As for materials with a low environmental impact, such as wood from reforestation and crude earth, their low instance of utilization for building components is a complex issue, and it involves divergent interests and stances among producers, architects and engineers, public leaders and even consumers, who are often culturally averse to the material. The abandonment of traditional techniques that make use of natural resources by professionals involved in construction is partly a consequence of the way these are treated in most universities. In the words of Segawa (1988), "wood and earth: they are either dealt with in a traditional construction techniques class, under the guise of the history of architecture, or they are reviled as symbols of archaism and precariousness, primitivism, sub-development and chronic poverty, in the common sense of people and sanitary codes."

Aside from planners, the business community and public authority figures are also unaware of the potential of wood, and think forestation a low profit activity, disregarding it in favor of other alternatives, mainly agriculture and cattle raising. Thus, the consequent prospective shortage of wood indicates an urgent need to revert the situation. According to Ripardo (2000), although the annual target for the country's reforestation, set by the Brazilian Forestry Society – SBS, is 350,000 hectares per annum, the current rate of reforestation is just 140,000 hectares. The SBS estimates that the level of investment necessary to achieve this annual target of reforestation is around R$350 million (US$ 175 million), which underscores the need for the Brazilian government to promote reforestation. In countries such as Argentina, Uruguay and Paraguay, governments provide incentives in the form of financing and monetary reimbursements in the order of 50% to 75% of the invested capital.

There are authors who predict that, if there is no forest replenishment program, the supply of reforestation wood in the next decade will not be sufficient to meet the demands of the paper, cellulose, steel, and wood-derived products industries. Ripardo (2000) shows that the total area of reforestation in Brazil today is 65% less than when the federal government granted monetary incentive policies; that is to say, companies are cutting down more trees than they are planting. On average, 350 million square meters of trees are cut down per year in the country, and over half of that wood still comes from native forest.

As a result of this lack of awareness on the part of professionals, the business community, and governments, the image of technologies that use wood and crude earth are closely associated with rural environments, poverty and *favelas*, and suffer discrimination and resistance from the population. It is clear that even those who naturally make use of these techniques in the countryside reject them when they migrate to the city, preferring their new residences to be constructed from conventional materials, as a symbol of their social ascent, material advancement and stability.

5. Proposed Actions for Governments, Researchers and the Construction Industry

5.1 Governments.

In a nutshell, the problems faced by the government consist of rehabilitating Brazilian cities, recognizing the existence of the "illegal city", where most of the population lives, and the planning and construction of new urban settlements based on an urban administration process which Bonduki (2000) called "environmental-participative".

Among the transition strategies for the 21st century developed by Ignacy Sachs are the following proposals for government actions: promote institutional change, have the capacity to devise multidimensional public policy packages, and to redirect technical progress (Sachs, 1993). The challenge is to find new approaches to development capable of preventing environmental degradation and excessive social costs, rather than focusing

on palliatives measures. Given that association to the processes of globalization is inevitable, developing countries should adopt a posture of selective participation in world trade and the development process, adapted to the specific socio-cultural and environmental contexts of each region.

In terms of the institutionalization of environmental concerns, Brazil took a significant step forward when a specific chapter on the environment was included in its 1988 Constitution. However, "Chapter VI – The Environment" is somewhat broad in its scope and requires the creation of mechanisms able to instrument it, in order to enforce the law in a more incisive way whenever civil construction activity seems likely to cause significant harm to the environment.

In the State of São Paulo, for example, the Secretariat for the Environment – Secretaria Do Meio Ambiente (1998) – issued a document entitled *Proposed State Policy on Solid Residues*. Among the highlights with regard to the obtaining of cleaner technologies and integrated administration of civil construction resources are the parts related to demolition, materials recycling, utilization of renewable resources, and the reduction of construction residues. This initiative is without doubt a landmark in environmental management in the State of São Paulo, and should serve as an example for other initiatives from the federal government in the creation of public policies.

The multidimensional public policy packages mentioned by Ignacy Sachs relate to the comprehension of the singularity of each city (with regard to natural, sociopolitical, historical and cultural configurations), which is an essential element in the search for specific solutions for urban development, drawn up and implemented with popular participation and complemented by efficient capacitation programs. In this sense, the transfer of control over urban issues to the state and municipal authorities and the consequent increase in housing programs financed from their own budgets has improved chances for experimentation in alternative housing management and production processes. Accordingly, those processes that take into account local and regional potential, and which encourage partnerships with organized society and private enterprise, should be strongly promoted by governments.

According to Bonduki (2000), the numbers of the housing deficit "...are frightening and often have the effect of paralyzing public authority, which feels incapable of facing up to them. It is true that the problem cannot be solved in the short term, since it is a result of the structural characteristics of Brazilian society. But in order to tackle it we must have a coordinated plan of action in the medium and long term, calculate the necessary resources, rally the agents that need to be involved and begin to act soon." Regarding the apparent lack of resources allotted to housing programs, the author declares, "if there is political will and it is given priority, in fifteen years the deficit and its vegetative growth can be addressed, with the investment of around R$90 billion (US$ 45 billion). To do this we need to set up a unified national system of financing, stimulate production by the private sector and self-managed cooperatives, and also reestablish a national housing system."

The successful urban experiments should be divulged and serve as a basis for comparative studies between cities, both nationally and internationally, mainly among developing countries sharing similar socio-environmental panoramas. The government should also set up networks of cities and intensify decentralized cooperation among them, stimulate the creation of urban observatories to improve understanding, monitoring and forecasting of development processes, and establish a cooperative research and training program into sustainable urban development. In the field of education and training, the federal government, via the Ministry of Education, should restructure primary and secondary school curricula to include notions of urban eco-development, economy of resources and increased self-confidence; that is, initiate children and young people into their future role of citizens, involving them in the environmental management of the cities in which they live (Sachs, 1993).

5.2 Researchers

In view of the nonexistence of a governmental national technological policy, laying the foundations for national scientific and technological development is a task for universities and research institutions, which have a fundamental role to play in sustainable urban development. Universities have the capacity to bring together the principal actors responsible for the urban development and housing production processes, and so should provide technical and operational support for the carrying out of experiments in the pursuit of sustainable development.

In Brazil today, one can say that the universities and research institutions have already produced considerable knowledge, not only of sustainable construction systems and processes, but also of strategies for the implantation of these, taking into account the social, economic, historical and cultural aspects of the localities where they are to be implanted. Besides having the technical support necessary to systematize, analyze and to propose solutions, universities have considerable human potential to advise on and implement local development projects and to meet the specific demands of civil associations. In view of the size of the problems and the lack of pre-eminent solutions, there is an urgent need to implement the solutions already developed, with the involvement of public authorities, private enterprise and the population. Meeting the needs of future generations only makes sense if the needs of those who are marginalized in the present are also met, considering the concept of sustainable development as defined by the Brundtland Report.

In addition to this urgency for the implementation of known solutions, the universities and research institutes need to intensify their activities and research into: (1) analysis and systematization of successful construction experiments, with a view to establishing approaches and parameters for the assessment of new programs; (2) development of sustainable construction technologies adapted to production processes based on community participation; (3) development of eco-friendly construction materials, i.e., ones which cause less pollution and consume less energy during their life cycle; (4) recycling of construction materials, construction waste and all types of urban residues; (5) production of biomass in ecologically, socially and economically sustainable conditions, as opposed to the consumption of non-renewable fossil-fuel energy, and, (6) development of manuals and handbooks, as well as the organization of seminars and lectures for the dissemination of the knowledge produced, both to the low income population and for the capacitation of professionals and technicians involved in the construction sector.

5.3 Industry

Academic research can help to direct private enterprise investments, provided it has technical and economic viability, aspects of fundamental importance if it is to adapt to market regulations. If civil construction companies do decide to take on board new technologies and construction processes, a long and complex retooling of the industries will begin which, even at a time of rapid growth, may take ten to twenty years to achieve. Nevertheless, as was pointed out by the CIB (1999), in order to get companies with market-led strategies to change their stance, it is essential to bring about change in market demand. To achieve this, the population must be made aware of the importance and meaning of sustainable construction, since market demand in Brazil for this type of construction is practically nil. Here, once again, the responsibility comes back to government spheres and to the research community.

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