Opportunities for Technological and Economic Development Policy in Brazil

by

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ABSTRACT

Brazil's transformation from an agriculturally-based colonial economy to an industrial republic spans seven decades – from the 1930s to the present – with three rapid growth phases which were each followed by economic and social chaos. Three administrations of different political persuasions implemented policies that brought surges of foreign direct investment, foreign technology, and mechanization to Brazil. The nation's economy grew at an astounding rate – for several years at the highest rate in the world – but increased industrialization only increased the gap between the rich and the poor, and failed to provide the long-term employment and domestic investment required for sustainable advancement. Brazil has a stable economy again, and ready for another period of rapid growth. However, future economic growth for the long-term will be dependent on aiding sectors that have been left behind in previous decades. What is needed is a set of policies that addresses the inequality within regions, poverty in the rural and urban environment, vast income inequality, and sustainable rural development. Combined with renewed investment in domestic innovation, community-based solutions can increase the returns on national investment in development. By working with community partners in low-income areas, appropriate solutions can be introduced to an environment of long-term support. A joint project between MIT, the Universidade de São Paulo, and the Escola de Canuanã in rural Tocantins, Brazil, serves as an example of how partnerships between local and outside organizations can introduce organizational and technical solutions adapted to local needs and constraints. In January 2005, this interdisciplinary team worked in Brazil with community partners to introduce technology at levels as different as evaporative cooling by pottery and a computer center to address the challenges and ambitions of their everyday life. The technology case studies are not to determine success but rather to discover what needs to be in place for their implementation. A similar model of incorporating community input in program design and execution could be used in national development plans with greater effect than previous methods.

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Title: Instructor, MIT Edgerton Center

Policy Advisor: Alice N. Amsden
Title: Professor of Economy, Department of Urban Studies and Planning

Biography

Stephanie Dalquist is originally from Minnesota. Her early appreciation for invention and communication was supported by her family. These traits fostered the skills that allowed this project to happen years later.

Since 1998, Stephanie has been a student at Massachusetts Institute of Technology. She refined her interests in engineering and design from basic scientific principles as an undergraduate in Chemical Engineering and a graduate student in Materials Science and Engineering. Combined with a love of new cultures and languages (for now Spanish, Portuguese, French, German, and Mandarin Chinese), she seeks to apply her technical skills to the challenges faced in underdeveloped communities the world over.

Acknowledgements

The work presented here belongs in one of those fields where it could never have happened without the support of many people and the communities they belong to. The people of the *aldeia* Canuanã, *assentamentos* Caracol and Pirarucu, *favelas* of Santa Marta, Mangueira de Botafogo, and community programs of Rocinha shared their lives, challenges, and celebrations with us. Instructor Amy Smith of the Edgerton Center and Professor of Economy Alice Amsden from the Department of Urban Studies and Planning at the Massachusetts Institute of Technology have helped me distill those experiences and their contributions into what is presented beyond this page.

It all began with a class developed and run by Instructor Amy Smith at MIT's Edgerton Center. Through D-Lab, I worked with the D-Lab Brazil team led by Leo Burd. A native of São Paulo, Leo helped us to appreciate the values and paradoxes that have become a part of modern Brazil. Each member of the team –Prachi Jain, Yerrie Kim, Tejus Kothari, and Jessica Shor – brought their previous knowledge and open minds to the needs of our partner communities.

When we arrived in Brazil, our first contact with the Fundação Bradesco was with Fabiana Valente, who remained our ever-curious and knowledgeable partner throughout the installation of the computer center Centro de Inclusão Digital in *aldeia* Canuanã village. Fabiana welcomed us warmly to the Fundação's schools and community centers.

At the Fundação Bradesco school Escola de Canuanã, much planning and preparation had occurred before we even arrived. We were very fortunate to work with Diretora-Assistente Cacilda Borges de Oliveira e Souza; Assistente de Direção Administrativa Edilson Maranhão Viana; Doutor Cicero Ramos de Souza, coordenador do Grupo de Saúde Rural; and Environment Instructor Lucrécio Filho de Oliveira. In particular, Cicero facilitated our introduction to the leaders of the settlements and to the people living there. His years of service as the only doctor to visit the settlements encouraged the participation of young and old. Lucrécio was always there for helping us communicate in the *aldeia*. A long-time friend of the islanders, everybody found him easy to talk to and by being friends of his, we became friends of the islanders. His limitless knowledge of the traditions, fruits, animals, and fish known only to this region brought us experiences that few have the opportunity to know first-hand.

While we were there, we shared those experiences with some of the students from the Grupo de Saúde Rural. Eleven of the thirty members came back to school over their summer vacation to be a part of the projects going on with MIT and the Universidade de São Paulo. It was a pleasure to work with, and a joy to become friends with, Adão, Ana Paula, Bete Mara, Douglas, Gisele, Jairo, Leydvan, Luis Fernando, Olavo, Ronaldo, and Rone.

MIT and GSR were joined by three others hailing from São Paulo. For these *paulistas*, too, it was also the first time in Brazil's interior. It seems few Brazilians take the opportunity to explore the diversity of cultures and environments present in their country,

but Profesora Tereza Cristina M. B. Carvalho, Thiago Moreira, and Cintia Priscila Yoshimura left behind the Universidade de São Paulo to join us in Tocantins. They are each still working to make this kind of experience possible for other Brazilian university students and to introduce new technology in their country.

Without any of them, this would not have been possible.

Maps

Figure 1. National map of Brazil. Source: US CIA, 1994.

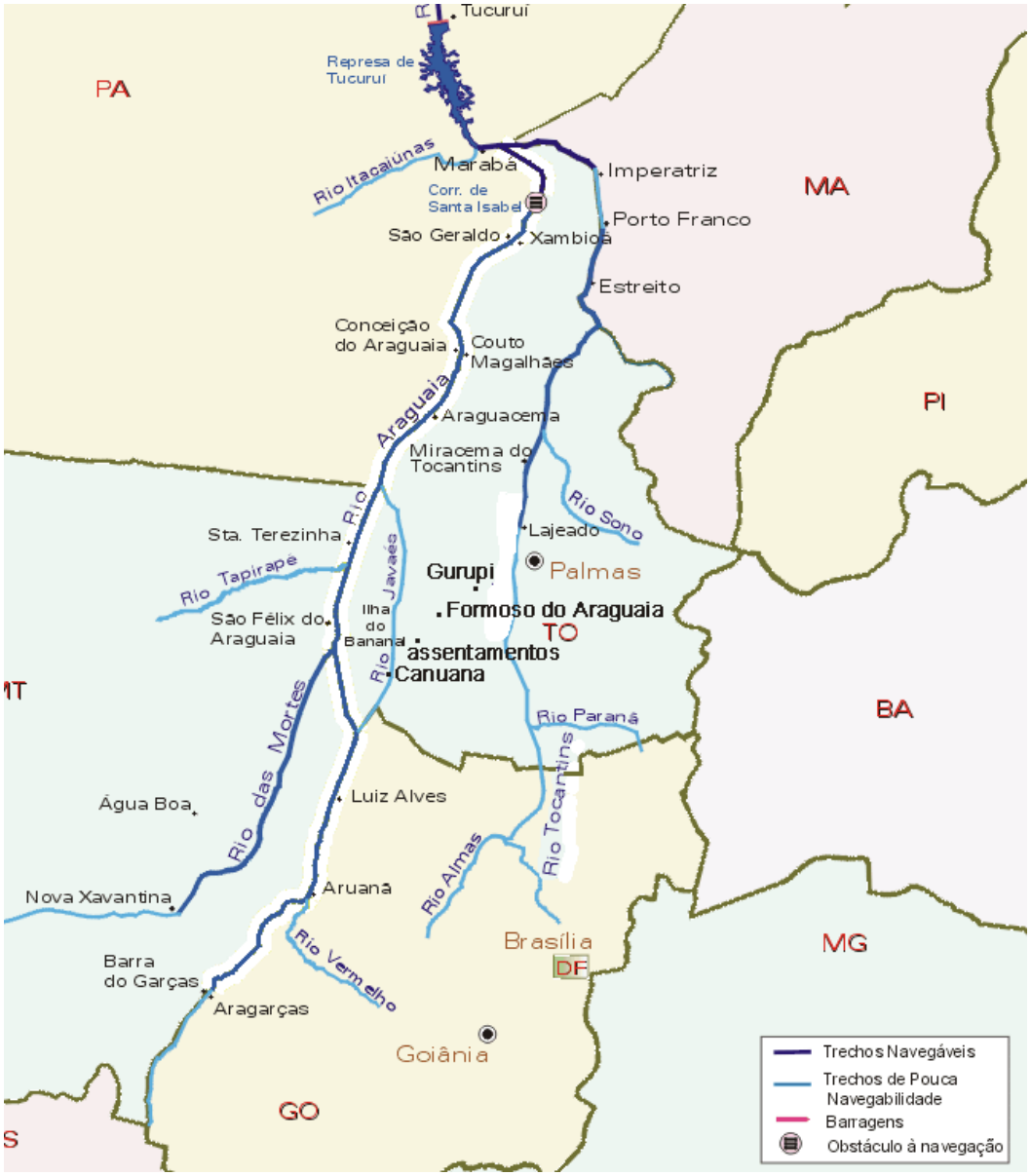

Figure 2 Tocantins (TO) and surrounding region. Source: Ministério dos Transportes, Governo Federal, 2005.

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Introduction

Import substitution industrialization for expansion of the Brazilian economy will soon reach its limits. Further economic growth is dependent on the nation's aid to sectors that have been left behind in previous decades. The time has come to shift programs and national funding for growth from the well-established industries on the coast to underserved regions in the interior and low-income communities in the inner cities. Instead of embarking on a new round of mechanization that increases the nation's inequality and makes thousands more jobs obsolete, a new policy paradigm must be found. By implementing a set of policies addressing inequality within regions, the endemic problems of poverty in both rural areas and the urban slums, the infamous gap between the Brazilian wealthy and poor, and the need for sustainable rural development, Brazilian policymakers can bridge the national divide and strengthen the domestic economy. Without also addressing the country's need for domestic innovation and a stronger commitment to education, these policies alone will not be enough. Increased access to information and education will increase the nation's overall competence, qualifying many more people to work in new economy jobs or start their own successful businesses.

It is possible to apply to many of these policies a framework known as participatory development. In participatory development, the challenges of designing a process for maximum impact, increased community buy-in, and long-term sustainability of development projects are addressed. By opening lines of communication with intended users, mapping user needs and suggestions, developing projects or programs in

conjunction with the community, and integrating their feedback into their community and similar projects in the future, development programs can better meet their objectives and provide long-term solutions to underserved populations.

A group from the Massachusetts Institute of Technology, along with the Universidade de São Paulo, and the Fundação Bradesco Escola de Canuanã, demonstrates how outside groups working with local community partners can successfully introduce new technologies or organizations to solve everyday challenges. By bringing solutions from around the world into a situation where they are analyzed by people from different geographical and technical backgrounds, previously local solutions can be adapted to meet the particular needs and constraints of communities facing similar needs. In the communities near Escola de Canuanã, the various levels to which basic technology were available determined the ambitions of the community. Based on their prioritization of the most critical needs, our international team introduced and adapted concepts to meet challenges in their daily lives. These adaptations become new local solutions, and are added to the portfolio of community-designed appropriate technology. The technology case studies are not to determine success but rather to discover what needs to be in place for their implementation.

As a model for future policies, participatory development takes advantage of the existing relationship between community leaders and government agencies. Instead of throwing money at a problem and hoping it goes away, this is truly an opportunity to bring policies in line with national goals and invest development money in projects that will have long-

term successes. The last seven decades of industrialization have shown that it is time for a new paradigm in Brazilian development policy, and this could be it.

MIT's role in International Development

In recent years, the interest of MIT students in applying their engineering skills in international and humanitarian settings has increased noticeably. New opportunities are available each year to expose students to the life and challenges in different parts of the world. Continuing relationships between MIT groups and partner communities all over the world ensure beneficial interactions for both groups.

One of the ongoing MIT links to communities in the developing world is through D-Lab, a class that helped make the work presented here possible. D-Lab is a year-long series of courses on development, design, and dissemination, which can also include field work for dedicated students. In the fall, students get a general background in international development and appropriate technology. A variety of guest speakers, case studies and labs demonstrate the challenges and rewards. In January 2005, D-Lab students then went to communities in Brazil, Ghana, Honduras, India, Lesotho, Samoa, and Zambia to learn about development efforts first-hand in their partner communities. Students had the opportunity in their host country and upon return to MIT to reflect on how the culture, language, economics, politics and history of their host country affected its development. Most groups bring with them technologies developed at MIT or in other parts of the world that could be useful in their partner community's environment.

The spring semester builds on the experiences of the fall and winter, but focuses on how technology is developed for under-served communities. The partner communities that host students in the winter typically work with students over the spring term, as well.

Students who visited in January often bring back design challenges for people in future classes or with a different set of skills. A project often takes more than one semester to fully develop, and so the class runs in an iterative fashion where projects are at different stages of the "pipeline" and may come back for several years as they are being perfected. Participants learn not only about the needs of their partner communities and about the different methodologies behind technology dissemination (e.g. mass-production and small-scale shops), they learn about the constraints of economics, materials, environment, education, and more, that make design for the developing world so challenging. As in the fall term class, a perspective on the country's industries and history of development keeps technology design in focus.

In January 2005, five MIT students examined the opportunities for technological development in a variety of different communities in Brazil. The group visited several of Rio's low-income communities known as *favelas*, as well as Canuanã, an indigenous village on the river Javaés in the state of Tocantins, and rural family settlements, also in the state of Tocantins. The visit was supported by local community leaders and our community partners, the Fundação Bradesco, Escola de Canuanã, and the Grupo de Saúde Rural. Students from MIT were joined by two students and a professor from the Universidade de São Paulo, who are interested in giving student in Brazilian universities the experience of learning more about their home country, the opportunities for its future, and the effects of its past.

Brazilian Development Policy of the 1900s

The coffee oligarchy that ruled Brazil before 1930 placed a low value on industrialization. Not until the bourgeois revolution of 1930 were the growing concerns of development and the new middle class addressed by Brazilian politics. Since then, *desenvolvimentismo* – or developmentalism – has been a key part of Brazilian national policy, and is in large part responsible for the current state of the nation.

During that time, Brazil has undergone vast political swings, but the economic development of the country has consistently been one of the primary driving forces. Through the democratic government of the 1950s, and even through the dictatorial regimes of the 1970s, left- and right-wing governments tried to prove themselves by stimulating the economy of an oft struggling country. In the 1950s and early 1960s, the leftist governments pushed nationalistic, protectionist, and interventionist policies. The overthrow of the Goulart administration in 1964 marked the beginning of two decades of military rule, where the economic development plan was characterized by large amounts of foreign direct investment (Eakin, 1997).

Each era brought finance, new technologies, and even whole new industries, to Brazil. Most were allocated to projects along the accessible coastline and its major cities. Rural development programs have had limited success to date.

The Vargas Years (1930-1945)

A military junta ousted President Washington Luís Pereira de Sousa in early 1930, after he tried to elect a friend as successor in a fixed election. Out with Luís went the Old Republic and the coffee barons that had ruled Brazil's politics and business for centuries (Bieber, 1999). Thus began Brazil's aggressive industrialization of the twentieth century under Getúlio Vargas, whose "colorless" campaign for the presidency painted proposals for change that would lead the nation in a new direction. Vargas served as dictator, congressionally elected president, and then dictator again, from 1930 to 1945 after Though Vargas grew up in an old gaucho family, and was part of the leading oligarchy, he had new ideas of how politics could support national development.

Vargas recognized the need to end the country's dependence on a single crop (Skidmore, 1999). Up until 1929, coffee was the primary export, accounting for up to 71% of the country's foreign exchange (Maddison, 2004). By the early 1930s, Vargas' fears that the economy needed to diversify from coffee were borne out. Worldwide demand dropped during the Great Depression, and the price of coffee on the global market continued to fall due to excess capacity (Hudson, 1998). By 1932, 60% of the value of Brazil's exports had been lost (Henshall and Momsen, 1974). Investment in manufacturing to replace now costly imports began to look more profitable to government policymakers and to businessmen.

The push away from coffee resulted in the diversification of natural resource exploitation. In order to encourage diversification, the state took a new role in economic intervention and incorporated economic nationalism with industrial growth. Many of Brazil's state-

owned enterprises developed from these early policies (Dickenson, 1978). A state-owned iron and integrated steel mill complex, the first in South America, opened in Volta Redonda (Eakin, 1997). The mill at Volta Redonda, in the north of Rio de Janeiro state, processed ores from the newly opened mines just across the state border in Minas Gerais. Much of that ore came from the newly formed Vale do Rio Doce Company, a state-owned extraction company. Vale do Rio Doce was formed in an attempt to diversify the nation's economy and provide much needed capital and jobs to the interior state. It remained a nationalized company until 1997. In the North and Northeast, though, a slow economic decline began as Brazil's sugar became less competitive on the international market, and no other crop emerged to take its place. Foreign direct investment (FDI) also became a key part of Brazil's growth between the two World Wars. FDI had been a part of early utilities development, but money began to flow into the manufacturing sector as well. Multinational companies like Ford, IBM, Siemens, and Firestone set up local factories to serve already established markets. This financing only came to major coastal cities, however, and was not a replacement for the declining agricultural industry in the interior.

Vargas's vision of the new Brazil was made official in the *Estado Nôvo* (New State), continuing the policies he started after his first election. Under the *Estado Nôvo*, though, Vargas ruled as by decree, with complete control over legislative and judiciary powers. His policies may have been in Brazil's best interests, but he was also quick to suppress social and political opposition. The Vargas policies included (Hudson, 1998):

- A protectionist policy to put limits on import of foreign goods

- Some of the highest tariffs in the western hemisphere
- Easy credit and tax exemptions freely available to domestic manufacturers
- Wage controls and strike bans to limit the power of organized labor
- The curtailing of state rights in favor of regional groupings
- State-regulated "worker interest groups" (*sindicatos*) with less influence than past unions, but greater membership diversity
- Fulfillment of a long-ago promise for workers' housing in Rio de Janeiro and São Paulo.

Combined, such economic policies kept domestic Brazilian manufacturers well-protected from foreign competition. The result was a strong encouragement for domestic production, and manufacturing flourished. The country's overall growth in GNP was a respectable 4.6% annually, and new industrial growth accounted for over a third of that growth. Strong protection against imports, like high tariffs, allowed traditional industries to grow and new ones to form, especially around cement, iron, and steel. For example, Brazil's cement production rose from 87,000 tons in 1930 to 745,000 tons in 1940 because of the high tariffs for imported cement products (Robock, 1975). The protectionist policies were a mixed blessing, though, as they also contributed to the growing inefficiency of business and higher prices for substandard domestically-manufactured goods (Eakin, 1997).

By the end of the Vargas regime in 1945, there were noticeable changes in Brazil's economy and industrial structure. There was a new upper crust in society: the most

powerful families were no longer from the old colonial coffee plantations, but from the recently surging immigrant businesses that grew up under Vargas's protectionist policies (Eakin, 1997). Between 1890 and 1930, nearly five million immigrants arrived in Brazil, primarily from Japan, Italy, and Germany; each group boasted entrepreneurs that changed the Brazilian business scene. The Japanese came to work in the plantations, but quickly came to own them, developing one of the largest farm cooperatives in Latin America. Francisco Matarazzo epitomized the Italian entrepreneur. He reestablished the family lard business in Brazil and went on to own United Industries, an empire responsible for ships, railway cars, trucks, chemicals, distilling, metallurgy, salt and sugar refining, meat packing, and insurance (Page, 1995). German immigrant Hans Stern came to Brazil to escape the Holocaust, then founded one of the largest international jewelry businesses. Germans were also instrumental in the establishment of Brazil's early breweries and its first airlines, Varig and Vasp.

When these entrepreneurs arrived in Brazil, most of them had few assets to their name. The country's policies during the birth of their businesses gave them the opportunity to change its future. It is for progress like this that Vargas's legacy as the "father of the poor, and the mother of the rich" plays to the memory of policies that went both ways. Vargas alternately appeased the elite landowners and military stakeholders while providing access and reforms intended for the growing urban and middle classes.

50 anos em 5: Juscelino Kubitschek (1956-1961)

Domestic policy later swung away from the corporatism that marked the two decades of Brazil under the ideals of Getúlio Vargas. The populist and nationalist economic development policies of the 1950s and early 1960s changed the path the nation would take, but not the ultimate goal. In 1956, more than one-third of Brazilians voted for Juscelino Kubitschek over the emotionally charged populist party, the major opponent in the election. Kubitschek became the only president post-Vargas to serve his full term until this decade, in part due to his common appeal and the dedication with which he pursued the nation's development (Maxwell, 2002).

Under the campaign promise of *50 anos em 5* – fifty years in five – Brazil's economy continued to industrialize at an amazing rate. Once elected, Kubitschek put into plan a *Programa de Metas*, or Target Plan. The *Programa* brought the state and private sector together to accomplish his high-growth strategy (Skidmore, 1999). With five major areas – energy, transport, food supply, basic industries, and technical education – the *Programa* outlined the goals and responsibilities of infrastructural development needed to reduce both technical and organizational bottlenecks in the modern society.

Among those goals was the creation of an automobile industry, based in São Paulo. Although there was no domestic automotive production or even production capability at the beginning of the decade, new factories had made over 300,000 vehicles by 1960 (Hudson, 1998). As the automobile plants opened, an oil refinery opened in Cubatão, also in the state of São Paulo, to serve their growing needs. It was soon joined by a steel

mill, fertilizer, cement, and petrochemical plants, until twenty-five heavy industries were operating in the small valley in São Paulo around Cubatão (Page, 1995).

The growing industry on the coast also served to open up the interior of Brazil. The growing availability of automobiles, freight railroad, and mechanized equipment opened the interior states of Mato Grosso and Goiás to mass cultivation (Hudson, 1998). For example, in the late 1950s, three-quarters of Brazil's farms used only human power in cultivation. Once tractors were adopted in Rio Grande do Sul, they spread quickly through São Paulo, Minas Gerais and other states even further from the coasts. To increase availability, a national manufacturing plan for tractors was established, they became popular throughout Brazil's larger farms. A similar path of subsidized growth increased the use of domestically manufactured fertilizers in agricultural centers (Henshall and Momsen, 1974). Beyond all these programs, one major project began to attract people into the interior: the beginnings of a new Brazilian city far from all the coastal metropolises.

Projects like these openly challenged the colonial Portuguese tendency not to stray too far from the coast. Kubitschek's administration used both organizational and engineering feats as an attraction to the interior, still rural and largely unindustrialized. Hydroelectric plants opened across Brazil, harnessing power available only in the interior, and attracting power-hungry industries. Highway projects connected the coastline to Brazil's minor cities, criss-crossing miles and miles of empty land with 13,000 kilometers of new highway (Catalão, 2002).

Accessibility did not immediately bring development to the interior, and "pull" policies were also employed to try to lure industry away from the already prosperous coastline. The new *Superintendência para o Desenvolvimento do Nordeste* encouraged investment, and in particular industrialization, in the Northeast. Tax-forgiveness was a major component in the plans of the SUDENE, though land reform was not (Skidmore, 1999). Other new public bodies – like SUDAM and SUFRONTE, the superintendents for the development of the Amazon, and Southwestern Frontier, respectively – were also created to bring investment and employment to other underdeveloped Brazilian regions. Their missions included leading literacy and health drives and the study of agrarian and land use regulation. Under Kubitschek, the government finally had the administrative capacity that it lacked under Vargas to meet the needs of a newly industrializing society (Lafer, 1970). For example, SUDENE's first development plan called for the establishment of a steelworks, a synthetic rubber factory, and a textile industry. The first two were delayed. The Northeast's textile industry was modernized to increase capacity and worker safety. New machines increased productivity and revolutionized the shop floor. Breaks on capital expenditures established new enterprises in the market and allowed other major players to grow.

These agencies were supposed to serve the development interests of the region; but the focus on industrialization, bordering on exploitation, put community trust in jeopardy. The modernization of the textile industry cost 20,000 jobs (Dickenson, 1978). The policies ended up being effective in attracting new industry and in diversifying goods, but

did not generate additional economic opportunity for the rural poor they were supposed to serve. Corruption of public development agencies in past eras violated community trust and reduced their positive effect on the target communities.

Administrative scandals occurred regularly – the Indian Protective Service, or *Serviço de Proteção aos Índios*, degenerated in these years under scandals of massive corruption, landgrabbing, labor exploitation, and human rights abuses, resulting from the dereliction or collusion of SPI agents. A 1968 government enquiry led by Attorney General Jader Figueirido exposed evidence of unfair pricing of land and wood, deliberate tuberculosis infection, agency resistance to and inappropriate demarcation of Indian lands (which covered only 10% of Indian lands by 1967, and now includes 12% of the national territory), and the forced removal of communities from Indian lands to make way for ranching, which ultimately led to the deaths of up to one-third of the transplanted Indians (Garfield, 2000). Although initiated to discredit the populist policies of earlier administrations, every allegation was confirmed by fact-finding missions from other groups like the International Red Cross. As a result, of the 700 SPI employees, 134 were charged with federal crimes, an additional 33 were fired from their positions in the agency, and 17 more were suspended (Garfield, 1999). The remainder were realigned with other groups to form the present Indian affairs agency, FUNAI. Between 1900 and the time the report was published in 1968, the million-strong indigenous population of Brazil had been halved (Ribeiro, 1995).

Perhaps more than any of the other *Metas*, Kubitschek will be remembered for fulfilling his campaign promise to relocate the nation's capital. The idea of a central capital that could unify the surrounding regions had been a part of the Brazilian destiny since the 1800s. Its creation was specified in the 1891 constitution, and a site was selected as early as 1893 (Skidmore, 1999). Located in Goiás – 630 miles from Rio de Janeiro and 700 miles from São Paulo – the site for Brasilia became the new Distrito Federal upon its 1960 inauguration. Brasília started as a planned and ultra-organized city, intending to represent the egalitarian and modernistic Brazil. The city layout was supposed to make it possible for all of the country's previously segregated social classes to live and work together (Meade, 2003). It very quickly overgrew even the most optimistic plans of the city designers, introducing both chaos and capital to the once uninhabited plains (Eakin, 1997).

By the early 1960s, many of the industrial targets had been met, and change was evident across the nation. During the previous decade, electric capacity had doubled, paved road length had tripled, steel production had nearly doubled, the cement industry had become self-sufficient, and the automobile industry flourished – turning out cars as fast as factories in more industrially advanced nations and using 90% Brazilian-made components(Henshall and Momsen, 1974). Still, growth had not been even throughout the country. Despite government efforts to attract manufacturing and other industrial sectors to poorer parts of the country, most growth took place along the coast. The already existing regional differences in firm and workforce concentration were exacerbated by the rapid economic growth under Kubitschek (Table 1 and Figure 3).

	1920		1940		1950		1960		1969	
	Firms	Workers	Firms	Workers	Firms	Workers	Firms	Workers	Firms	Workers
Region	*Percentages*									
North	1.86	1.41	1.93	1.57	1.44	1.22	1.59	1.00	2.44	1.20
Northeast	17.03	18.69	13.69	17.03	17.53	15.69	15.63	11.00	17.26	9.04
Periphery	14.69	11.11	15.97	11.82	16.21	12.55	16.77	14.06	18.47	14.00
Heartland	52.11	57.58	52.75	59.82	56.70	60.69	48.75	64.72	44.52	66.68
Rimland	14.39	11.19	15.66	9.75	18.11	9.85	17.26	9.21	17.31	9.07

Table 1. Regional distribution of manufacturing establishments and workers in Brazil, 1920 – 1969. Adapted from Henshall and Momsen, 1974.

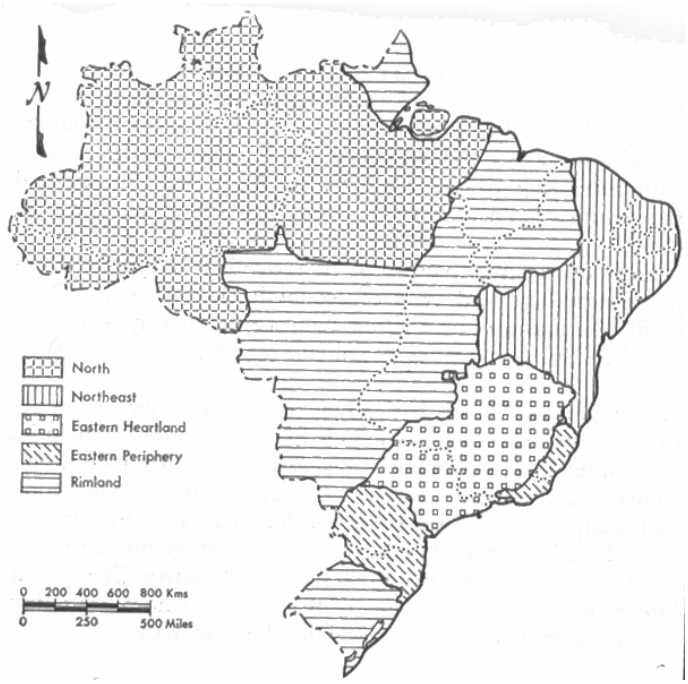

Figure 3. Regional divisions used in Table 1. Source: Henshall and Momsen, 1974.

Countering the shift of workers from the rural to urban areas, the less developed regions also showed higher than average economic growth rate over a similar period (Table 2). Unfortunately, much of this economic growth was a result of new capital-intensive firms. These new businesses eliminated jobs in the region, but brought a net gain in revenue. People put out of jobs in small businesses ended up moving to the rapidly growing cities, hoping for a better outcome.

	National area (%)	Pop./ km^2	Percentage Distribution						Per Capita Income		
			Population			Total Income			% National Average		
Region			**1950**	**1960**	**1970**	**1949**	**1959**	**1970**	**1949**	**1959**	**1970**
North	42.0	1.01	3.6	3.7	3.9	1.7	2.0	2.0	47	54	51
Northeast	18.2	18.23	34.6	31.6	30.2	14.1	14.0	12.2	41	44	40
Southeast	10.9	43.38	43.4	43.8	42.8	66.5	64.1	64.5	153	146	151
South	6.8	29.35	15.1	16.7	17.7	15.9	17.5	17.5	105	105	99
Central West	22.1	2.70	3.3	4.2	5.4	1.8	2.4	3.8	54	57	70

Table 2. Economic growth in rural areas was rapid through the mid-twentieth century. Adapted from Robock, 1975.

The growth of informal settlements in urban areas – including São Paulo, Rio de Janeiro, Recife, and the new Brasilia – were a result of the poor land distribution policies in interior agricultural or ranching states leading to the migration of displaced workers. The rural poor went from being rural wage earners and sharecroppers to being an itinerant labor force (Page, 1995). Many of them gave up and moved to the cities, where their actual earning potential was much lower than they imagined. Over the 1950s, 1960s, and 1970s, 20 million rural poor moved to Brazil's urban centers – the largest migration ever of its sort (Hudson, 1998). Those that stayed on in the country and tried to claim land were ignored by the government, which created conflict when the lands were sold *en masse* to mechanized agricultural corporations or ranchers. The migration to the cities continued despite attempts to develop the Amazon and to limit the size of the largest cities in favor of strengthening mid-sized cities.

The ambitious development during the Kubitschek era was not without environmental consequences or social costs either. In Cubatão and near other newly industrialized areas, informal worker settlements sprang up near the heavy industrial facilities. The cities clouded over with smog, and the air and water filled with pollution. People were getting sick from industrialization in Brazil at the same time that the environment began

to emerge on the agenda of European countries and the United States. Similarly, the highways built across sensitive ecologies against the warnings of government scientists demonstrated the nation's prioritization of industry and society. Many of those ecologies also encountered complications from the changed hydrological cycle as a consequence of bringing hydroelectric power to the interior.

Worse, the poor were still poor. Though many people had moved to the cities hoping for better job opportunities and economic conditions, their situations did not improve. In 1960, 40% of national income was distributed among the top 10% of the population, 36% in the next 30% of the population, and 24% among the poorest 60% of Brazilians (Hudson, 1998). Half of those in the poorest category lived on rural farms, where they still practiced traditional subsistence agriculture. The other half were those who had come from a background of subsistence agriculture and then found themselves in the cities and unemployed.

Brazil may not have quite made up *50 anos em 5*, but the advance in industry and economy was undeniable – and it would turn out to be costly. Domestic savings were kept low, domestic investment was low, and the foreign capital attracted to Brazil was not sufficient to maintain the high rate of growth (Skidmore, 1999). As a consequence of Kubitschek's economic policies, an era of inflation and economic instability began in the early 1960s. Unable to bring the nation's fiscal situation under control, Kubitschek's successor, João Goulart, was overthrown in 1964. Even under the military rule that

lasted until 1985, the country earlier known as the “sleeping giant” took giant steps into the future.

The Brazilian Miracle (1969-1973)

In the government's September 1970 *Metas e bases para a ação de govêrno* (Targets and Foundations for Government Action), General Emilio Garrastazu Médici laid out the steps Brazil had to take to make this last big step into the developed world. He proclaimed that the March 1964 revolution had created "the basic conditions for true development, democracy, and sovereignty," when Brazil most needed "above all, a government without commitments to the interests of any group, class, sector, or region" (Skidmore, 1988).

The earlier policies of import-substitution industrialization, particularly of consumer durable goods, paved the way for rapid expansion and modernization of Brazil's industries in the late 1960s to early 1970s. On a quest to legitimize the new military regime to critics both inside and outside Brazil, Médici and chief economist Finance Minister Antônio Delfim Neto sought to return the nation to its upward growing path.

Industrialization under the Kubitschek administration (1956-61) had emphasized the growth in capacity and market for consumer durables. After the economic foundations of the *50 anos em 5* collapsed in 1962, demand dropped sharply. The quickest way for the new military government to re-energize the economy was to stimulate demand for these products and reactivate idle capacity. As a side effect to this stabilization, the purchasing power of an already relatively affluent part of society was increased (Skidmore, 1988).

The policies that drove the economy forward in the early years of military rule sought to make better use of the increased capacity and mechanization achieved during the previous surge of growth. The consumer durables industry was again called into action in the sixties. Credit restrictions were eased so the growing middle-class could purchase durable goods like automobiles and refrigerators, increasing domestic sales of goods. As demand went up, so did productive capacity, and the size of the workforce, and therefore the demand, creating a cycle that strengthened the economy on macro-scales but actually decreased real income for the lower classes and increased the wage gap (Table 3) (Page, 1995).

Income Groups (Percentile: Lowest Income Group to Highest	Relative Income Levels (Percent of Total Income)			
	1960	**1970**	**1980**	**1995**
1-10	1.9	1.2	1.1	1.1
11-20	2.0	2.0	2.0	2.2
21-30	3.0	3.0	3.0	2.4
31-40	4.4	3.8	3.5	3.2
41-50	6.1	5.0	4.5	4.2
51-60	7.5	6.2	5.5	5.3
61-70	9.0	7.2	7.2	7.2
71-80	11.3	10.0	9.6	10.1
81-90	15.2	15.1	15.3	16.1
91-100	39.6	46.5	48.3	48.2
	100.0	100.0	100.0	100.0
Bottom 50%	17.4	15.0	14.1	13.1
Top 5%	28.3	34.1	37.9	34.6
Top 1%	11.9	14.7	16.9	13.9

Table 3. Income distribution in Brazil, 1960-1995. Notice that the percent of total income for all income group percentiles but the richest decile declined between 1960 and 1970. Adapted from Eakin, 1997.

Brazil's sought to stabilize the economy yet again, but without the tough monetary and fiscal policies prescribed by the International Monetary Fund (IMF). The government

hoped to draw back private investment by reduced inflation in conjunction with new economic policies favorable to producers. With authoritarian power to speed the process, the Generals acted quickly on a somewhat orthodox and very gradual return to growth.

Under the Campos-Bulhões plan first introduced in July 1964, Brazil began enacting "transitional" measures to reduce inflation. Key economists cited three main sources of inflation: public sector deficits, excessive credit to the private sector, and excessive wage increases (Skidmore, 1988). The three main components of the policy were the immediate reduced expenditure by government to cut the public sector deficit, indexation of fixed assets, overdue tax bills, and a new type of government bond; and a wage policy that closely tied unions to federal control. None of these would have been possible without the presence of an authoritarian regime, which created a central bank from nothing in 1965 and persuasively enforced its fiscal policies by eliminating other alternatives.

Their traditional approach to debt in developing countries rejected, the IMF expressed "great skepticism about the 'gradualist' approach to the problem of inflation" (Gordon, 1964). But by 1969, Brazil's was the fastest growing national economy in the world, with an annual GDP growth rate of 11%. Inflation had returned to 17%, from several hundred percent a few years earlier (Skidmore, 1988). Subsequently, foreign direct investment returned by the millions.

An economic success story like this may be known as a miracle, but this became known as the Brazilian Miracle. From 1969 until 1973, Brazil maintained the highest economic growth rate in the world through an environment favorable to producers, with policies that included:

- Suppression of worker wage demands – for example, workers' wages were capped so that even with the reduced inflation rate, their real income was depressed
- Powerless unions, even in the face of increased pressure for productivity and the consequent increase in industrial accident rates
- High rates of foreign and domestic private investment – invited not only by increasing exports but also through increased extraction and processing of natural resources.

By 1973, Brazil was exporting USD$10 billion, up from less than USD$3 billion in 1968 (Page, 1995). Much of the growth was related to the increase in production and manufacturing-oriented businesses (IBGE, 1986). State-owned enterprises were among the fastest growers.

The capital goods sector hugely benefited. Brazilian industry leaders used to have to buy machines and other capital equipment overseas. During the late sixties, the domestic capacity for production equipment grew solidly. Foreign businesses also played a big part in the new developments – foreign direct investment contributed heavily to basic industry, development of the infrastructure, and production of military hardware (Skidmore, 1988). Despite the military administration's claims of nationalism and

autonomy, their new growth model relied almost completely on the influx of foreign capital to maintain itself. The major weakness lay in turning over control of the nation's money and knowledge centers to foreigners in exchange for their new military hardware and increased budget.

Productive growth was still focused on the economy as a whole, and therefore disproportionately emphasized development of the major coastal cities. As the available productive capacity filled up, policymakers turned to the interior for additional growth opportunities. In the Northeast – still impoverished from the collapsed sugar economy and recent years of bad drought – huge tax write-offs did lead new companies into the region. Most of them, though, were still capital-intensive rather than labor-intensive. As in the fifties, the new Northeastern urban industries were actually destroying jobs rather than creating them (Skidmore, 1988). In particular, Recife, capital of Pernambuco state, was flooded both with investors looking to produce a quick mechanized buck and the rural poor – looking for jobs that were not there.

The northern states, like Amazônia, fell victim to similar fates even when development was done specifically in cooperation with regional planners such as the *Fundo de Investimento da Amazônia* (Fund for Investment in the Amazon, or FINAM). A wide range of new technical equipment was brought into the region, but few positions were created. Those that did appear were not suited for those people who needed them the most (Clüsener-Godt and Sachs, 1995). Highly technical jobs did not match the low average education in the region, and qualified technicians were loath to leave better jobs

in the cities. The jobs most needed in the region were unskilled positions requiring only a limited education and no special knowledge. Instead of creating them, the highly mechanized processes reduced job opportunities. This was true even in job fields that used to employ many uneducated Brazilians, including ranching and agriculture.

After the failure of new job creation in the Northeast, General Médici sought to incite rural-rural migration. Following the idea of the Belém-Brasília Highway that connected the new capital to the northern coast, Médici initiated the Transamazônia Highway. Starting in João Pessoa, Paraíba, at the northeastern tip of Brazil's coast, the Transamazônia Highway would run from the Atlantic all the way through the Amazon to the state of Acre and eventually the Peruvian border. Construction would create new jobs moving farther and farther inland, with the hopes of creating migration from the Northeast. In particular, movement was expected from the most impoverished states of Pernambuco and Bahia. The final destinations on the *Programa de Integração Nacional* (National Integration Plan, PIN) were supposed to be new villages along the highway. The villages would be located in the states of Rondônia, Mato Grosso, and Acre. But once the highway was finished in a region, so was the village. Deserted settlements were left all along the highway as the interior was populated and then again abandoned. Those who did stay found themselves on the dead-end path of subsistence farming. Major landholders already owned much of the surrounding land, and had taken advantage of the favorable investment climate to mechanize their farms. Already low-paying jobs had now been rendered obsolete, and entry into commercial agriculture was near impossible because of the concentrated ownership of land.

Many of the people who started out on the highway did not even continue westward – they diverted south to answer the "pull" of São Paulo state (Meade, 2003), which was still experiencing incredible growth that every unemployed country man thought could be his next big leap. What was supposed to be the solution to two of Brazil's problems – "men without land in the Northeast and land without men in Amazônia," in General Médici's words (Skidmore, 1988) – solved neither and turned into an ecological disaster. Migrant workers in the roadside settlements laid claim to land, then deliberately cut and burned the forests. Failing to grow crops, they ceded the land to cattle ranchers, who burned down more of the forest. In other areas, the highway allowed the introduction of environmentally exploitative industries like paper mills and mining, which polluted the waterways.

The government's so-called "Pharaonic Projects" created during the Brazilian Miracle – that is, projects fit for a Pharaoh – left behind more of a legacy than their creators may have wanted. Highway and industry projects in the Amazon basin created significant ecological damage, frequently epitomized by deforestation and indigenous rights violations. As can be imagined, the new electricity plants brought with them similar consequences. They made industrialized business and middle-class living possible in rural Brazil. But they also wiped out huge amounts of land. Along with the land went the trees, animals, and peoples living on it (Clüsener-Godt and Sachs, 1995). Each major energy project – like the Tucuruí reservoir and the Itaipú hydroelectric plant – displaced at least 20,000 people from some 250,000 hectares of land (Survival International, 1987).

Problems in indigenous relations related to human rights abuse, landgrabbing, mining, and disruptions to tribal lands and migrations arose frequently, and were dealt with by the military under a heavy hand. A second miracle under these conditions was the resilience of the inter-relationship of sociodiversity and biodiversity under such adverse conditions.

It is conceivable that another round of growth like that seen in the early seventies could be the end to many of Brazil's native cultures and species. Throughout the 1900s, almost 100 of Brazil's 510 distinct indigenous groups disappeared (Clüsener-Godt and Sachs, 1995). The cultural extinction was a result of assimilation as well as the extinction of a lifestyle. Major development projects like highways and hydroelectric plants as well as industrial projects like mining and agricultural expansion also divide land. Previous travel routes of nomadic tribes, hunting grounds, and spiritual places have been at risk. The regional plant and animal species that are a part of indigenous life in Brazil are also on the decline – fish are poisoned from upstream extraction of ores, trees are removed for agricultural expansion and lumber trafficking, and animal habitat is shrinking. With their lifestyle in the interior decimated, many people have headed for better fortune.

Those northerners who fled the side effects of rural development often found themselves in worse situations in the cities. Informal housing settlements, known as *favelas*, were springing up around the nation's cities to accommodate the poor who had recently landed there. In a sense, many of the infrastructural and planning problems of Brazil's modern cities are consequences of bad rural land planning that has now shifted to bad urban planning.

Despite the country's improvement in overall economic position, and the increased affluence of the upper and middle classes, the Brazilian Miracle was not so beneficial for the poor. The decrease in real income exacerbated the national inequalities of wealth (Table 3) at the same time as fewer rights – both labor and human – were available to the common Brazilian. One cause of the increased poverty levels was the growing concentration of people moving into the urban areas, looking for new jobs. At this point in history, Brazil had truly transformed from a rural state to an urban one. In 1950, even before the leadership of Juscelino Kubitschek, 64% of the population was rural, and 36% lived in urban areas. By 1980, the proportions had already reversed to 33% rural and 67% urban. Brazilians in this era had more to worry about than their wages though – the military regime was and still is infamous for its repression, torture, and death squads. Though their economic policies fostered amazing industrial growth, the human developmental conditions remained at a low. What the military policies overlooked was that long-term technology development cannot take place without human development, and human development is not possible without basic human rights, many of which were not available to Brazilians between 1964 and 1985.

A whirlwind of development between 1969 and 1973 brought the nation to a dizzying pinnacle, one that obviously could not last long. Over that short time frame, there was three-fold growth in exports, and unprecedented industrial growth in fields as diverse as basic industry, infrastructure, and military hardware. The São Paulo auto industry and the materials associated with their domestic supply chain are a good example of national

industry growth in the Brazilian Miracle. Steel production went from 2.8 million tons in 1964 to 9.2 million tons in 1976. This allowed automobile production to rise from 184,000 vehicles to 986,000 vehicles in the same period (Dickenson, 1978).

The 1973 oil crisis marked the beginning of the end for the Brazilian Miracle, and so many other economic dreams of the early seventies. At that time, Brazil was importing 80% of its oil, and was hit hard by the oil shortages and rising costs. In contrast, it now produces half of its own oil, and has proven reserves that could last over a decade at current consumption rates (EIU, 2004).

The bubble burst in 1973, and ended under huge foreign debt, inflation, a recession, increased income disparity, and the fear that Brazil would never truly make a success of itself (Meade, 2003). A weak attempt to continue development from 1974 through 1985 focused on the import substitution of basic inputs and capital goods, along with expanded exports of manufactured goods (Hudson, 1998). Mid-seventies growth was still highly dependent on international borrowing, international aid, and investments from foreign multi-national firms. These sources of capital also dried up as foreign investors worked to recover from the energy crisis on their "home fronts." It seemed nothing could bring the nation back on track.

Out of the disruption brought on by the economic collapse came more confusion. Rapid inflation led the military to increase the presence of civilians in the government until ceding to democracy in 1985 as the economy tumbled out of control. None of the early

democratic governments could restore inflation to normal rates, either. President Fernando Affonso Collor de Mello tried, and failed, with the radical approach of confiscating all of the population's savings, before his administration was torn apart by exposure of corruption that surprised even Brazilians (Meade, 2003). Cocaine use, embezzlement, kickbacks, and political favors for large corporations were among the indictments leading to Collor's 1992 impeachment. Accusations of corruption in the state government of Paraíba even led to one governor shooting his predecessor (Page, 1995). Violence was increasingly common in Brazilian daily life. Particularly in the *favelas*, waves of random massacres and drug-related executions stunned the nation and scared city-dwellers. Until the late nineteen nineties, economic and social chaos, rather than development, prevailed.

Partner Communities

One of the greatest challenges to Brazil's development is the great diversity in communities and people that also makes it a beautiful country. The variations in culture, climate, and population density complicate development efforts because few organizational structures or technologies meet the specifications of all the deserving groups across the country. Profiled here are two different types of community in the rural state of Tocantins and the *favelas*, (informal low-income settlements) of Rio de Janeiro, as well as the opportunities for technology policy development in them. The first step to working with the Brazilians to understand and express their future opportunities is understanding the constraints and resources of their local reality.

Community: *Aldeia* Canuanã

Brazil is a large country with great variety in culture, climate, environment, and needs. Even rural areas vary greatly from the forested regions in Amazonas to the desertified Northeast states like Pernambuco to the *pantanal* (a sort of wetland) and *cerrado* (savannah) regions. Tocantins is mostly *pantanal* and *cerrado*, with its borders just touching the forests and the desert regions to the north. The state of Tocantins was officially established in the 1988 Constitution from the northern territories of the state of Goiás, launching a new autonomous region with the initiative of bringing foreign and domestic investors to a modern, developed state. The following year, the capital city of Palmas was founded. A purely planned city designed to meet the target population and industry growth of the new state, it is Tocantins' major connection to the rest of Brazil and the world (MRE, 2005).

Some five hours by car from Palmas is the *Ilha do Bananal* (Banana Island). *Ilha do Bananal* is a fluvial island nested between the rivers Araguaia and Javaés. It is the largest fluvial island in the world, at about the same size as the state of Massachusetts (some 1800 hectares). Each year, up to two-thirds of the island is flooded throughout the six month rainy season. The island is divided into two parts. The northern half, known as the *Parque Nacional do Araguaia* (National Park of Araguaia) (IBAMA, 2005) is an ecological sanctuary with rivers, lakes, woods, and wildlife. The southern half of the island is the *Parque Indígena do Araguaia*, where around 1,700 Javaé and Karajá live in small villages, each known in Brazilian Portuguese as an *aldeia*, like Canuanã.

The *aldeia* Canuanã, also written Kanoano, has about 400 residents living in 70 family groups. The people of Canuanã are primarily indigenous Brazilians of the Javaé tribe. Some people have come from other tribes, like the Karajá, Tuxá, Xerente, and Avá-Canoeiro. About 70% of the people in Canuanã are multilingual – speaking Portuguese and at least one language of the Macro-Ge family, mostly Inỹ, but also Javaé and Karajá (Survival International, 1987).

Like many traditional villages, Canuanã is organized in rows along the river Javaés (Figure 4). The most important families and buildings are built closest to the river, in a straight line along the bank. In Canuanã, the people who live closest to the river include the *cacique* (political head of the village), the *pajé* (spiritual head of the village), teachers, and craftsmen and artisans. Along with these people and their families, important civic organizations are located near the river. These include the *escola tainá* (school), a very small market, and the Canuanã office of the *Fundação Nacional do Indio*, Brazil's national Indian affairs agency. Just beyond these is a low concrete building with dried *palmeira* leaf roof, painted inside with traditional designs. The building serves as both the town meeting hall and sports court.

A second row of homes is built beyond the first, and so on, to five rows. In the back area of the village are a palm grove where the dead are buried, space for livestock and crops, and the *casa dos homens*. The *casa dos homens* (men's house) is a site for socialization and ritual celebration – but only to be entered by men and boys over 11. Women are

barely allowed within sight of the *casa dos homens*, and punishment for violating the taboo is severe.

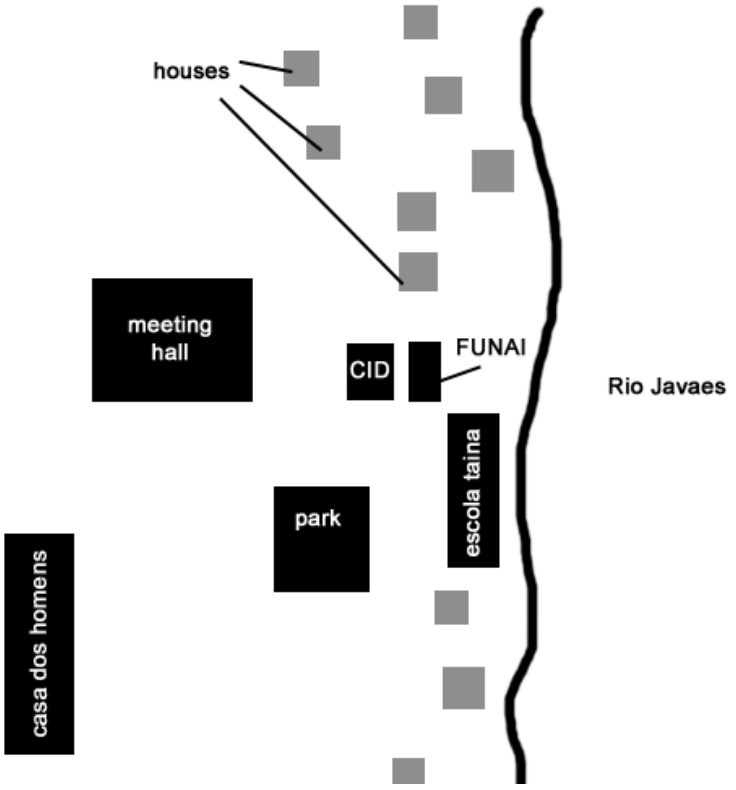

Figure 4. Canuanã is organized along the river Javaés in rows, with the most important people and civic functions located nearest the river.

Despite its rural surroundings, Canuanã has a surprisingly well-developed civil infrastructure. Near the school there is one pay phone. The main street can be lit by incandescent bulbs. No cars are in the village, but streets are wide and kept clear of debris for pedestrian, bicycle, and horse traffic. Even in the traditional *palmeira* houses, people live fairly well. Some homes have running (but untreated) water. A couple naked incandescent lights in a home are not uncommon, and several families even have televisions and a video game console. Most family groups have a small garden for vegetables and cassava (*manioca*); chickens that run loose in the house, yard, and surrounding village; and enough fishing equipment to provide for their family. Fruits

grow everywhere, and are treated as communal property. There is no refrigerated food storage anywhere in the village, so meats are either eaten freshly killed, left outside unprepared, or salted to dry in the sun in the style of *carne do sol*. Dogs and livestock run unattended throughout the village, creating both hygiene and safety problems.

The living conditions in Canuanã are typical of the indigenous villages in the area. Other villages nearby, like the *aldeia* São João, have similar structure and facilities. One major difference between these two villages, though, was the different importance of hierarchical political structure. The social structure in Canuanã is much more easy-going, and its community leaders much more gregarious. This may be an effect of having a different tribal composition, but it was clear from the infrastructure and village layout in São João that this was not just related to who was in charge of the village at the moment. The contrast may also be connected to Canuanã's increased interaction with outside culture through television and closer proximity to the nearest city of any size, Formoso do Araguaia.

People in Canuanã no longer lack the basics for sustainable human existence. At this point in the region's development, they have met their basic needs, but want more connection with the world around them. The Ilha do Bananal has become part of Tocantins' plans for regional ecotourism as well as increased agricultural output. To be a part of this new economic growth, the people in Canuanã are interested in things like learning Spanish and English, interacting with their state government, and participating in the food markets that could sell their crops and regional fruits to other parts of the

country and the Mercosul group of countries. One of the constraints to the village's development, however, is the need to ensure that the thriving traditional customs of the Javaé people is not overwritten or forgotten as a new generation grows up with a greater understanding and interest in outside practice. Care must be taken in all projects to supplement, rather than undermine, the old ways.

Understanding the constraints of the region they live in and the desires of the people of Canuanã in the village's and region's growth is critical. Constructive development of new opportunities within the village and the village's relationships to Tocantins and the rest of Brazil are possible only with a clear view of the area's local history and ambition for the future.

Community: *Assentamentos* Caracol and Pirarucu

Much of the rural population of Brazil lives in groups even more remote than the village of Canuanã. During the last decades, the national government's attempts at land demarcation (Survival International, 1987) have made necessary the relocation of families in many regions through the *Instituto Nacional de Colonização e Reforma Agrária* (National Plan for Colonization and Agrarian Reform) (Ramos, 2005a). In Tocantins, the creation of the Indian reserve on Ilha do Bananal led to the "option" for several hundred Brazilians to move off of the island in exchange for a plot of land. The plots offered were in the middle of nowhere, even by Brazilian standards, but the government promised to come through and connect them all by a paved road and to bring the infrastructure together once people had established themselves.

Now, just across the river Javaés from the Ilha do Bananal, around 600 people live in 200 family *assentamentos* (settlements). Collectively, the groups are known as the *assentamentos* Caracol and Pirarucu (meaning Snail and Pirarucu, a large fish exclusive to the Amazon and other large rivers of northwest Brazil). The *assentamentos* Pirarucu have 267 people in 74 families, and in the *assentamentos* Caracol there are an additional 124 families with 355 people. Each of these settlements is between 120 to 240 acres. A typical settlement has three dwellings on it which are used as houses or storage. Most are made of traditional dried *palmeira* leaves. Some are built of brick, with clay roof tiles or corrugated tin roofing provided by national development initiatives. Centered between

the houses is typically a *palmeira*-topped shack for food preparation and other outdoor activities.

About seven to ten people live on each settlement as a group. It is not likely to be a single "nuclear" family, but rather parents, their children, and an aunt/uncle family or elders. When they get married, women typically move in with their husband's family, and the family expands thusly. The multiple houses together allow some measure of privacy between generations. An average settlement has 50 cows, and 50 square meters of planned cultivation (being Brazil, most of the things eaten in rural areas grow wherever they please).

The level of infrastructure in the *assentamentos* is noticeably lower than in the *aldeia*. There is no running water, and no electricity, not even from car batteries, generators, or other distributed sources of low capacity.

Hygiene and sanitation standards are generally low. Foods, including fruits and fish, are left out between the time they are brought to the house and the time they are cooked. Leftovers also sit out after being cooked, as do uncooked foods which have been partially prepared. Waste, be it biodegradable foodstuff, plastic wrappings, or hazardous elements like alkaline batteries and pesticides, are tossed onto the ground just outside the house. There is no specific waste bin or collection pile in any of the settlements. Along with a lack of running water, the households often do not have a designated toilet area either. Children urinate on the house's dirt floor without correction, and animals freely defecate

in the main rooms of the house. (This was not the case for older children and adults, though. So although behavior patterns for young children and animals are different, they are not scolded.)

Water is typically extracted from unlined, uncovered wells using a bucket on a pulley. Distribution of water to the house, garden, and livestock is done by hand. A few of the better-off families had more advanced systems that required less time and less physical strain per liter of delivered water. One even had a gravity-fed pipe system to deliver water from the well to a trough and to the house. The water is rarely treated or even filtered, so water for any purpose – washing, cooking, or drinking – is highly turbid, the opacity of skim milk with the color of a *cafe com leite*.

People living in the settlements also have less contact with outside culture than those living in the villages like Canuanã. The typical settlement does not have any electricity, access to newspapers, or the means or reasons to go to the cities. A bus connects the settlements – running once a day along the long, empty dirt road that connects them to each other and to the nearest towns. Even the concepts that keep the region and the world running – cash currencies and salaried jobs – are not the norm in the settlements. Wealth, in many families, is still measured in cows, which are sold off as major purchases are needed. Most of the families' time, and physical needs, are filled by life at home.

What connection the families do have to outside areas is mostly through the *associação dos assentamentos*, a loose-knit association of the settlements. The association manages

relations between the settlements and the government organizations in Tocantins. The president of the association lives in the only household with a telephone and any electricity. At his settlement, meetings are held every month to update others in the settlements about new government programs, who is going into the towns when, and other local events.

The standard of living across the settlements represented by the association was quite similar, though some differences in economic level and education were apparent (and, of course, related). People with better water systems and better sanitation/hygiene tended to have closer ties to the local technical high school in Canuanã or had household members who had spent some time living in the city and may even have gone to the university.

Perhaps owing to less access to results of increased development or to general satisfaction with the way of life in the settlements, people have less motivation for change and development in their region. Many dream of sending their children to school, but ambitions of material possession or riches are not the standard in rural Tocantins. Most adolescents dream of having a house and family, but lack the opportunities or exposure to other ambitions and the means to make them reality. For those living in the *assentamentos*, even meeting basic sanitation needs could make the difference in local health and opportunities. Improved access to (clean) water would also be a great improvement to the public's health and the likelihood that that region of Brazil could remain populated.

Even if people prefer life out in the country – and indeed, many of the people visited indicated that they were happier out in the settlements starting from scratch than living on the island – improvement in basic human needs will assure better health and growth in the settlements and the region.

Community: The *favelas* of Rio de Janeiro

Many of the people who live in Brazil's informal housing communities like those in Rio de Janeiro began life in rural states like Tocantins and came to the city looking for improved economic conditions and a better life. The rapid influx of Brazil's poorest led to the growth of large low-income communities in all its cities, lacking infrastructure and opportunity.

This migration has been happening in Brazil since the end of the nineteenth century. Rio's first *favela*, at Morro da Providência, was founded in 1897 by former slaves escaping the Northeast sugar plantations after abolition. Migration has continued to the point where 80% of Brazil's population is urban. Now 4% of the national population or approximately 6 million people live in the nation's *favelas* or *comunidades* (Lazarte, 2004).

Within the state of Rio de Janeiro, at least 1.8 million people – or one-third the state's population – live in one of Rio's five hundred *favelas* (Figure 5). This is up from just around 1 million in the 1991 census (de Queiroz Ribeiro and Corrêa do Lago, 2001). This and other census data is widely acknowledged to underestimate the size of these communities. Regardless of the source, though, the overall trend still shows that the *favela* population is growing at a faster annual rate (about 7.5%) than the state's overall population (2.5%).

Figure 5. Locations of *favelas* (black) in Rio de Janeiro in the 1990s. Though only a small portion of the region by area, a high population density allows nearly two million people to live in these neighborhoods. Adapted from Prefeitura do Rio, 2005.

As the *favelas* grew, and the jobs and economic growth sought by newcomers failed to develop, the neighborhoods came to be associated with drugs, violence, poverty, and poor living conditions with inadequate water and sanitation. The contrast between life in the *favelas* and the neighboring *bairros* (districts, neighborhoods) is evident, and nowhere more so than in Rio de Janeiro. The *favelas* there are built into the hillsides and mountains, overlooking and intertwined with some of the wealthiest and most exclusive properties in the world.

Pressure from overlapping communities and the continued internal social unrest eventually led to the creation of programs intended to "urbanize" the *favelas*, home to nearly two million *cariocas*, as people from the state of Rio de Janeiro are known. The largest program, *Favela-Bairro* (from slum to neighborhood), is a "tool to promote urban and social integration of *cariocas* and reverse the process of urban decline" (Prefeitura do

Rio, 2005) by bringing basic infrastructure and municipal and social services to the *favelas*.

What started as a temporary solution for the working poor in a new region of the country has become a large part of the city's housing policy. As the communities have urbanized, the word *favela* has come to be a misnomer for many of them. Some, like Rocinha, are now known as *comunidades* (communities). *Comunidade* reflects the permanence, inter-relatedness, and growth of what is no longer "just" a low-income neighborhood.

Rocinha

The neighborhood of Rocinha is a good example of how a *favela* has become a *comunidade*. Rocinha is undoubtedly the largest low-income community in Brazil, and many say in South America, with a population between 127,000 and 500,000 (Lazarte, 2004). Through the favela-bairro project, it has also become one of the most developed, and in 1992 was elevated to *bairro* (district, neighborhood) status.

Rocinha now operates more like a "city within a city," with its own public transportation, local TV channel, schools, and civil services. Despite being a "low-income community," the lifestyle of many of Rocinha's residents is familiar to people living in other parts of Rio and even here in the United States. A 2003 survey by the Rocinha TV channel found that of a few thousand respondents, 56% shop at the local shopping mall, 23% have a credit card, and 93% have at least one television in their home (Canal Comunitário da Rocinha TV, 2004). The development of Rocinha has also changed the class structure of

the neighborhood – about one of five residents now has a job in a "middle class" social occupation, such as routine worker, technician, or teacher (de Queiroz Ribeiro and Corrêa do Lago, 2001).

The change to *bairro* has given recognition to the hard work of community leaders in Rocinha and from the Prefeitura do Rio, but there is still work to be done. Rocinha now has the distinction among the 32 peer administrative regions of having by far the lowest education and average income levels because of their previously existing *bairro* status and wealthier population (Juca, 2004). This represents both opportunity for improvement relative to peer communities and the challenge of getting appropriate aid to continue the *comunidade*'s growth as a new political entity.

Santa Marta

Most of the *comunidades* in Rio still have not yet made as much progress in partnership with urbanization projects like *Favela-Bairro* before they will have benefited as much as Rocinha has. For example, Santa Marta is a densely populated *favela* in the Botafogo municipality. As Rio's favelas go, it is rather small, with a population between 7500 (Attivarci, 2002) and 10,000 (Lazarte, 2004) residents. Most of the families in Santa Marta originally came to the neighborhood in the 1930s and 1960s, from the south of the state Minas Gerais. Despite the age of the community (around 75 years now), the current residents, as normal in the *favelas*, are very young. 44% of the population of Santa Marta is between 10 and 29 years of age (Attivarci, 2002).

Santa Marta is an example of the challenges that must be overcome for infrastructural development in the *favelas*. Like many other *favelas* in Rio, it is built into the side of a hill, and presents the challenge of verticalization. The upward growth separates the neighborhood economically. In Santa Marta, the poorest people live at the top of the hill – contrary to planning in other areas – where despite the great view that normally drives real estate prices at high elevations they must also climb to the top of the hill. Residences at higher elevation in vertical slums also tend to have fewer utilities than those at the bottom, where connections (legal or not) are easier to make. Verticalization is always a hazard, but especially when the poorest and worst quality buildings are towards the top of the hill. There is always the threat of ground breaking free from the hill, sending buildings collapsing down the side onto lower levels.

Working with residents to reinforce upper-level buildings and protect people from areas where building- and land-slides have recently happened are major aspects to the civil works going on in Santa Marta.

As a side effect of the vertical alignment of the neighborhood, transportation is very difficult. Cars are not allowed or physically able to enter Santa Marta, where the main thoroughfare is a narrow and makeshift stairway. Though the first stairs are concrete, the materials change as one ascends the hill into the less affluent parts of the neighborhood. Higher level stairs are made of scrap wood, cinder blocks, sandbags, and other irregular materials. The consequences are apparent. Business opportunities are limited by the cost and difficulty of shipments. Open sewage systems, which form a river that runs through the hill from the very top to the very bottom, overflow during rain. The overflow creates

a cascade of sewage, refuse, and other unsanitary waste that runs all the way down the neighborhood and spills out into the streets below the hill.

More so than in Rocinha, the urban threat of drug-trafficking still plays a role in community life in Santa Marta. Fewer than one in ten people in the community is active in the drug trade (Tôrres Barbosa, 2005), but the business affects everyone in the neighborhood. Some streets are unsafe to photograph or even walk on because they are gang territory. The effectiveness of police is hindered in all types of enforcement and community relations because people are afraid to use them as a resource when their business could be mistaken for snitching. The future of the community's younger generation, which often has limited exposure to realistic views of life outside the *favela*, is always in jeopardy as life in the trade is romanticized by drug runners in the neighborhood and the "high life" is exaggerated on the television and other media that they do have access to.

At the same time, Santa Marta is also home to some spectacular projects whose objective is to strengthen the community from within. These efforts, which include everything from day care centers to neighborhood photography seminars, are being started by both residents and outsiders, and bringing attention to the needs of *favela* residents in Santa Marta and other parts of Rio de Janeiro and Brazil.

Mangueira de Botafogo

Across the neighborhood of Botafogo from Santa Marta is the *favela* Mangueira de Botafogo, which extends from the foot of Morro da Saudade (Hill of Sorrow) up into the hills, connecting to other favelas on Morro dos Cabritos. It is also a small *favela*, of around 12,000 residents (Massa de Campos, 2005). It looks more like a regular neighborhood than many other *favelas* because of its paved streets, single family homes, and relatively low population density. Like many *favela* communities, it is unofficially unrecognized. For example, it will not turn up on a map. It can be located only by finding the big green spots which label the hills (*morros*) the neighborhoods are named for (like the Morro Dona Marta of Santa Marta). Representation in the city council or other legislative bodies is almost unheard of. Legal deeds to land on the hillsides are uncommon. Legitimate connections to city services and utilities are equally rare. Here, as in other lower-income parts of the city, connection to local utilities is made by splitting off legal subscriptions or the mainline into hundreds of little connections. In Brazilian Portuguese, this is known as *fazer um gato*, or to make like a cat, by digging claws into the utility pipeline (Figure 6).

Figure 6. *Favela* homes and businesses connect to public utilities by *fazendo um gato*, or making an illegal connection to main lines or one legitimate subscriber.

These informal (and illegal) connections are made for water, electricity, telephone, cable television, and even internet. Despite its prevalence, the trend has gone "unnoticed" by government officials and utility companies. Even the governor's palace, Palácio de Laranjeiras, serves as a main utility connection to the neighborhood.

Because of its relative structural and social stability, people are choosing to stay in Mangueira de Botafogo even as their education and income level rise. Ties of this strength are important to the ongoing improvement of the community's living conditions and introduction of new municipal services to the area.

Long-term community development

Despite their differences in size, one thing these communities all lack is the internal social network or motivation necessary to get improvement or development projects up

and running. There are great examples of successful projects in each neighborhood, but the pervasive attitude that there is not enough time or that someone else will take care of the community's problems is much more prevalent. Neither is access to technology the issue here. The use of technology for growth and creation is, though, an uncommon ambition. Technology is used almost exclusively for passive interactions, like television and video games, rather than authorship or active learning. The types of technology that people living in *favelas* invest in reflect basic needs, like refrigeration and air conditioning, followed by entertainment, like televisions and game consoles.

The challenge of fostering social networks in the *favelas* can be related directly to the demographics. In a typical *favela*, over half of the residents are less than twenty years old (Figure 7). Only one of five will continue school past the seventh grade (Figure 8). In order to make ends meet, people often work multiple jobs, odd jobs, or a combination of a regular job and informal employment. This leaves few people with the ambition or time necessary to give back to the local community on a voluntary basis.

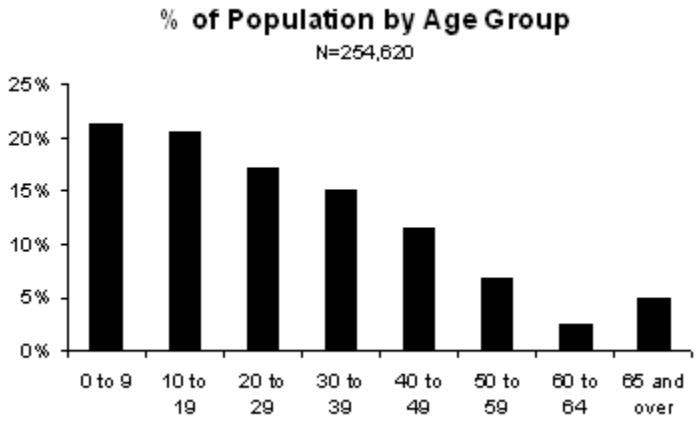

Figure 7. The population living in these low-income communities tend to be concentrated in the age range below 20 years old. Adapted from Lazarte, 2004.

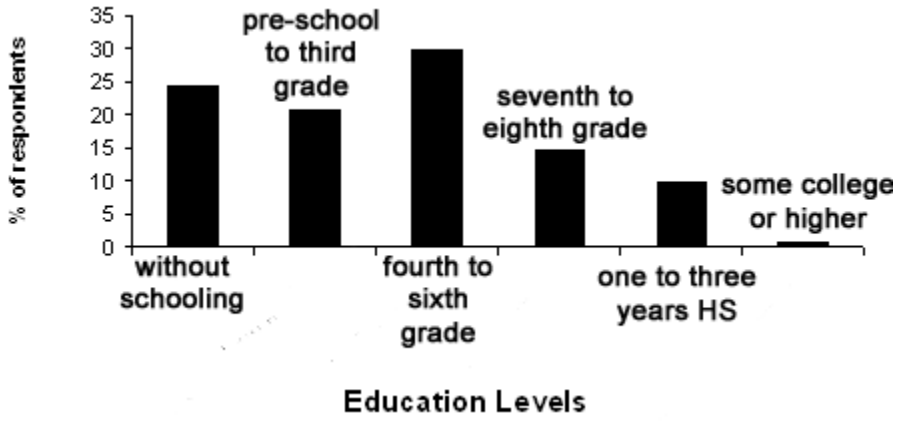

Figure 8. Educational attainment as percent of sample opulation. Adapted from Lazarte, 2004.

There is room for hope, however. People who live in the *favelas* tend to stay in the neighborhood for a long time (Lazarte, 2004). Long-time residents are a foundation for building the strong connections necessary for consistent community improvement. An increasing number of *favela*-residents economically moving into the ranks of Brazil's middle class may also help. Middle-class residents commit to only one job and have income beyond the minimum which they can dedicate to their children, community, and future. They also have increased interest in the safety of their neighborhood as their family grows, and will have to help the community if they intend to stay in it, as they have shown likely to do.

Fostering long-term development of the *favelas* into *comunidades* will become even more important over the next few years. After stagnant growth in the 1970s and 1980s, the 1990s and 2000s have again brought rapid increased growth to Rio's *favelas*. The urban sprawl has made it harder for people to buy their own homes on the outskirts of the city, and the price of land has gone up at the same time the purchasing power of workers has

decreased (de Queiroz Ribeiro and Corrêa do Lago, 2001). Neighborhood growth now comes from within the city itself, rather than from the rural states as in the past.

This year was MIT's first experience working with communities in Rio's *favelas*. With community partner CIESPI – the Brazilian non-governmental organization *Centro Internacional de Estudos e Pesquisas sobre a Infância*, known in English as the International Center for Research and Policy on Childhood – this winter of 2005 was spent learning about present reality and the role technology should play and how it could be introduced.

Community partners

Spending many years and millions of dollars is not necessary to reach the conclusion that meaningful technical and economic development in small communities is challenging. What a community partner can do is make an already ambitious goal achievable. They provide an exclusive perspective on the community and its living conditions that shapes design from the very onset of the project. When outside groups leave, they can then be responsible for keeping the project alive in the long-term. Their value derives from their knowledge and commitment to making their society a better place to live.

Community partners are people or organizations that already work within the community and serve as local contacts for outside agencies. They provide first-hand knowledge to learn about the community, the challenge being solved, and the constraints that have to be worked within. They provide local expertise in culture, environment, finances, organizational style, and other aspects that can affect project design and success. Their established presence in the partner community facilitates the participation of new groups. If the community partner is trusted by the people around them, it can ease the introduction of new members and new organizations from outside and created within the society. Without their support, getting access to and confidence from people can be difficult.

Even beyond initial meetings, the community partners play a strong role. One of the biggest challenges in international development projects is defining the realistic sustainability of a project and perpetuating it. Projects that fizzle out after the originating

group leaves are not helpful to anyone, and community partners can help prevent that from happening. As stakeholders in the project, they have an interest in seeing it continue. If there are recurring costs in staffing or equipment, or additional upkeep, they need to be a part of the planning on ensuring that such situations can be prepared for and overcome.

In the case of the projects presented here, they would never have gone so well or even happened at all without the participation of a few really good community partners. They each played a different role which together made way for successful interactions.
The projects described here were made possible by partnership with the Fundação Bradesco, the Escola de Canuanã, the Grupo de Saúde Rural, the association of *assentamentos*, and the leaders of the *aldeia* Canuanã.

Fundação Bradesco

In 1956, Amador Aguiar, founder of Bradesco, now the largest private bank in Brazil, started an organization to provide education and professionalization to young children, youth, and adults across the Brazil (Fundação Bradesco, 2005a). The Fundação Bradesco opened its first school in 1962 in São Paulo, and has been working on this goal ever since.

The Fundação now serves 107,000 students in 40 schools across the country (Valente, 2005), and has recently opened 26 computer centers with the same social mission. There is at least one school in each of Brazil's 26 states, and one in the Distrito Federal. The Fundação's Escola de Canuanã is one of the five working farms and one of the two boarding schools in the system. The organization's budget comes from the endowment set up by Aguiar at its founding, and the yearly expenses of running the schools comes to about R$148 million (US$53 million) each year (Valente, 2005).

Expressly created to support low-income families in Brazil's strapped and too-small public school system, the schools educate a diverse range of Brazilians from the urban *favelas* to the indigenous settlements. The driving motto behind them has always been

educar é transformar vidas e abrir caminhos
To educate is to transform lives and open paths.

Behind the philosophy lies an entire way of teaching that unites education with quality of life. The three fundamentals to the Fundação's teaching methodology (Fundação Bradesco, 2005b) are the

- Continuing education of teachers: By facilitating teacher interaction with other institutions, academia, and the community, teachers are expected to increase their technical and pedagogical competence and use newfound knowledge in classroom experiences.
- Democratization of the school: The Fundação provides open discussion spaces within the schools, with the express intent of giving students and teachers the freedom to talk about whatever will help them in their quest for knowledge.
- Active citizenship: There is hope and support that students will participate in creativity, leadership, and development to their full potential through extra-curricular activities. Being an active citizen includes taking action in the school, a microcosm of larger society.

Each school serves as a social reference point for its region. The successes of its students exemplify for the surrounding communities the possibilities to expand horizons and to realize dreams.

Escola de Canuanã

In each area that a school is opened, the Fundação becomes an active part of the community. The school in Canuanã opened over three decades ago, and is now an indispensable partner in local activities. Its size and geographical integration with the

communities its students grew up in ensure strong relations based on a practical education.

The Escola de Canuanã is one of only a few working farms and boarding schools in the Fundação system. As such, it's also one of the largest schools, with a total land area of about 25 km^2 and 72,400 m^2 of built space including dormitories, classrooms, administrative areas, and recreational facilities. The school has some 921 students for the 2004-2005 school year, including 20 preschoolers/kindergarteners, 640 elementary through middle-school students, and 261 high school students (Fundação Bradesco, 2005c).

Students at the Escola de Canuanã come from all over the state, but mostly from the communities nearby. Many of the students, though, come from the *aldeia* Canuanã on the Ilha do Bananal, just across the river Javaés from the northern boundary of the school, and from the *assentamentos* – settlement lands that form the school's other boundaries. (Fundação Bradesco, 2005d). Those from further away come from the larger cities in the state, like Gurupí, or Formoso do Araguaia – at 60 kilometers away, the nearest city to the school.

Along with the close relationships built by living at school, the working farm environment provides each student with practical knowledge of rural life. Those who want to understand the social and public health conditions of the area better have the opportunity to do so through extra-curricular activities run by the school's teachers.

O Grupo de Saúde Rural

One of the activities created to bring the students at Escola de Canuanã face-to-face with the challenges of development in rural Tocantins is the Grupo de Saúde Rural (Rural Health Group, commonly known as the GSR). Started in 2001 by Dr. Cicero Ramos, the GSR brings together the students from the Colégio Dr. Dante Pazzanese and the people of rural Tocantins to teach of fundamental hygiene and basic preventative medicine. The GSR was a great community partner, without whom the field work in the *aldeia* Canuanã and in the *assentamentos* could never have been so successful.

Since its inception, the school has held regular "health days" where community members came in to the school for activities, check-ups for kids, and other services. From that grew the GSR, which takes students from the school and into the settlements. The "health days" transformation into the GSR was guided by the United Nations Development Programme's Millennium Development Goals (UNDP, 2004).:

1. Eradicate extreme poverty and hunger
2. Provide basic universal education to all
3. Promote equality between genders and autonomy of women
4. Reduce infant mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria, and other diseases
7. Preserve environmental sustainability
8. Establish a worldwide partnership for development

Under these guidelines, the founders of the GSR developed education on preventative practices in the area of health and well-being of the settlement communities. For them, the overall idea was that health and well-being are necessary to and an incentive for self-actualization of the community (Ramos, 2005a). With improved health, the people of *assentamentos* Caracol and Pirarucu would be better able to participate in citizenship and solidarity with the school and neighboring communities. As the school doctor, Cicero Ramos put it, this process was "*indispensável para qualquer sociedade socialmente responsável"* (Ramos, 2005b) – a necessary and indispensable part of any socially responsible society.

The program has begun to make a noticeable effect on living conditions in the settlements. For the students, it is valuable to see that their actions had an impact on life in the settlements, but also in their school and on themselves. The internal development and active participation in citizenship is exactly what the Fundação has hoped to promote through its teaching philosophy (Fundação Bradesco, 2005b).

GSR activities have been successful in part because of the school's strong relationship with the neighboring community – with joint activities, and many of the students coming from the area – but also because they have been approaching the challenge systematically. Rather than focus on specific illnesses, the GSR has taken a broader approach to treat causes, rather than symptoms. Therefore their activities emphasize improving the living conditions that cause high rates of preventable disease, a continual challenge to the community in the present day. Broad steps that are taken in GSR

activities (Ramos, 2005a) include the development and teaching of preventative practices, the incentivization of sustainable self-actualizing development within and by the community, and the strengthening of the feeling of citizenship.

One of the first major activities of the GSR in 2001 was to undertake a questionnaire to determine the living conditions and demographics of the area. By traveling through the settlements themselves, the students gained the trust of people around the community, saw the challenges of daily life first-hand, and got more detailed and reliable census results than even the state of Tocantins's agency on rural development. The survey aimed to find out not only who was living in the *assentamentos* and in what conditions, but what was missing, and what the residents felt they needed in their lives. This kind of information helped the GSR as they chose their next actions.

Since that first survey, a variety of initiatives have been started by the GSR in response to the stated needs of the settlement dwellers. Those that are still going on include (Ramos, 2005b):

- Health education: General education about basic hygiene and preventative medicine. Includes cleaning and boiling water, brushing teeth, sanitation guidelines, etc.
- Vaccination campaigns: GSR students accompany school doctors or outside programs from the state government to encourage people to participate. They also entertain children during treatment to make their vaccination experience a little less "*dolorido"* [hurtful]

- Check-ups: Again with the doctor from the Escola de Canuanã, the GSR educates people in the settlements about and encourages them to participate in basic health check-ups. Basic check-ups can include height/weight, vision, blood pressure, and other quick, low-cost measurements that can indicate problems or general well-being.
- Encourage participation: Brazil and Tocantins have been very active as governments and with other agencies in getting health programs, censuses, voting, and other citizen activities to rural areas. Without the support of a local community connection, though, getting people to participate can be difficult. The GSR serves as a trusted connection between visitors trying to do something beneficial and the people in the *assentamentos* who do not know who they are or what they want.

In total, there are now thirty students in the GSR. There are many more students who want to participate, but as always time and resources are lacking. Each student who applies must be in US equivalent of grade 5 or higher, and writes a full application and sits an interview with the faculty advisor to the GSR, Dr. Cicero Ramos, and then with a group of students already working with the GSR. Eleven of these students worked with MIT and USP on our visits to the settlements. Their presence was invaluable, and demonstrated how necessary a good community partner is to successful local development work. They not only understood the settlements, Tocantins, and Brazil, but eased communication and trust between families who had probably never left the state and people who had come from halfway up the world.

Community leaders of *aldeia* Canuanã

As in the settlements, the support of local leaders was necessary for projects taking place in the *aldeia* Canuanã. The different leadership positions in the *aldeia* include the cacique and his vice-cacique, the pajé, and the anciões. The cacique was the most involved in the daily activities while MIT/USP was in Canuanã. However, all of them were aware of the projects and gave their support and solidarity towards those efforts. Each one's specific role in the community determined their role as a community partner.

The cacique is a political leader and the contact for the government's Indian affairs agency, the Fundação Nacional do Indio (FUNAI). There is also a vice-cacique. Responsibilities of the cacique include running village meetings, assisting in dispute resolution, and maintaining good relationships with other villages and other levels of government, like the FUNAI and the *Instituto de Desenvolvimento Rural do Estado do Tocantins* (rural development division of the government of the state of Tocantins). The current cacique is easy-going, and maintains his political support by riding around the village and nearby areas on his bicycle. Especially as the computer center was being set up, he dropped by frequently to watch the progress, chat with officials from the school, and sometimes even to lend a hand. Until the mid-1900s, it was a hereditary position, but now each cacique serves for six years. His successor is chosen by the council of elders.

Known as the *anciões*, the council of elders is responsible for far more than choosing the cacique. Choosing the cacique is only one of the many actions that they take in their charge to pass on traditional culture and values. The challenge is at least doubled by the

coexistence of several indigenous groups in the one village, all of whom have overlapping, but distinct, beliefs, practices, and traditions. They serve beside the cacique during village meetings, and participate in special ceremonies like those performed at relating to the grand opening of the *Centro de Inclusão Digital*.

While the *anciões* take charge of passing on tradition, they are also guided by the *pajé*. The *pajé* is the spiritual leader of the village. He can make contact with spirits for harvest, health, and other purposes, and also guards the knowledge of traditional herbal cures. At the opening of the computer center, he was there to give his blessings and welcome the spirits with positive energy to the new space.

Connecting with the *aldeia*'s leaders, and the traditions that they follow, made the work in Canuanã official and acceptable to the people in the village. These connections were necessary to inspire trust in outsiders, gain first-hand knowledge from the community, and to ensure the continued success of the "seeds" of ideas being planted within.

Associação dos assentamentos: The settlement association

Even with the support and participation of the GSR and the Escola de Canuanã, a partner within the community was important to getting access to people and gaining their confidence. Since there is really no such thing as a "local government" at the level of the settlements, connections were made instead through the "offices" of the loose association of the settlements Caracol and Pirarucu. Though the organization has no official status outside of the settlements, the association is locally recognized as a gatekeeper to the community and a centralized way to distribute information.

The centralization is a result of the minimal structure of the settlement association. It is run by one person who is elected from all the settlement dwellers. The same man has been "president" of the association for several years now, owing to his ability to make connections, the smiling personality that puts people at ease, and the technology (the only phone in the region) that helps him stay in contact with people in "far away" cities like Formoso do Araguaia, Gurupí, and Palmas. He manages to get information about local market prices, new government programs that might bring money into the region, and deliveries of goods and services, into an area with fewer than 4 people living in each square kilometer (Ramos, 2005a).

Even though the association is loosely organized, his cooperation is important for getting access and support from people living in the settlements. This group had a much less active role in the MIT activities than the GSR did, but instead "paved the way" politically for everything that happened. The association was told about the MIT visit in advance,

so there was sufficient time for word to spread by the occasional bus that travels through the settlements, bringing people to the city and back. Upon arrival in the settlements, the president of the association was the first person visited. It was not so much that he was needed to give an official perspective about their needs and lives. Rather, visiting him first was an act of respect, which allowed him to pass final judgment on what would happen in the community.

Some projects that were started in the settlements require additional education or material distribution after the departure of the MIT/USP team. Further developments will be coordinated between the settlement association and the GSR. Their continued support will ensure that no action is left half done.

The Next Brazilian Development Policy

Brazil's industrialization policies since the 1930s have failed to generate employment on a large scale, increased income inequality, and left behind a significant portion of the population. Now in a good financial position after nearly two decades of chaos, it is time for a shift in domestic policy paradigm. The development programs of Brazil's past subscribed to the premise, then prevalent in nations all over the world, that industrial growth was the means to the end – the way for under-developed countries to generate employment for the increasing number of people who were underemployed and for the unemployed rural poor.

So far, Brazil has gone through three major growths in industry. Each time, its overall economic and industrial stance improved through technical industrialization, but the "wholehearted embrace of modern Western technology," with no consideration of alternate technologies, left behind exactly those people who industrialization was supposed to help (Dickenson, 1978). Attempts to establish Western technology in the interior have often followed a continued coastal desire for control, perceived import-export advantages from environmental exploitation, and the establishment of a Brazilian presence to preempt boundary disputes with neighboring rebel factions. The mid-twentieth century emphasis on the Amazon, for example, arose during a time when the administration feared that if the Brazilian Amazon basin were not developed soon, the region would be lost to subversive elements of neighboring countries (Clüsener-Godt and Sachs, 1995).

Policymakers are now in the position to recognize technical, personnel, and institutional limits, and use those to upgrade development performance rather than designing the perfect plan. In the late 1990s and early 2000s, the domestic economic stability has increased substantially and the preconditions for growth are present again (Robock, 1975). The GDP has been growing steadily the last few years, reaching USD$582 billion last year (EIU, 2004). There is also now the administrative and financial capacity to reform policies for national development. Key policies will be necessary to obtain future growth. The economic conditions that will make policy reform possible include (Kanitz, 1995):

- Relatively low international interest rates
- Low levels of corporate debt – as corporations prepare for another cycle of growth and new debt
- Return to profitability – as above, institutions of all sorts have recovered from the financial chaos of past years and from the previous capacity expansion
- Increased inflows of foreign capital via bank loans and equity markets
- Improved management and manufacturing quality compared with prior growth phases

Under these conditions, Brazil can undertake domestic policy that will finally address the inequalities within its regions, the community or "micro" level approach to poverty reduction, the national problem of income inequality, and the challenge of sustainable rural development.

Regional focus: The inequalities within regions

Regional planning has been a significant part of Brazil's development plan since the late 1950s. As a result, though, the already developed areas in both richer and poorer regions received almost all of the capital and knowledge going into state or regional development programs (Queiroz Guimarães, 2004). Now it is time to shift to an intra-regional focus rather than regional policy. A shift towards policies for the under-developed parts of each region will be the first to resolve the inequality within states where opportunity and poverty do not fall along state borders. Bringing technology, economic opportunity, and leadership to poorer regions will improve income in Brazil's underdeveloped regions, creating new markets for products and services produced elsewhere in Brazil. For politicians, the growth of new businesses will increase tax revenues in previously impoverished areas.

Tocantins, like many other states in Brazil, has taken steps themselves to create an agency that focuses on state development in the rural areas, outside of the more prosperous capital city. A similar policy on a national scale would benefit areas underdeveloped by national standards, as well as the more prosperous. Focusing growth policy on underdeveloped regions would create an environment where it would no longer be favorable to wait for cues from the government to decide on the direction of business or technical research. Because of the tendency for volatility in regulations and economic structure, Brazilian corporations have used government cues on the country's next steps to determine their business plan and research paths for decades. This system has hindered innovation as firms wait for those cues before embarking on new plans (OECD, 2001). Shifting the government focus to underdeveloped regions will reduce cues to big firms.

Corporations will have to will diversify the directions chosen within industries stimulate domestic inventiveness.

Effective policies in addressing regional inequality will require, among other things, greater cooperation and liaison between development agencies working across the nation and in the same region on different programs. Resources will have to be distributed in a more equitable way than they have been in development attempts to date (Dickenson, 1978). Increased equity in resource allocation is necessary to

- Stabilize the flow of resources for research in regions, through the normal congress-approved budget
- Clearly identify counterpart projects in other regions to negotiate transfer of skills, technology, personnel, and funding between government agencies and other organizations
- Make an effective effort on the part of the national development agencies to recover, maintain, and widen their links with national and regional institutions dedicated to the production of knowledge.

The cooperation of policymakers, particularly in Brazil's development agencies, will increase project productivity without adding significant burdens to project expenses.

The "micro" approach to poverty reduction

Brazil has been trying the "macro" approach to solutions in poverty – that is, industrial growth as the means to employment and development – with limited success. Clearly, it

is time to try the "micro" approach and invest substantially in community level initiatives. This has the advantage of addressing the typical challenges faced in development programs: weak local buy-in, lack of time, and lack of money. By focusing government-sponsored development initiatives on local communities, increased community participation can be sought. Working with a particular community, rather than imposing "development" on them, improves local buy-in and improves the chances that the program or technology will be useful after contact with the originating agency has ended. In the end, it may not save time or money, but will instead increase the returns on the time and money already committed to development.

What the "macro" approaches fail to recognize is the way change works within communities. Working with small groups can encourage individual changes. When those are particularly effective in a community, they can foster transformation of nearby groups and eventually of the whole social structure (Mariz, 1994). One example of this in Latin America is the *Taller la Corea* workshop in on old working class neighborhood of Havana, Cuba. Sponsored in part by government development agencies, people who participated in the *taller* started with one block of homes as a model for neighboring blocks. They learned how to improve sanitation by improving sinks and bathrooms, added other components like structural roofs and basic electricity, and made aesthetic improvements that made people proud of the work they had done. When the one block was finished, people were quite proud of their work, and showed it off to people in surrounding blocks. Over the last ten years, housing improvements have spread over an area about ten blocks on a side. New jobs have been created, new community centers

have started, and the pattern is still spreading. The benefit to a program with a "micro" focus is that in stressing the standpoint of the poor themselves, goals can be set with a limited, immediate, and specific impact on lives. Additionally, the theme of the program can be largely transferred to other areas, because it is not entirely dependent on the structural elements of the whole society. Past programs in Brazil have emphasized sectional and regional development through public bodies (IBGE, 1999). The participation of local community partners will be introduced to new government planning for poverty reduction.

In many parts of Brazil, the government infrastructure is already in place to take this kind of approach. Even in the most rural parts of Tocantins, for example, there are offices of and agents of the state and national governments. So the expertise, community relationship, and funding are already in place. Their application to community-focused development programs would be locally beneficial in the short-term, with quantifiable returns, and nationally beneficial in the long-term, by increasing the state of development in heretofore neglected regions.

There exists a wide variety of challenges that could be addressed by the "micro" approach to poverty reduction. For individual, small programs as recommended, it is important that the parent agency ensure:

- Stakeholder involvement, in terms of both ownership and participation
- The availability and transparency of resources and time
- Institutional credibility and capacity for change

- The relationship to national policy: basic political, social, and cultural rights are necessary for sustainable human development. Human rights are not given in addition to development, they are required (Smillie, 2000).

Alongside the organizational or technical solutions to communities facing poverty, it is necessary for Brazil to directly address its infamous income inequalities and un(der)employment. The current macroeconomic stability is needed for continued industrial growth and for poverty reduction. The connection lies in the tendency for capital to flow in as economic activity accelerates, increasing wages, real income, and thereby reducing poverty (The World Bank, 2004). A successful set of combined policies on these two issues would go a long way towards increasing the country's capacity for future growth into the knowledge-dependent world economy.

Income distribution

Brazil has advanced rapidly in the last century in technological terms, but the inequalities in wealth that were a part of its colonial days have only grown, becoming a part of the country's international reputation. Exacerbated by over-mechanization, where industrialization turned a nation that used to import slaves by the millions for manual labor to one where labor was on the verge of becoming obsolete (Viotti da Costa, 2000 and Ribeiro, 1995). In the past, Brazilian industrialization policies assumed that income distribution and poverty could be divorced from growth and added on to the national plan when convenient. Even with the fastest growing economy, the gap between the rich and poor intensified throughout the twentieth century. This was particularly true in the rural interior and in dense urban settlements. The increased gap over the Vargas, Kubitschek,

and Médici years goes to show that to truly advance, Brazil will need to deal with the human as well as mechanical factors of development (Smillie, 2000). Further challenges to equality were imposed by the macroeconomic volatility of the intervening decades. Macroeconomic volatility has adverse effects on income distribution and poverty indicators (The World Bank, 2004). For example, it tends to cause high turnover in employment, interrupt educations, and destabilize the business environment. As a result, the income of wage-earners in the formal sector is reduced, the earning potential of new wage-earners is limited, and the overall opportunity for employment is reduced. The common factor among policies that would reduce inequalities in wealth is that they tend to be opposite to those policies formulated to attract foreign direct investment in the last century. Some aspects to a unified policy paradigm aimed at decreasing the income gap in Brazil might include:

- Reduced barriers to entry into formal business – administrative overhead in business start-up in Brazil is very high, as are the costs of taxes and land for new commercial ventures. A focus on small businesses would require a way to make entering business accessible for less wealthy and less educated people.
- Programs targeted for small business development in under-developed states or regions – similar to the objectives above, but with additional incentives for people in rural areas or for those who would move to rural areas to start new businesses.
- An emphasis on employment in the interior that creates jobs requiring simple production methods and local production materials for local consumption (Smillie, 2004). The survival and creation of simple production units is not a far-out fantasy. Brazil is still industrializing, and in all regions of the country and

many fields of production, commodities can still be processed for local use in an economically feasible way (Dickenson, 1978).

- Support for the small, nascent movement of people from jobless cities to franchising in smaller towns further from the coast – this is one way that people start businesses in the interior right now – by developing one franchise and using the profits from that to start their own business (Kanitz, 1995).
- A new *programa de metas* that emphasizes five new areas for change – the new target plan will reflect the country's need to grow small and medium enterprises (SMEs) as well as economic opportunities in rural areas and underdeveloped urban areas.
- The generation of qualified human resources all over the nation – increased production needs increased management and local research capacity. Renewed commitments to public education, universities, and improved communications structures increases formal and informal training in professional interactions.

Local community and business initiatives for income inequality have a history in Brazil, and they have even better prospects for the future. Even in the 1800s, there were attempts at small-scale economic opportunity development in Minas Gerais. The town council and *matriz* (mother church of the parish) joined efforts to create long-term positions and programs on public health and education, urban planning, transportation, and communication (Bieber, 1999). Unfortunately, the towns had varying levels of success relative to their connection to the state legislature. The established political relationships between government agencies and many small villages in different states will give a leg-up to enough communities that "cells" can be started from which ideas can

spread. One modern showcase for local initiatives is the *Foro Social Mundial* (World Social Forum). Hosted at the same time as the World Economic Forum in Davos, Switzerland, the *Foro* brings together innovative companies and non-governmental organizations from all over Brazil (and now, the world) to showcase their local development programs. Establishing continued national support and funding for these initiatives would make them possible all over the country at a level that has never before been attempted.

Sustainable rural development

Like many industrializing and industrialized countries, Brazil now faces the challenge of having to find ways to continue growing without adversely affecting the opportunities for future generations. From thirty years ago, when its ministers openly said that Brazil could be the importer of pollution, to the present day in which Brazil has ratified the Kyoto Protocol, Brazil has had to do an abrupt about-face on its objectives of environmental policy (Embassy of Brazil, Ottawa, 2004). The country's abundant natural inheritance makes it especially important for careful consideration to be given to the path by which the country chooses to strengthen its rural areas. Sustainable rural development policies may include:

- Developing and supporting farmers' cooperatives and food processing – Supporting the small farmer's struggle against the large, tenured landholder will create employment, diversify crops, and strengthen the agricultural market. In some states, small settlements cannot profitably sell surplus crops because of the

high overhead that would be required for one small farm to go into business. Working together would enable them to compete with larger producers. Alternatively, the development of food processing industries creates a "value-adding," knowledge-based, process to the domestic product stream. This policy would also have to address the long held political influence of major landowners. If small cooperatives start out in markets that are less attractive to large-scale farming – for example, specialty regional fruits or those that are more conducive to manual effort than mechanical harvesting – they could grow without being direct competition to established markets held by tenured landholders.

- Encouraging environment-based employment – Reversing the environmental degradation affected during the last hundred years would be a challenge in any society. One way to make it easier is to facilitate the opening of employment opportunities associated with the natural economy. In Tocantins, this has been done to some extent with ecotourism in the thermal springs in the south of the state and on the Ilha do Bananal in the west. Some small businesses have been started in the Amazon to collect and dry or make preserves from native fruits, many of which are not available even in other parts of Brazil.
- Emphasizing poverty alleviation – the environmental ruin of rural areas is a consequence of their relatively impoverished financial state and consequently minimal political influence compared to other parts of Brazil. For a long time, it has been more profitable to extract natural resources from the naturally wealthy parts of Brazil, which also happen to be the financially poorest. Sustainable growth can be encouraged by either supporting the rural poor in developing small-

scale productive occupations or providing them with more (still unsettled) land for local agricultural production. The former is preferable, as it increases the nation's overall economic strength and will lead to improvements in other social factors like education. If increased demand for labor does not precipitate in rural regions, though, people will need more space to provide for themselves sustainably (The World Bank, 2004).

- Actively enforcing a policy to reclaim deforested or mined areas – although Brazil is a vast country, abandoned quarries and burned forest can be turned into profitable centers for different industries. The creation of incentives for companies responsible for degradation to repopulate and repurpose land that has been semi-permanently altered by their presence has worked in other big industries with significant environmental impact like cement production (Lafarge, 2003).

The next step: Specific actions for policy options

No single policy will resolve these challenges, but a new policy paradigm that focuses on regional inequalities, community poverty, income inequality, sustainable rural development could be the key to Brazil's next big growth phase. Each of these four strategies, coupled with policy directions to guide them, can be accomplished by undertaking specific actions at the government levels or creating policies that will affect the way other sectors work. The biggest challenge is initializing specific actions that match political will and financial resources. In many cases, political will can be increased by framing the policy in the ways that an action can be beneficial to politically

influential regions of Brazil and to the nation as a whole. Capital can be redirected through the rearrangement of existing programs so it covers similar objectives under a new organizational structure. Both proven and innovative actions can be part of the policy portfolio that makes this new Brazilian development policy a reality (Table 4).

Targeting these four specific objectives with specific domestic policy actions in combination with a long-term approach for increasing the application and development of knowledge will put Brazil on the fast track for economic growth in the early twenty-first century. It will also help the country to earn and appropriately channel the funds used for internal development. Results can be determined by the quantitative increase on returns: number of jobs generated, number of businesses started, improvements in standard of living in underdeveloped region, even increased GDP. Even in a few years under a cohesive new development policy, Brazil could see improvements in these four strategies that are not being met by many current programs.

Strategy	Policy Direction	Specific Action
Reduce inequalities within regions	Stabilize the flow of resources for research in underdeveloped regions	Give preference in government contracts to specified regions
		Allocate some funds for public universities to cooperative projects, e.g. between university in Rio and in Gurupí
	Identify similar projects in other regions within and outside Brazil to coordinate efforts and resources	Participate in or host topical professional gatherings
		Post and keep accurate contact information for publicly sponsored projects; use contacts made to create a national register
	Make links with national and regional institutions dedicated to the production of knowledge	Specify already available funds for institutions forming desired connections
		Revise intellectual property rules so university-developed research is not public domain for commercial use – increases value for companies while free for more research, public uses
Approach poverty reduction on "micro" level	Increase stakeholder ownership and participation	Decentralize by putting locals in district offices of government agencies, as in Libya
		Increase responsibility and resources of local officials
	Keep resources and schedule available, transparent	Include local stakeholders in decision-making, recordkeeping
		Keep program records in durable, replicable, distributable format
	Increase institutional credibility and capacity for change	Undertake programs with other organizations credible in their fields
		Solicit innovative strategies from students in top universities
	Connect to national policy on basic political, social, and cultural rights	Use Brazilian constitution, international documents as inspiration for objectives and metrics.
		Involve socially conscious volunteers and interns in national development policy and agencies

Table 4. Specific innovative and proven actions that can be undertaken to meet new policy directions in four specific strategies: addressing the inequalities within its regions, the community or "micro" level approach to poverty reduction, the national problem of income inequality, and the challenge of sustainable rural development.

Strategy	Policy Direction	Specific Action
Reduce income inequality	Reduce barriers to entry into formal business	Simplify required paperwork to start formal business
		Implement *e-government* initiatives in community computer labs, using Indian model
		Create incentives for formal business over informal sector
		Make credit easier to obtain for small business ventures
	Target programs for small business development in under-developed states or regions	Partner with or start small business organizations
		Compile regional registers of service providers for small business start-up
	Create interior jobs requiring simple production methods and local production materials for local consumption	Import select technology, entrepreneurs from other developing regions whose skills apply to Brazil
		Record and disseminate traditional production methods from one region to another
	Support the nascent movement of people from jobless cities to franchising in smaller towns	Seek large corporations looking to expand, connect to those wanting a first-time business
		Encourage banks to start small business loan programs for qualified owners
	Create a revised *programa de metas* emphasizing new areas for change	Adjust the *programa* – which dealt with higher technology – to new development goals including small enterprise, rural and underdeveloped urban areas, etc.
		Include diverse political and business interests in creation of *programa*
	Generate increased management and local research capacity	Sponsor students to study overseas with promise of work in Brazil upon completion, as in Singapore
		Use new links between universities and private sector to increase the number of people with research experience in private sector

Strategy	Policy Direction	Specific Action
Select sustainable options for rural development	Develop farmers' cooperatives and food processing industries	Coordinate training of people from agricultural regions who want positions in management, trade
		Use model of existing major cooperatives like Cotia
	Encourage environment-based employment	Transfer fruit processing to market unique regional plants for food and medicinal value
		Introduce eco-tourism, which has a successful Latin American model in Costa Rica
	Emphasize poverty reduction and connection to sustainability	Include agricultural sector in development plans, particularly small farms
		Establish metrics to judge programs before and during implementation
	Actively support reclamation of deforested or mined areas	Require corporate reclamation or charge for government to do so
		Plan subsequent industry development based on current land use

Examples: How policies can fail to meet community needs

Misguided development ideas are endemic not only to Brazil's past, but also to the present. They affect rural areas and the inner cities; the community, the firm, and the individual. While there are examples of positive effects of development programs in many parts of Brazil, perhaps more can be learned from the attempts that have not ended as planned. There are examples everywhere of how projects have turned out to be incomplete, inappropriate, or underachieving. Many of these would have ended better had there been increased community participation in the proposal or undertaking of the project, resulting in direct ownership and responsibility for completion and continuity. The following are examples from present day programs in Canuanã village, the Caracol and Pirarucu settlements, and the *favelas* Rocinha, Santa Marta, and Mangueira de Botafogo.

Incomplete projects

Incomplete projects tend to leave the community hanging and the relationship with the development agency torn. In Brazil, it seems, incomplete projects start up and then trail off rather than having any official closing or end. It may be a result of a decrease in funding, change in national priorities, loss of personnel, or any of a variety of other factors. In most cases, no one knows the exact reason because there is limited communication between the agency responsible for the project's undertaking and the community that it will affect.

The original settlers of Caracol and Pirarucu under the *Instituto Nacional de Colonização e Reforma Agrária* (National Plan for Colonization and Agrarian Reform) encountered one such project, never to be completed, right at the start. Encouraged, or persuaded, to move from the Ilha do Bananal, families relocated to very empty lands on the other side of the Javaés River. They were promised copious amounts of land, as well as a house, clean water, livestock, and other benefits, in exchange for the inconvenience of moving and in an attempt to develop subsistence or better occupations in internal Tocantins. Once they had moved, and their old homes on the island were gone, people began to wait. After waiting for the government to follow through on its other promises, many left the area and moved to one of the nearby cities. Now, nearly a decade later, the people who remain in the *assentamentos* have given up hope that there will be any follow-up on the things that were supposed to get them started on the frontier. Those who have stayed have built their own houses, dug their own (unlined, unfiltered, and untreated) wells, and have just enough to get by. Many of the families visited by the team from MIT said that they were happy now in the settlements, and would not move back to the island if given the choice. Even so, it is hard to tell how different life could be if they had received continued better support in their move across the river.

At some point, another agency decided that getting clean water to the Caracol settlements would be a good project. A water storage tank and pipes were installed to extract water from the ground, but the project fizzled and the actual pump was never installed. It is unclear whether any more work will ever be done on it, though the rural development agency does pass through occasionally and inspect the pump site. Despite their regular

visits, no progress on installation has been forthcoming for several years now, and no one has been alerted as to the status of the project. People still obtain their water from wells dug themselves. The well is usually not lined, the water is not treated or filtered, and has high turbidity.

Halfway across the country, in the low-income neighborhood of Rio de Janeiro known as Santa Marta, another project goes uncompleted, but in a different way. The previous two examples have simply not been finished. In Santa Marta, the project is being finished, but its scope has taken an incomplete view of the conditions surrounding it. Santa Marta, like many of Rio de Janeiro's low-income communities, is built vertically into the side of a *morro*, or steep hill. Here, stairways are the most common means of transportation, and the main thoroughfare from the bottom to the top of the hill is a stairway about two meters wide (Figure 9). Going farther and farther up the hill, into less affluent parts of the neighborhood, the stairs narrow and are made of consistently less stable materials. From bottom to top, they go from cement, to wood, to sandbags, and even less structural materials. The current project in Santa Marta replaces the steps that are wearing away and those made of less stable materials with cement steps or ramps.

Figure 9. The main "street" in Santa Marta is a set of stairs which narrows from the base, shown here. The lowest steps on the hill are concrete. The sand bags on the right are being used to make steps farther up the hill.

The renovation is coming along well so far, but fails to take into account one of the main consequences of the verticalization of Rio's neighborhoods. During heavy rain, which is frequent in the region, water from all over the hill runs down towards the bay. Any refuse or human waste from the top of the hill is carried down the stairs where everyone has to pass and down to the base of the hill. At the bottom, all of the water and the waste it carries with it pours out into the surrounding neighborhoods. Beyond the sanitation and flooding aspects, the rapid downhill flow also carries away individual steps and makes many materials too slick for safe travel. The new stairs, unfortunately, have not been built with consideration to improved drainage and sanitation. Stairs may be the best way to get around in the verticalized neighborhood, but renovating them without improving their basic structure indicates an incomplete understanding of the challenges faced by the local community.

Inappropriate projects

Other projects reach the objective of the development agency, but fail to meet the needs of the local community. By conforming to metrics designed by the donor agency without tailoring them to the needs of the recipient community, projects started with good intentions can have minimal effects. Sometimes, proposed plans can even be detrimental to the community.

One of the projects that has been clearly successful by its own metrics delivers building materials to families in Canuanã and the settlements surrounding it. They saw a need to replace the traditional *palmeira* housing (Figure 10) with a more durable and more permanent material. This region's need was probably defined by the heavy rains and flooding that occur every year, which inevitably leaks into grass houses and destroys some of them. The response was to send out bricks and clay roofing tiles. Some people got assistance in building a house, but others built by themselves. Clay and brick houses are way too hot for the region's year-round high temperatures. People find the temperate livability of *palmeira* houses so much superior to the brick and clay that they will tolerate the leaks during the rainy season. Many of these materials, therefore, still sit in piles on otherwise unused land.

Figure 10. A brick building with tin corrugated roof next to a traditional *palmeira* building in the *aldeia* Canuanã. The dancers in front are part of a harvest celebration for the spirit Haruanã.

Another delivery to Canuanã that proved to be an ineffective expenditure on the part of the state was the supply of two tractors to the *aldeia*. These new, full-size tractors were sent to the Ilha do Bananal about ten years ago. Since then, they have sat idle next to the shore of the Javaés River. Large land areas of crops that need tractors are almost non-existent on the island. Family garden plots measure, at the largest, 10 meters on a side. Most of the plants are not grown in tractor-friendly rows. The money spent on the tractors could have been better spent providing a drip irrigation kit to each family, with resources to spare.

Other potential projects are inappropriate no matter what material they are made from or what technology is chosen. Socially and culturally inappropriate solutions do not aid in development, and can create animosity between community partners and donor or development agencies. In 2004, the government of the state of Rio de Janeiro decided that it was necessary to intervene in the drug-related turf war that tore apart the Rocinha and Vidigal neighborhoods. Their planned solution was to impose upon the communities a three-meter-high wall that would surround the two neighborhoods, separating them from the high-income areas around them (BBC, 2004). Ostensibly, this would "mark off

territory," and was not intended to "stop the violence," said Deputy Governor Luiz Paulo Conde. The wall would have prevented outsiders from getting caught in the cross-fire, and allowed the gangs to settle their battle for the city within a city violently without interrupting daily life for the rest of Rio. In a country that needs to address its social and economic inequalities, it was the worst idea possible. Such a wall would have separated the *favelas* from the few schools and jobs that are available on the outside, reversing whatever progress had been made in terms of addressing the limited education and employment opportunities near the low-income neighborhoods. This is one case where working directly with community leaders would have left a really inappropriate concept at the "brainstorm everything, even the crazy ideas" stage of project generation. The idea immediately drew international criticism, and even the mayor of Rio de Janeiro city spoke out against it. Creating bad public relations outside of, but especially within, communities whose cooperation is necessary for local and national development does nothing for establishing the credibility of a government or outside agency.

Underachieving projects

Even well-planned and well-executed projects may leave only minimal effects on the local community. Good community partners for sustainable operations and continued support for projects that remain in government hands will allow good projects to reach their full potential in meeting community needs and providing long-term solutions to daily problems. Those components are not always present in development projects, and the correlation to mediocre achievement is evident.

One recent example of a project falling into disrepair is the new neighborhood health center in the Rio de Janeiro community of Mangueira de Botafogo. Built by the city government around 1999, the building has been unoccupied since 2002. It was originally intended to have a regular schedule of doctors, preventative health clinics, and community day care. The government chose to build the health center in a part of the neighborhood that was known by locals to be under the control of drug dealers. Things went as planned for only a short while after the center's opening. Residents were hesitant to come into a drug zone to take care of their current health problems, knowing full well that it could cause them new and more serious health problems.

Life is always interesting in the *favelas*, where even whole neighborhoods can be built up and others torn to pieces, all under the guise of community development. In the middle of the twentieth century, several working-class *favelas* with minimal infrastructure and high crime rates were demolished. The residents were moved to newly built housing with utilities on the arid flatlands known as the Baixada Fluminense on the outskirts of the city (Page, 1995). Without continued support for community building, what promised to be an otherwise nice neighborhood devolved into a war zone similar to the one they had left behind (Mariz, 1994). The material improvements alone provided to the community did werenot sufficient to foster the necessary capacity to reestablish themselves with a new, peaceful existence in the Baixada Fluminense.

One of the challenges of getting projects to meet their planned potential is knowing the target community. This is particularly difficult for agencies without strong community

contacts who must rely on data generated by other public bodies. For example, funding estimates and project scale can be strongly influenced by the number of people served. In Brazil, government censuses hugely undercount the population of low-income neighborhoods in cities, particularly the dense, vertical *favelas*, and also that of very remote regions where accessibility to rural inhabitants is limited by environmental factors and transportation. The national census undercount is estimated at 4%, but undercounting in these areas is much higher. In the *favela* Complexo da Maré, for example, the official census report showed 60,000 residents, while the neighborhood association's own census found 138,000 – more than double the number counted in the official census (Lazarte, 2004). Having a better understanding of the community's size would help more projects live up to their objectives, by providing services with a capacity sufficient for local needs.

The need to address similar inadequacies in other programs could not be clearer. The connection between inadequate infrastructure and the bottleneck of economic expansion needs to be stemmed by successful, community-based development programs (Smillie, 2000). Addressing the shortcomings of past projects improves the potential for future development opportunities.

Brazilian Policy on Knowledge and Innovation

Knowledge is now recognized as one of the key factors behind successful industrial development. As compared with facts, knowledge involves the application of facts to a practical use. One of those uses is the development of technology. More than just a product, technology is a tacit and transferable type of knowledge, and it has played a role in the industrialization of Brazil since the Vargas years. Despite policy intentions to bring innovation into the development plan, Brazil's potential in the global knowledge economy has gone largely unrealized.

In addition to modernizing the existing industrial facilities – increasing capacity and efficiency – the Vargas administration created a plan for the construction of large professional schools. The goal was to create a large network of professional research institutions to reach all corners of the country. In theory, these universities would also partner with local government initiatives by providing auxiliary materials and technical guidance (Vargas, 1999). Before Vargas could get it going strong, the nation's growth was put on pause.

Kubitschek again tried to bring knowledge into the policy equation. His administrative plan involved the implementation of a "nuclei" of advisors. By borrowing personnel from other state ventures, Kubitschek made some in-roads into ways to bring competence and expertise from the rest of the bureaucracy in to advise policymakers near the top.

Under military rule, the objective in the knowledge field was to make Brazil technologically self-sufficient (Skidmore, 1988). The state projects undertaken during the Brazilian Miracle make this point very clear. Between 1964 and 1985, the military made the nation's first attempt at an atomic energy plant (which is still online, but is frequently shut down because of numerous design flaws), created and funded the majority of the research institutions in existence today, and initiated a 1969 university reform across the nation that created graduate degree programs in technical fields and coordinated curriculums at both undergraduate and graduate levels of study (Page, 1995). One of the results of that reform was a rapid increase in the number of Brazilians trained in and applying scientific knowledge. For example, in 1954, there were literally only a dozen economists in all of Brazil, all of whom worked directly for the government. By 1974, there were several thousand, advising not only the government but also major banks, investment firms, and large corporations (Hudson, 1998). By creating state projects and reforming technical training, policymakers tried to ensure that industrialization would be accompanied by scientific growth both in entrepreneurial (urban, private) and hierarchical (bureaucratic, state) agencies.

Despite the nod to the importance of knowledge, it ended up playing a side role in the country's industrialization. Increasing production capability through mechanization starred from year to year. Later on, one federal minister acknowledged how "naive" they had been, and how the Brazilian Miracle had "attributed almost exclusive importance to industrialization" such that "managers thought only in terms of machinery without being aware [of the] economic status of the region and the lack of technical-education resources

and adequate relationships with the country's decision-making centres" (Henshall and Momson, 1974).

Unfortunately, the technology lobby has lost influence since the 1980s in both the public and private spheres. Since the last military presidency and into the present day, science and technology sectors have been treated as just another pressure group by the Planning and Economy ministries (Hudson, 1998). Before then, when the military was spending heavily on new hardware and research, science groups had easy access to Brazil's leadership. Recent budgets have spent the bare minimum on science and technology while trying to deal with debt and, until the last few years, serious inflation. In consequence, Brazil now does less than 1% of the world's scientific research as measured by either dollars of funding or patents awarded (OECD, 2001). Public funding is small, but still 150% greater than private research funds (Figure 11), and almost no R&D funding comes from overseas.

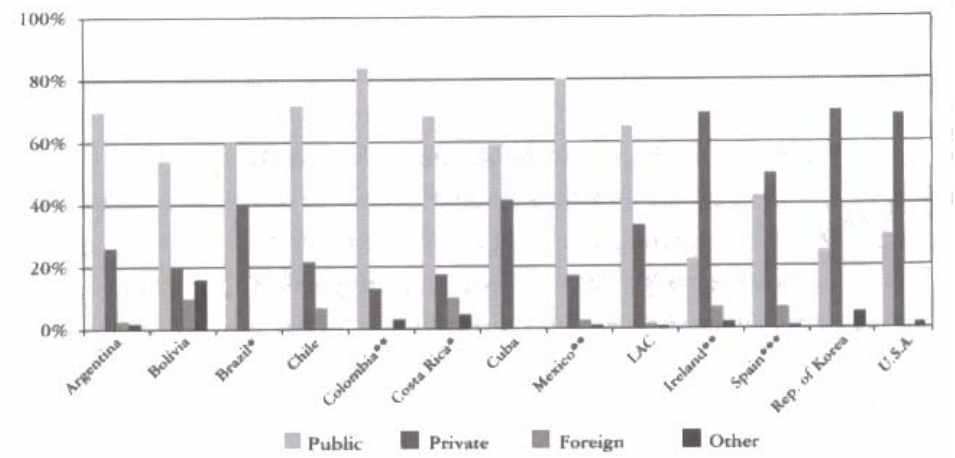

Figure 11. Sources of Brazilian research and development funding in 2000 relative to other countries. Source: The World Bank, 2004.

Only a small fraction of the public investment in research and development is made by a small group of state corporations, focusing on a narrow set of fields. All of that money goes to oil, mining, telecommunication, and aeronautics. The remaining public investment in research and development is connected to public university and research institution demands. Few of these funds are ever translated to commercial applications (OECD, 2001). Though the funding for equipment is still limited, the government has been more than generous in providing space for researchers at universities, even though in many cases the universities lack the managerial capacity to coordinate and lead major research projects (The World Bank, 2004).

Even in the private sector, innovation is not yet the top priority. Over the years, the government has required local product development in some fields like telecommunications and computers, and supported a few other industries, notably agricultural mechanization and military equipment (Hudson, 1998). Most of the country's firms, as a result, have limited experience in planning and conducting innovative research.

Research goals are limited by the way in which knowledge is neither particularly ubiquitous nor sufficiently deep to sustain businesses that try to move ahead of the crowd. Only 0.5% of the people who earn Ph.D.s in Brazil work in the private sector (Husdon, 1998). This figure is much higher in countries that have a strong investment in knowledge and research. Of United States science and engineering Ph.D.s, for example, about 16% work in the private sector. Almost all Brazilian Ph.D.s work in the

universities or nationalized research institutions, and must counter bureaucracy and a work culture contrary to the fostering of innovative solutions. Of those firms that participate in research, few of them have actual plans that guide their investments. Because of the shortsighted planning, many of their projects are small and short-lived. The results, then, tend to be evolutionary rather than revolutionary, and focus on advanced development products that can be brought to market almost immediately. The consequences are visible in the international marketplace. Very few Brazilian companies enter into international competition on the basis of their application and extension of knowledge (i.e. innovation).

To join the international marketplace based on innovative technological capabilities, basic changes will have to be made to research and knowledge values in Brazil. Localizing the knowledge will prove to be as important in the path of industrialization as localizing manufacturing. The link between the two and the next best phase of industrialization is for Brazil to get a greater share of the value added to products by bringing more of the knowledge-intensive stages of production activities into the domestic sphere.

Recommendations for Brazilian knowledge and innovation policy

Over the last seventy years, Brazil has gotten really good at low to intermediate technology. The additional intensity has been driven largely by inherited competitive advantage like its abundance of natural resources and substantial investments in capital and the production chain. The research capacity that is missing will become key to Brazil's continued growth in the twenty-first century. There are policy options that can place shared knowledge near the top of the development profile. A big step towards success will include the horizontal integration of projects across the country and the correction of inequalities that have plagued Brazil's development since colonial times.

On the whole, Brazil has been gaining by improving production capacity and project execution skills. There are still only a few examples of Brazil at the "knowledge frontier." Brazil could be on the world's map as a site of high-tech knowledge in the future with

- Technology companies engaging in novel, pioneering work, rather than enlarging and cheapening work initially done by others
- A greater number of local firms linking to information exchanges, on the basis of a commitment to the acquisition and application of knowledge to both domestic problems and the international marketplace
- The presence of international firms investing significantly in R&D within Brazil, as has happened in other rapidly and successfully industrializing countries like China and India.

In the next few years, Brazil will have to address two main questions on how knowledge relates to future national development. The first issue is how to improve research productivity and quality, to provide adequate return on the resources committed. The second issue is how to translate the best research into commercial applications. That last step is necessary to turn research into concepts that can be applied to improving society and economy (UNDP, 2005).

The research productivity in government and universities would benefit from tearing down the walls between similar programs. There are a plethora of public agencies, and many groups within universities, doing work on the same problems without communication. Unification of similar programs, or at least cooperative communication, would help coordinate efforts on nationally set objectives and priorities. Horizontal integration will become important not only for multiple projects with similar objectives, but also for those whose objectives can be related in practice to form systems-level development based on innovative solutions.

Renewing the commitment to the university – which has faded since the 1969 education reforms – will strengthen graduate research and improve connections between programs throughout the country. These links will also broaden the access to academic and technical information across different parts of the country.

Another consequence of addressing the horizontal structure of development is the general increase in training and competence. This is true even outside of the university. One of

Brazil's coming challenges in development is the correction of unequal income distribution and mass poverty. The cycle between these two is a dire obstacle to future economic growth within the nation. The poor, both urban and rural, have limited access to information, which leads to high prices, at the household, firm, and institutional levels. They also have lower than average levels of education. Improvements in the education system at lower levels will qualify more people for more responsible jobs in the new economy.

Increasing the knowledge of individuals will also increase knowledge within the firm. Brazil has a strong entrepreneurial sector, but lacks what are known as "knowledge-based entrepreneurs." Knowledge-based entrepreneurs are the actors who bring new ideas and research to market. These ideas may have been conceived in a university or research institution, but their application ends up creating gainful employment (OECD, 2001). If the notion of creating gainful employment can become as or more culturally accepted as rote job seeking, the transfer of research from the public sector to commercial success will be increased by people leaving the universities. Connecting innovators to the resulting businesses will increase technology transfer from universities to commercial applications. Increased transfer increases return on investment of public funds by increasing GDP. At this level and for those without as much education, lower entry barriers will encourage people to apply their education to new small and medium sized enterprises. The fact that it takes ten times as long to formally start a new business in Brazil as it does in the United States (The World Bank, 2004) is an example of the

obstacles that discourage individuals from going into business on their own in the current environment.

No single institution can be responsible for the development of a nation. Transfer of research from the incubation goals of the academic world to the production goals of the commercial sphere can link institutions in the creation of new Brazilian ventures based on innovative technology. Such transfer requires the creation of stronger relationships between universities and businesses, both small and large, which have a domestic R&D presence (UNDP, 2005). The university-enterprise connection can also foster the growth of business incubators for people trying to apply their science and engineering skills to a new business idea.

By expanding the reach of knowledge developed within Brazil's research institutions, the country will be able to reconsider investments – replacing the uncertain future of foreign direct investment with capital that it has more influence on. Along with economic policies favorable to small businesses, initiatives that improve the standing of universities and their relationship to the domestic corporate world can strengthen Brazil's future prospects of development as an innovative industrialized nation.

One way of facilitating such relationships is the domestic innovation of solutions for Brazil's diverse communities and their daily challenges. The exchange of technical and regional knowledge requires the participation of local communities but is rewarded by new opportunities for growth and innovation.

The Opportunity for Participatory Development

The age of Pharaonic projects may have ended a few decades ago, but Brazil still makes a sizeable budget available for underdeveloped regions and communities. For the amount of money spent though, returns are low. Even successful projects continue to rely on the government for funding long after they should have matured. Giving up on development is not an option in either rural areas or in the poorest neighborhoods of urban Brazil. Past policies have focused on the mechanization and industrialization of industry at the expense of community and knowledge development. In order to continue the country's growth, development must begin to move forward across the entire nation. Cities with inadequate infrastructure – like housing and utilities – create bottlenecks for economic expansion (Smillie, 2000). Overexploitation of the natural environment and overemphasis on agricultural mechanization are both closely linked to rural poverty. The link between human poverty and economic stagnation is clear, and adopting community-based policies could be the way to the future.

One type of community-based action typically used in other sectors is participatory development. Participatory development is a people-centered practice whose process ensures community ownership and indeed, participation, in design, implementation, and evaluation, of new concepts introduced to their community, usually in conjunction with outside agents (Jennings, 2000). The ultimate foundation of participatory development is the idea that people can and should be responsible for the development of their communities and themselves. In the policy sphere, it means that top-down mechanisms must give way to bottom-up mechanisms that shape local entrepreneurial ambitions.

Grassroots needs are satisfied by increased access to information and innovation. The catch is that the initiative must come from local inhabitants, even though outside leadership, finance, and government do play a role (Richardson, 2000).

Each application is context-specific, and so the concept of participatory development is inherently optimized for and even limited to work at the community level. The process itself ensures that the solution will also be specific to the constraints of the local community. The main process can be summarized by:

- Opening lines of communication with intended users
- Mapping user needs and suggestions to the system
- Developing a prototype in conjunction with users
- Presenting best proposal(s)
- Integrating feedback and reiterating.

The very nature of the process enables application of similar steps to a wide variety of challenges. In Brazil, not only are the environmental, cultural, and financial situations widely diverse across the nation, but the community needs for sustainable development also differ. Some need the most basic technologies adapted to their living conditions (e.g., water collection and purification in the settlements). Others lack organizational structures that could improve economic opportunity at low capital costs (e.g., farmers' cooperatives or ecotourism set-ups). These two common conditions, and most in between, can be approached with similar practices.

Opening lines of communication with intended users

The objective of participatory development is to create more successful solutions by involving the target community in the project. Connecting with the community instills trust and confidence in outside agents. In the other direction, people coming from outside can begin to understand the constraints that they must work within to bring improvements to the area. Having a good community partner is also a key to the success of introducing individuals from diverse backgrounds. Working with someone in the community who is trusted eases communication, even between people from different parts of the same country. Many of the attempts at development that were present in Tocantins or in the *favelas* only went halfway towards solving the problem they were meant to address. Improved communication with the local community could have ensured much better programs with, for example, appropriate materials and long-term sustainability. By working with the residents, the agency that built the health center in Mangueira de Botafogo could have selected a safer part of the neighborhood so drug activity would not have scared locals away from going to the activities held there. Similarly, the building materials sent to the settlements to make new houses could have been better selected if the donor had known how hot the homes would get during the summer.

Additionally, at this stage, people and organizations are identified that can take responsibility for the continuation of a long-term project. The most disappointing part of any special event is when it comes to an end. Projects that are planned without the involvement of the local community risk a lack of continuation when people have not been involved at the early stages of growth.

Mapping user needs and suggestions to the system

The exciting part about working with communities and cultures that are in many ways different from one's own are the opportunities to learn about alternative viewpoints of the essentials of daily life. In the case of designing appropriate technology with a partner community, what begins as small talk can become critical to project planning. Challenges present within the community may come up that people may not even have noticed before, because they had just been a part of life. Information about readily available materials, services, and skills can be discerned. Data on a wide variety of topics like those above can turn general programs into specific actions, ideas into finished products, and hope into action.

Developing a prototype in conjunction with users

Whether working consistently in the field or long-distance, involving the future users and co-owners will improve final results and aid in creating ownership and self-determination within a partner community. By working with future users, important design specifications are met throughout the process, rather than as a checklist at the end. This keeps design flexible and ensures that expectations are being met along the way. It can otherwise be difficult to make changes late in a design project, no matter what the final product is destined to be: designers get attached, budgets get spent, and deadlines approach. At the same time, the diversity of people collaborating brings a variety of textbook and practical solutions that may not have come together had they worked separately. For both outside engineers and community members, the process of co-creation can lead to capacity building and empowerment for pursuing future ambitions.

Working at such difficult problems, any process that facilitates the growth and implementation of ideas is of benefit.

Presenting best proposal(s)

Because of the way news spreads, especially in small and tight-knit communities, many people besides those actually working on the project will know how things are going. This is the time to celebrate the work done, talk about possibilities for the future, and emphasize everyone's role in making the day possible. At this point, the results really become "theirs," and should remain a part of the community. The capacity to reproduce those results also stays. It is, however, replicated in a way that makes it useful for more than one occasion. The "ta-da" moment for any project can be among the best, but the project is not over yet.

Integrating feedback and reiterating

Careful introduction of technology is critical, though. Initial reactions, verbal and non-verbal, should become the basis for improvement. Comments on appearance, function, cost, or even basic concept can lead to changes that were not even considered before. Once things have been running smoothly for a while, changes that need to be made in this community or for future evolution will become apparent. At this point, those initially involved can help on the next revisions, leave them to be spearheaded by the long-term community partners, and use them as a basis for options in a similar situation when working with another community.

Conclusion

The concept of community participation itself is not particularly revolutionary in the field of international development. What separates the experience described here is the joining of institutions from around the world with the objective of sharing knowledge for community improvement. Students from the Massachusetts Institute of Technology, the Universidade de São Paulo, and the Fundação Bradesco Escola de Canuanã joined together to share local and international solutions for the daily problems encountered in a village and settlement region of rural Brazil, like water collection and food storage. In these communities, there are already established relationships with relevant government agencies, but little effective or sustainable change has come about from their relationship so far. Modified policy for interior development should incorporate local communities' feedback and ownership to ensure long-term gains from national development. Incorporating a process like this into domestic development efforts could make the difference in unifying Brazil in its naxt major period of growth.

The application of technology in participatory development

Having community partners like these involved in participatory development activities facilitates an "injection" of technical knowledge into local community. This is not to say that the results could not have been done by the community itself, or that the results will be totally-new-never-been-done-before solutions. The key is turning user needs and suggestions into applied solutions. Some of the suggested concepts may already have been present in the community, but may not have been expressed in the "right" way to initiate action on applying them as a solution to everyday problems.

Outside input also brings with it the network of agencies, universities, and other groups that share experiences worldwide. In this way, such organizations can bring a local solution to a global audience. Intermediary organizations may facilitate dissemination since it is easier for communities to find or be found by an intermediary (e.g., MIT) than to make direct contact with other communities, because of their similar and shared limitations. As a result, meetings of participatory design bring about not just "wowie" new solutions, but also an application of this canon of solutions developed in distant communities that have faced similar constraints to meeting their goals with available resources. Often, a direct transfer of an idea directly from one location to another is not effective. But, by integrating feedback from the community, modifications can be made so an idea suits the local constraints without completely "reinventing the wheel."

During extended field work in Canuanã and the *assentamentos* of Tocantins, MIT students worked with other students from the Universidade de São Paulo and the local

Escola de Canuanã to explore relevant solutions to the challenges faced in daily life in the rural *cerrado*. After getting to know the community and discussing their local needs and ambitions, technical concepts were exchanged. Solutions from outside were welcomed as concepts that could be applied to Tocantins, and the school's own designs were recorded to share with other communities that MIT works with.

The concepts and designs explored in Tocantins had counterparts local to other parts of Brazil (e.g., the Centro de Inclusão Digital), with origins at MIT (e.g., the Test Water Cheap water analysis kit) or other research institutions (e.g., Light Up The World WLED lights and low-cost drip irrigation), or from distant communities with similar day-to-day constraints (e.g., the pot-in-pot). Each of these technologies met a need of the local community. Some needed more adaptation than others to be effective in an area different from the one they were originally designed for. The technology case studies are not to determine success but rather to discover what needs to be in place for their implementation. A similar model could be used in national development plans with greater effect than previous methods. Those that were most adaptable to the local conditions may become a part of daily life in the *aldeia* Canuanã or the *assentamentos.*

Technology: CID

The Centro de Inclusão Digital (or CID, Center for Digital Inclusion) is a national project started by the Fundação Bradesco to bring information technology labs to communities across Brazil. The objective of the CID initiative is to promote the effort to join the information age and stimulating social responsibility and action (Fundação Bradesco, 2005e).

The Fundação has been working with multinational corporations from the IT sector since 1997, developing curricula for teaching student mentors as well as for local mentors who will teach community members, and organizing volunteer service and donated hardware. The first events in 2003's *Mês Nacional de Inclusão Digital* (National Month of Digital Inclusion) were so successful in terms of attendance, learning, and community excitement, that a possibility to offer permanent access was sought.

Finally, in 2004, 22 centers were opened across the nation (Figure 12). Mostly located in small towns and villages, they served around 10,000 clients in their first year of operation alone. The goal for 2005 is to open 18 more, including the first in an indigenous village, at the *aldeia* Canuanã in Tocantins.

Figure 12. Locations of the first 22 CIDs, including the one opened in Canuanã in January, 2005 (light grey, center of state). Adapted from Fundação Bradesco, 2005e.

The first and primary goal of the CID (Valente, 2005) is to increase public access to information technology and digital equipment. Through this technology, the CIDs are to be used to increase opportunities for participative social management and youth proactiveness in the local and greater Brazilian community. For their first 18 months off the ground, the CIDs have done remarkably. The long-term goals of the Fundação Bradesco go beyond bringing IT to rural communities, and extend to the very roots of the places they are a part of. Through the CIDs, it is hoped to:

- Foster local autonomy and acts of citizenship
- Increase school participation and support of the Bradesco foundation
- Create a social activism network around the country
- Train facilitators and community leaders through the curricula at the CID
- Use the schools and CID as a sociocultural reference point for each region.

The success of the CID in the IT realm will then be used as a booster for conversion of the CID and school network to a Centro de Inclusão *Social*, forming a *rede* (web) of socially inclusive organizations that serve primarily rural or low-income communities.

Application: CID

Opening a CID in Canuanã was a new adventure for the Fundação Bradesco. This was the first CID to open in an indigenous village, which presented an entirely new set of challenges. People from MIT and the Universidade de São Paulo helped make it a successful event for everyone involved. In an IT situation, technological hurdles always arise. Besides those, there were also cultural and linguistic challenges to be met before and during the opening of the Canuanã CID.

The plans for the center include ten workstations and a central server that doubles as a workstation for the mentor. Once the computers were working, a printer and scanner were added. As of spring 2005, a digital camera is also made available at the CID. To assure a clean and consistent power supply, power is provided by connecting the center to the power facilities at the school. Internet connections are also made to the school – from the workstation, to the central server, by radio across the river Javaés to the school, and then by satellite.

Getting the hardware to cooperate is only the first stage of preparation. Another big concern is how to introduce digital technology to an ethnic society with strong traditions. All over the world, increasing contact and trade with other cultures has tended to diminish culture traditions. In indigenous groups that have until now been relatively isolated by the rural nature and vast expanse of their countries, rapid introduction into modern technology and the information age has the possibility of eroding traditional belief systems, practices, and teachings. The risk grows as younger generations are more

and more attracted to interactions with outside groups and traditional teachings are taught less and used less in daily life.

Even from an outside perspective, the importance of the new CID to village life and its presence as a village space open to everyone is evident. The community decided to put it in one of the newer buildings which also has some offices of FUNAI, the Indian affairs agency of Brazil, and of the local *cacique* (village political leader). The building is very close to the river, signifying its centrality in daily Canuanã life. In other regions, being situated near local and national government offices would make people wary of using the facilities. Here, the relationship between villagers, local leadership, and FUNAI has been positive overall. The proximity suggests their approval and support, rather than control. In big letters above the door, the indigenous language for the CID has been painted – in the same size as the Portuguese. Known in Inỹ as the *Itya Wo-ò Tamỹderexina*, the local name brings together existing word roots to make a name that derives from communication and togetherness. Two of the traditional Javaé headdresses frame the door to the CID, one for the *cacique* and one for the *pajé*. The headdresses represent not just these two individuals, but also the long tradition through which the positions have been handed down (and, recently, elected!) and the strength that they give to the society.

Inside, the local theme continues. Recently painted white walls were repainted again as part of making the CID a Javaé space. Indigenous cultures in Brazil and elsewhere around the world often have geometric designs that represent things or characteristics in the world around them. One of the teachers at the local school, *escola tainá*, had been

collecting drawings of these patterns as a sort of cultural database. Local painters chose several of these to line the walls (Figure 13) of the CID, personalizing it for the village. Another wall was chosen to host pen and paper drawings and then later, in addition, printed drawings by the children of Canuanã (Figure 14).

Figure 13. The patterns chosen by the Javaé painters represent, from left to right, the letter *S*, the spines of a bush, beans, and a chameleon.

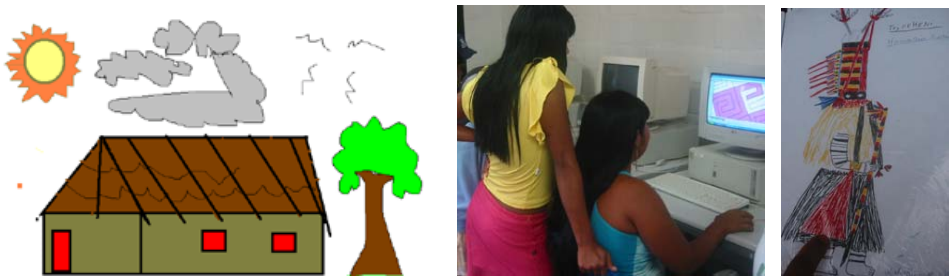

Figure 14. Some drawings by children in Canuanã. As children in the US may draw representations of their family and the cultural characters that are a part of their lives, children in Canuanã draw *palmeira* houses along the river with palm trees and sunshine, as well as traditionally painted dancers and spirits like Haruanã. From left to right: a palmeira house; two girls practicing drawing on computer with traditional patterns; a pen and paper drawing of a *Txyreheni*, a traditional dancer.

Adults were also interested in looking at internet materials related to the Javaé and other indigenous peoples in the Tocantins region. Popular destinations included a project on the Javaé language that the village took part in with the Universidade Federal de Rio de Janeiro (Maia, 1986) and videos of the most recent *Jogos dos Povos Indígenas* (Native People's Games – a nationwide contest of traditional and introduced sports). Though

popular at home, no American cartoons or Brazilian *telenovela* stars had come into the CID yet.

In addition to the cultural challenges, more tangible difficulties were also present. Language, in particular, is one area where information technology (the CIDs) and the users will have to meet in the middle. Computers rarely speak the same language as humans, as evidenced by the special dialects, known as Scheme, FORTRAN, etc., needed to tell them what to do. Even entering information for other humans, though, and understanding how to transmit that information, requires language that was not common before the prevalence of computers and still does not exist for societies where information technology is new.

Most of the Javaé in Canuanã are bilingual in Portuguese and the local language, Inỹ. For communication between people in the community, they tend to use Inỹ, which is also used as a written language. For beginning computer users, this presents a problem when there is no key for some of the letters in their alphabet. Those characters, like ỹ (small Latin letter Y with tilde), are often available from extra symbol menus in internationally mainstream programs like Microsoft Office, but even using them on the web for searches or entering personal information on forms lies somewhere between difficult and impossible. Omitting diacritical marks is not a sufficient option in Inỹ. As many as four options are available for one letter (e.g. ỹ, ỳ, ý, and y).

Learning how to use, mentor, and maintain the CIDs has also required the creation of new words and concepts in the Inỹ language. The local name for the CID itself is an abstraction created from roots that already existed in the language. *Itya Wo-ò Tamỹderexina* translates roughly to People's (*Itya*) Place (*Wo-ò)* for Communication and Togetherness (*Tamỹderexina*). But other common computer phrases like "mouse," "browser," and "processor" presented new barriers to new users and people learning to be mentors in the center. Between the visitors from the Fundação, MIT, and USP, and a few people from Canuanã who had experience with computers outside the village, translations were found for all the most common words. An attempt was made to bridge the gap by using words in Inỹ that matched the etymological concept in Portuguese. So, the Inỹ word for mouse is used for *o rato*, and to browse is related to the Portuguese word to navigate (*navegar*) rather than the passive "browse" activity preferred in the English language.

Some of these linguistic issues still need to be resolved, but part of this is a matter of time and a matter of learning. The more time people have to work with and talk about new technology, the more opportunity they will have to find ways to discuss it in terms that match their own reality. The language created within that space will reinforce the local ownership of the center.

The introduction of the CID when it was finally ready had to make clear to everyone involved that the center was a village space for everyone. Though it was initially set up and largely funded by people outside the village, the transition to local ownership was as

important part of the center's opening. Even before the opening, a sense of ownership developed among those in the village who had been working towards its opening. People from Canuanã had been involved in the siting, building, painting, and purchase of CID equipment; they had invested their time, effort, and money into the project.

By opening day, work had been going on in the CID for almost two weeks. People would come and go, take a chair and watch the work, then leave. The sun coming in through the open windows was often hidden by people who preferred to watch from outside, climbing onto the ledges or standing on each other's shoulders. Once the computers were all online, people started to come in and ask what they could do with the new computers, where the computers (and we) had come from, and, most importantly, when the village would get to start using them.

At the same time, another group of students from the three visiting schools (MIT, USP, Escola de Canuanã) were walking through the village and spreading the news about the opening of the CID. Although it had been the biggest news in Canuanã for the last month, a personal introduction was important, especially to women and the older generation. After hearing about the CID, and learning about the people, their families, and what sorts of things they thought they might want to use it for, we took pictures for them and the opening night ceremony. This would be the first time that many of them would see (and keep) a picture of themselves, and to beat that, they would be projected in the Canuanã meeting hall at sizes larger than life. For many of them, this was their first step into the new digital world.

The opening day slideshow was part of a day-long celebration that formalized the transfer of the CID from its set-up phase with the Fundação Bradesco, MIT, and USP, to its operation phase as village public space. The celebration was important to symbolically and openly acknowledge the change of hands. A formal ribbon-cutting was officiated by leaders from the Escola de Canuanã and the *cacique* of Canuanã, followed by a town meeting and traditional celebration songs and dance. The whole ceremony was video-taped as the beginning of a collection of cultural records that could be shared by the Javaé from the CID computers.

The village of Canuanã had to start learning the basics in order to make the most use of the CID, and to share cultural information from the Ilha do Bananal to other groups within and far from Brazil. In the first days after opening, mentors from the Escola de Canuanã helped early adopters learn the basics in computer use, common applications, and creative potential. Within a few weeks, the teachers from the village's *escola tainá* joined them. The local teachers were introduced to more advanced processes, common maintenance needs, and the curricula that were intended to get people "up to speed" to meet various personal and academic goals. Until the middle of 2005, the mentors from Escola de Canuanã will be working with the teachers. After that, the school will step back, and all management will be done in the village. Because Escola de Canuanã is right across the river from the CID, they will still be available for problems beyond the current capabilities of the new CID mentors. This maintenance plan reinforces the community's interaction within and ownership of the CID.

Material taught at the CID by the mentors reflects the community's state of development and their hopes for the future. Meeting people around the village throughout the preparation of the CID allowed plenty of opportunity to learn what people were interested in *doing* and how the new public access to IT could facilitate their ambitions. Teaching plans were matched to community goals (Table 5) so that group classes could be offered where the people of Canuanã could work together to meet their personal and shared goals.

Ambition	**Skills taught**
Keep in touch with people far away	Webmail, typing
Cultural database/collections/recordings	Scanner, Digital camera, Paint
Education	Paint, typing, educational games
Joining island ecotourism	Website design, cameras
Market, government information	Browsing, searching

Table 5. Courses taught at the CID will coordinate the villagers' goals with the skills that will be taught.

The contacts made by their common ambitions extend beyond Canuanã, even beyond Tocantins and Brazil. But surrounding these ambitions is the goal to maintain and share the traditional way of life on the Ilha do Bananal. The CID supports this goal, as well as the development of new economic opportunities, and the exposure to new creative media. For some developing communities, this kind of an endeavor may not be technically, financially, or culturally feasible. In Canuanã, all of the needed conditions came together so that the CID could be used to help them further their goals of economic development and cultural exchange.

Technology: Test Water Cheap

All over the world, ensuring water quality is a challenge to public health. The high cost and difficulty of conventional water testing procedures limit their applicability to developing countries, but a recent innovation by MIT students may be changing that. The Test Water Cheap water analysis kit is an inexpensive way to quantitatively analyze the *e. coli* and total *coliform* count in suspect water.

Clean water is one of the few essentials to life on earth, yet over one billion people worldwide do not have access to it (The World Bank, 2003). In most cases, the water is contaminated with fecal matter or other *coliform* bacteria. Consuming such contaminated water can lead to diarrhea and other water-borne diseases.

Even contaminated water, however, can look and smell clean enough to drink. If there is no other water around and no clear doubt about its safety, people will use it. There is no way to know whether a community's water is bacterially contaminated without doing quantitative analysis, but conventional analysis is expensive. Unfortunately, existing commercial systems have capital costs of around $1,000, and each water test costs around $6, putting them out of reach of small communities in developing countries.

Designed by MIT Amy Smith and refined by MIT engineering students in a program on technology for development, Test Water Cheap is an inexpensive product for testing microbial contamination of water (Chandalia, et al., 2004). It is intended to help communities distinguish safe from contaminated water sources; to evaluate how well

water treatment methods are working; and to serve as a diagnostic tool for health care workers in regions affected by water-borne diseases.

To meet the objective of designing an inexpensive and reliable way to quantitatively test water, a new process was developed to use a concept similar to that used by conventional equipment, but with cheap and readily available materials (Figure 15). The base of the design is a baby bottle with disposable drop-in sterile inserts. These are relatively cheap and convenient in most parts of the world. (In the communities visited by MIT, they would be easiest to find in the *favelas*. They would not be available in Canuanã itself, but in some of the state's larger cities and certainly in Palmas.) The drop-in inserts, though they add an additional recurring cost, ensure sterility for the least cost and waste per test. The bottle is then topped with a metal washer, filter paper, wire mesh, rubber washer, and a spout, all fixed by a screw-on lid. The spout is connected to a large syringe by a length of rubber hose.

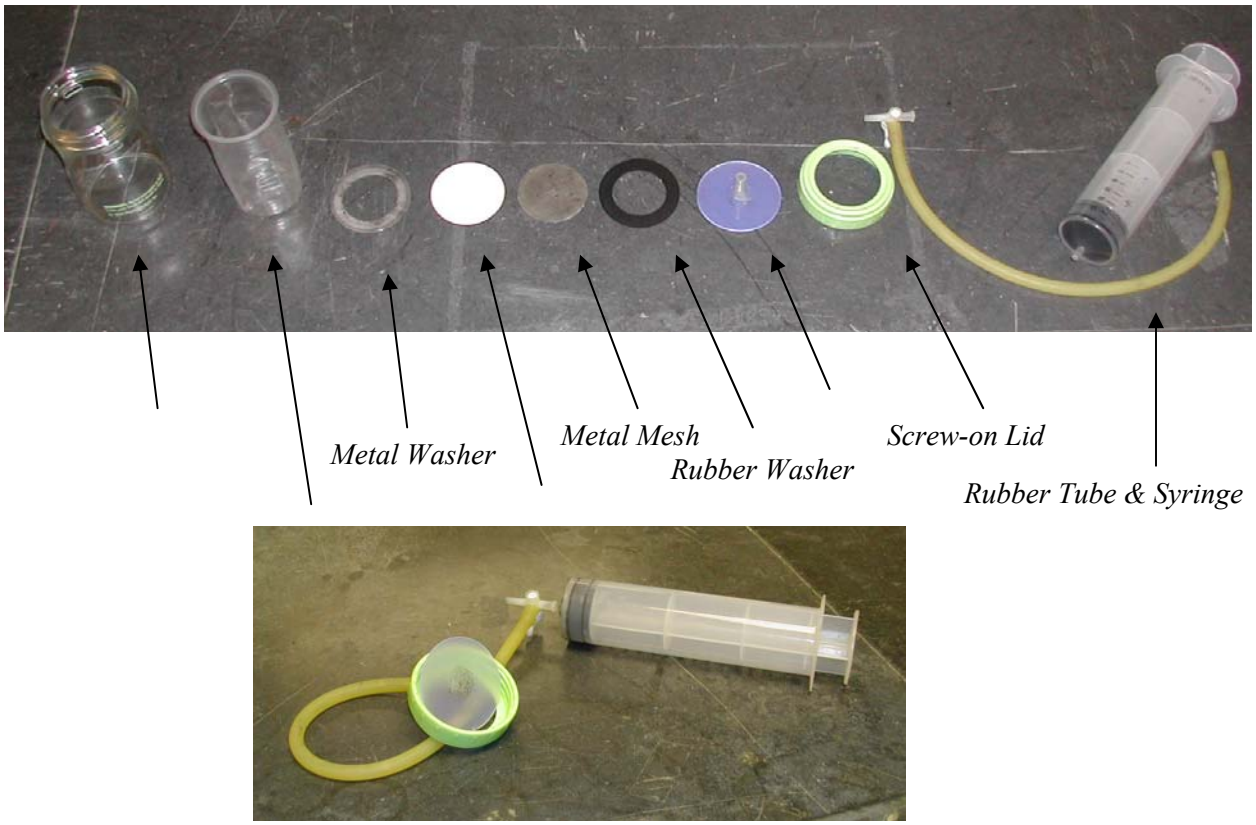

Figure 15. The components of the Test Water Cheap kit disassembled (top) and assembled (bottom). Source: Chandalia, et al., 2004.

By pulling the syringe, water is drawn through the filter paper, through the rubber hose, and into the syringe. The bacteria are collected on the filter paper. When a 100 mL sample's worth of bacteria has been collected on the filter paper, a Petri dish is prepared by adding 2 mL of "broth," or bacteria food, to stimulate the growth of colony forming units (cfus). The filter paper is placed in the Petri dish and covered to incubate. After 24 hours of incubation at about 35ºC, the Petri dish can be opened and the bacteria count made.

The overall costs for the system are far lower than for conventional testing. The capital costs are less than $20. The total cost for a sterile insert, a circle of filter paper, and the

broth for the bacteria amounts to less than $2.50 for each test. Thus, the capital costs have been reduced to 1% of conventional systems, and the recurring costs to 16% of conventional systems.

After more than a year of testing, with samples run in over a dozen countries, the design is performing around the level of accuracy of the commercial versions (Coulbert, 2004) but at a fraction of the cost. The Test Water Cheap system will soon be usable the world over to facilitate alternate clean water sourcing, water treatment method selection and evaluation, and disease control.

Application: Test Water Cheap

The Test Water Cheap system was an ideal candidate for testing and sharing with a technically-focused school in the rural region of a developing country, like the Escola de Canuanã. Water testing in Brazil provided interesting results that will be useful in the design and examination of new technologies, gave feedback that the designers of the water test can integrate into a future design more suitable for this environment, and gave the local organization the capability to continue performing water tests as needed.

Water testing

Samples from the Escola de Canuanã, where the water is treated before being sent to the taps, kitchens, and other points of use, tested clean for *e. coli* and other types of *coliform*. The water in the village and the settlements had high counts of *e. coli* and other types of *coliform*.

For now, however, the results are not very beneficial to the people using the water. The presence of *coliform* bacteria did demonstrate the need for cleaner water sources or improved treatment and storage of water once extracted. Any treatment is an improvement over using the water straight, as is current practice. The ability to test the water will be useful in the future for analyzing prototype designs for water purification and storage.

The biggest challenge in using the Test Water Cheap system in Tocantins was the high turbidity of the water. The water extracted from the river and wells had a high

concentration of suspended solids, primarily clay, and in some locations green algae. For easier use and improved quantitative results in this region and other areas with high turbidity water, the process or system will have to be modified to include a method for removing these solids before trying to collect the *coliform* on the filter paper. This is one example of how a great technical idea can be improved for local use based on the characteristics of the surrounding environment.

Teaching water testing

It was possible to do a large number of water tests over quite a large land area because the students at the Escola de Canuanã were part of the testing team. The relative simplicity of the Test Water Cheap design makes it easy to teach non-experts how to use the system, and the low capital and recurring costs required to make the tests ensure that it can be used without concern of depleting local financial resources.

MIT students demonstrated the testing method to the students from the Escola de Canuanã's Grupo de Saúde Rural while being video-taped. The video-tape will make it easier to review the first-hand instructions. Review can ensure that the process is not modified or degraded over time, and that even as students move on from the GSR, that the method can still be used for water testing in the region.

Students from Escola de Canuanã then did water tests from the school's tap water (purified, treated, and filtered) and from the river Javaés (untreated). Tests were done in

pairs so students could learn from each other and rely on their partners to answer most questions they would have through doing the procedure for the first time.

After the initial testing, groups went back to the village and to the settlements to take water samples at peoples' homes and in public and natural water sources. When the tests were done, the testing equipment was left as a gift to the school. Replacement materials (bacteria food, filter papers, etc.) are available in Brazil, though they will have to be shipped or driven in from a larger city like Palmas, capital of Tocantins.

Test Water Cheap provides the opportunity to do accurate and inexpensive water quality testing locally, but there are some concerns for the sustainability of its application. Looking at the materials cycle necessary for a test can demonstrate why. For one, the materials may be more difficult and more expensive to obtain in Tocantins. They should be available from Palmas, at the most distant, which has a nascent biotech industry and university research programs in biology. Gurupí is closer and also has biology laboratories. Another question comes up after the tests: what to do with non-biodegradable and potentially hazardous materials? The plastics have to be either recycled or landfilled. The *coliform* colonies have to be thoroughly killed with bleach before being disposed of. Presumably the school's campus can handle this, but doing field tests will require on-site disposal or carrying live bacteria back to the school for disposal. Issues like these will have to be kept in mind for future revisions to the product and for each test undertaken in a potentially sensitive region.

Technology: Low-power WLED lights

The condition of utilities infrastructure in rural areas limits or prohibits access to electricity in significant portions of developing countries, including much of rural Tocantins. Living off-grid is a constraint to many daily activities. Moreover, evening activities are severely limited by the lack of light needed to work, study, or do household chores. The effective shortening of the day limits opportunities for economic or personal development. One such organization that literally lengthens the day in many developing countries is the Light Up The World Foundation, an international humanitarian organization affiliated with the University of Calgary. The Light Up The World Foundation is dedicated to illuminating the lives of the world's poor (LUTW, 2004c).

Since 1997, LUTW has been installing solid-state lighting technology in homes around the world. The white-light emitting diode (WLED) provides an affordable, safe, healthy, efficient, and environmentally responsible option for lighting in homes. It is an alternative to kerosene lamps and meager, short-lived incandescent lights (Table 6). WLEDs on battery, photovoltaic, or human power have other advantages over the grid. The use of centralized power in rural areas also increases the monetary and environmental costs of electricity. The installation costs of electric transmission are very high, as are the costs of eventual transmission. In large part, this is a result of the low efficiency of transmission.

Lamp Type	Homemade Kerosene	Incandescent	Compact Fluorescent	WLED
Efficiency (Lumens/watt)	0.03	5 - 18	30 - 79	25 – 50
Rated Life (Hours)	Supply of Kerosene	1,000	6,500 -15,000	50,000
Durability	Fragile & Dangerous	Very Fragile	Very Fragile	Durable
Power Consumption	0.04 - 0.06 liters / hour	5W	4W	1W
Correlated Color Temperature°K	~1,800°	2,652°	4,200°	5,000°
Color rendering index	~ 80	98	62	82
$ After 50 000 hours	1,251	175	75	20

Table 6. Comparison of lighting characteristics for kerosene, incandescent and compact fluorescent lights, and WLEDs. Source: LUTW, 2004b.

Each light is part of a pre-made printed circuit board with the appropriate connections left open for a variety of power sources. The flexibility of the circuit allows mass-produced lighting to be converted to a range of power sources depending on local availability, but also adds to the cost of each light unit.

The WLED and circuit are nested in a hard plastic case. Inside the case, the electrical components are safe from water, animals, and other possible hazards. The top of the case is a lens, which distributes the WLED light over a room-sized area. When connected to a power source, the light immediately floods the home (no switch was built into the set-up tested in Canuanã). This particular system has been used now in over 4,000 homes worldwide (LUTW, 2004c), including those in the *assentamentos* of Canuanã.

Application: Low-power WLED lights

LUTW's low-cost, low-power WLED solution to rural lighting needs sounded like it might just be the thing for Tocantins. Current technology in the settlements and in less affluent families in the *aldeia* Canuanã is still kerosene lamps, which cause significant quantities of indoor air pollution (Warwick and Doig, 2004), have high recurring fuel costs, and do not provide sufficient light. The WLED lights are long-lasting, with limited recurring costs depending on fuel source, and no indoor pollution. After trying them out in the settlements with the students from the GSR, it became clear that the LUTW lights were not ideal for the local reality of rural Tocantins, though.

With a car battery scrounged for power and a shelf to "hang" it on, the first low-power WLED light was turned on in the *assentamentos* of Canuanã. The cold white light overwhelmed the kerosene lamp which burns in the house throughout both night and day, illuminating the black streaks on the wall where smoke residue had stained clay tiles over the years. The house was marvelously lit for the visit by students from MIT and the Escola de Canuanã, casting away the shadows that darkened the house even under the bright Brazilian sun.

The light provided by one LUTW WLED was sufficient for lighting the traditional palm-covered houses, and easily overpowered the kerosene lights used in many settlement homes. However, at 12 V and a list price of US$35 for a 1.5 W bulb (LUTW, 2004a),

dissemination within this community may not be easy. Some of the key specifications don't meet the electrical or financial means commonly available to individual families.

In Canuanã, idle car batteries (12 V) are not very common, though new batteries can be obtained from as nearby as Formoso do Araguaia (60 km). Where they exist, there is likely to already be lighting or better uses for the car battery. If the LUTW lights could be run off of AA through D cells, which are much more readily available in the area and at far better cost, there would be decreased resistance to using them. In an economy where money is only obtained when it's needed, the $35 per light price structure is incompatible with purchase by individual families. At that cost, it would be necessary for the settlements to find a partner organization to support the costs and installation of the lights. Since the lights are rated for 50,000 hours (LUTW, 2004b), replacement costs are not an issue. Such a set-up may be typical for the clients that LUTW works with right now, but there are no such organizations working in Tocantins today. Direct negotiation with LUTW may also achieve a lower direct cost to the community, but that would also be difficult due to the lack of telephone service and people who speak English in the *assentamentos*.

Another possibility for disseminating WLED lights in areas like Canuanã has opened up in recent years. The increasing availability of low-cost WLED lights made as flashlights for the developed world makes banks of WLEDs possible for low-income areas. An array of WLED flashlights could be run from AA batteries for the same cost as one of the

more flexible LUTW. Lights like this are an example of how mass-manufactured products can be applied to problems in underdeveloped regions.

This is not to say that these low-power WLED lights would not be useful for another community or another organization, but it is a good example of how certain assumptions about the design or distribution methods of a new technology can determine its appropriateness in target communities. Despite the seeming match between the local needs and the objectives of the LUTW lights, it is unlikely that this community will be adopting them as quickly as they might adopts some of the other technologies presented in these case studies. The local constraints particular to Canuanã make them less than ideal for the Canuanã families who would need them the most.

Technology: Pot-in-pot

Another consequence of the limited availability of electricity is inadequate food storage. For many rural areas, subsistence farming is the norm. It provides little extra food for families or additional income, and the lack of adequate food storage increases the proportion of that food that goes to waste. The pot-in-pot preserves the food using traditional non-electric methods. The technique has been used for thousands of years, but in the 1990s, the innovation of a Nigerian schoolteacher brought it into renewed widespread use.

For at least the last three thousand years, water-cooled pots have been used in Egypt for cooling wine. Other parts of Africa and Latin America have also lined water and wine pots with damp sand, cooling the liquids inside to provide refreshment in the hot weather (RAE, 2004). Mohammed Bah Abba, who came from a long line of potters from the rural north of Nigeria, had always been fascinated by the way that water seeped through porous pots and evaporated from their surface.

From this observation came the technical improvements that renewed the use of pots for cooling worldwide. Abba's experiments eventually led to the design that made headlines around the world. Between two earthenware pots, one of a slightly smaller diameter than the other, a layer of sand is packed. Water poured into the sand spreads throughout the layer. The evaporation of water requires a relatively large amount of energy, which draws heat away from the inner pot. Evaporated water leaves through the porous clay of the outer pot, and the water remaining in the sand is cooler. A similar process is present

in nature; the same concept applies when animals sweat and when leaves transpire through pores (Time, 2001).

The key innovation behind Abba's design was the creation of a cool air space in the inner pot and the use of the sand-water mix instead of just water in the interstitial layer. Other improvements that Abba made to the cooling pot improved the efficiency of the evaporation. Some versions include a lip on the pot edge that covers the sand-filled gap, preventing the evaporation of water from the top of the pots. Additional efficiency is provided by adding a damp cloth over the opening of the smaller pot. The cloth protects the food inside from the sunlight and holds a large quantity of water on an additional evaporative surface that lengthens the amount of time cooling is provided before the sand dries out.

As a result of these protections, the temperature drop is significant. Depending on the humidity (the pot-in-pot is more effective in drier air), the temperature of the inside pot can be 10 to 15ºC cooler than ambient air. This slows the growth of bacteria and the kinetics of food decay (e.g. by ethylene emission from the decomposition of ethephon in ripening fruits and vegetables). The high inner humidity is also ideal for storing vegetables. Using this design, the shelf-life of a variety of foods could be extended. Abba's results showed that tomatoes stayed fresh for three weeks, not days (Time, 2001); that spinach lasted in the pot-in-pot for up to 12 days, whereas outside it wilted within hours (Lubick, 2000); and that eggplants were edible for 27 days instead of three (ITDG, 2001).

Improved storage techniques have several advantages for the rural Nigeria communities they were first designed for. First, the sale of surplus fruits and vegetables was no longer a buyer's market – farmers did not have to sell everything the day of the harvest, but could instead store the food for bigger markets and better prices (Lubick, 2001). Additionally, the pot-in-pot allowed "mini-markets" to open, where women could sell food from their homes (ITDG, 2001). Foods stored in pot-in-pots had reduced bacteria counts compared to food stored in the open, and could be connected to reductions in food-borne diseases. The pot-in-pot also provided an alternative to dried foods – which both limit the variety of foods allowed in the diet (some foods cannot be dried) and reduce nutritional intake (some vitamins, like vitamin C, are not well-preserved by drying) (Lubick, 2001).

Besides the innovative double-pot design and specific application to food, Abba revolutionized the distribution of the product and the education to use it. After first starting the project on his teacher's salary and giving the pots away for free in his and neighboring villages, the project is now able to sustain itself. The cost of making each pot is US$0.30 (ITDG, 2001). By selling them for US$0.40 (Lubick, 2001), Abba makes a US$0.10 profit on each pot which is being used to fund the project's expansion throughout northern Nigeria.

By the end of the 1990s, Abba and his factories had distributed 10,000 pot-in-pot systems all around northern Nigeria (RAE, 2004). He estimated that it would take another five

years to bring the pot-in-pot to every village in northern Nigeria. Meanwhile, attention from the mainstream press and development agencies around the world has made it possible to bring the idea to worldwide distribution at a much faster rate than one man alone ever could. The transfer of knowledge has hastened access to improved food storage solutions using local materials for a "local" global solution.

Application: Pot-in-pot

The pot-in-pot turned out to be ideally suited for Brazilian needs. Originally invented in Nigeria, the pot-in-pot is an option for practical unpowered refrigeration in many regions where improvements in food storage are needed. The students in the Grupo de Saúde Rural and the people living in the settlements liked it so much that it has its own Portuguese name now: *o pote-no-pote*.

For Tocantins, the *pote-no-pote* was an obvious choice to meet existing manufacturing capacity. The area is well-known for its carefully formed ceramics and pottery. Potters use the abundant porous red clay that can be found in the roads, as floors in homes, in ditches, along the river, and anywhere else in the area. This type of clay is ideal for making pottery that can "breathe." Additionally, the shape is simple enough that any of the local potters can work with it.

The students were immediately taken with the idea. One of them, whose family still lives in a settlement while she attends the residential Escola de Canuanã, was eager to share this technology with her family when she went back during break. In her house, she said, her family had several pots "just like this one" that were not being used. With some sand and water, they could now be used before to solve one of their constant challenges in a way that hadn't occurred to them before.

With the school's Environmental Education teacher, Lucrécio Filho de Oliveira, contacts were made with a local potter to have experimental pots made to match the ones that had

been brought from MIT. A pot-in-pot made locally in Tocantins will not cost more than US$3, a sum affordable to most families in the area. Others can use already purchased pots for this purpose if it is of enough value to them. The first pots are being made to demonstrate that the Tocantins clay is porous enough for the pot-in-pot to work well. Once their efficacy has been demonstrated, more can be made to disseminate the technology to other families in the area. This is happening in spring and summer 2005 through the settlement association meetings.

In this way, a straightforward scientific concept with a practical application will be taught to the people who most need improved food storage and those who can create new job opportunities to meet increased demand for local pottery. The concept and its manufacture were easily transferable between regions with little to no adaptation.

Technology: Drip irrigation

Drip irrigation is a proven method to reduce the water needed for cultivation. By delivering water directly to the plant through tubing, a minimal amount of water is lost between the water source and the root system. The process of drip irrigation has also been conventionally associated with large commercial farms that can afford the capital-intensive set-up (IDE, 2003a). For rural farmers though, an affordable drip irrigation kit was not readily available and produced until 1995.

The International Development Enterprises (IDE) "Easydrip" irrigation kit tested in Brazil by the MIT team holds up to 20 liters of water in a storage bag suspended over the garden. The storage bag needs to be both durable and watertight. Finding those two characteristics in the same material leads to more expensive materials that are difficult to source locally and are either more difficult or more expensive to manufacture. For this kit, the solution is a bi-layered storage bag: the outside layer is made of rugged woven plastic, like rice bags, and the inside is like a heavyweight garbage bag made of thick dark polyethylene. Neither material is sufficient without the other. A threaded cap is screwed into one bottom corner, allowing the pipes to be attached by a valve with a threaded end. A central pipe runs from the storage bag to the ground, then splits into several smaller pipes that can be laid out to match the locations of the plants. The pipes themselves are made of flexible black polyvinyl chloride with plastic drippers inserted at intervals. The dripper is made of similar material, with thinner outer diameter and thicker pipe walls. A knot in the dripper pipe can be adjusted to control the direction and rate of flow. The tradeoff on using the flexible pipes though is the decreased life span; the pipes

are expected to last only one to two years (IDE, 2003a). IDE has shown in other markets that most customers find the short useful lifespan of the flexible pipes acceptable because of their low cost and ease of set-up. Other drip irrigation sets from the same organization which use rigid pipes have an expected useful lifetime of up to five years for three to five times the cost of the flexible pipes. These are primarily targeted at owners of commercial plots.

Getting the irrigation kit ready to use is quick and easy (Figure 16). Only one to two meters of head are needed, so the bag can be strung between two trees without much effort. With the main pipe screwed into the storage bag, the sub-main and lateral pipes can then be spread out and lined up with the plants. For the average family garden plot in Tocantins, only the smallest version (up to 25 m^2) is needed. This was sufficient for many garden plots. If the entire plot was larger than 25 m^2, people were still interested in being able to control flow to the plants that need the most water for successful growth.

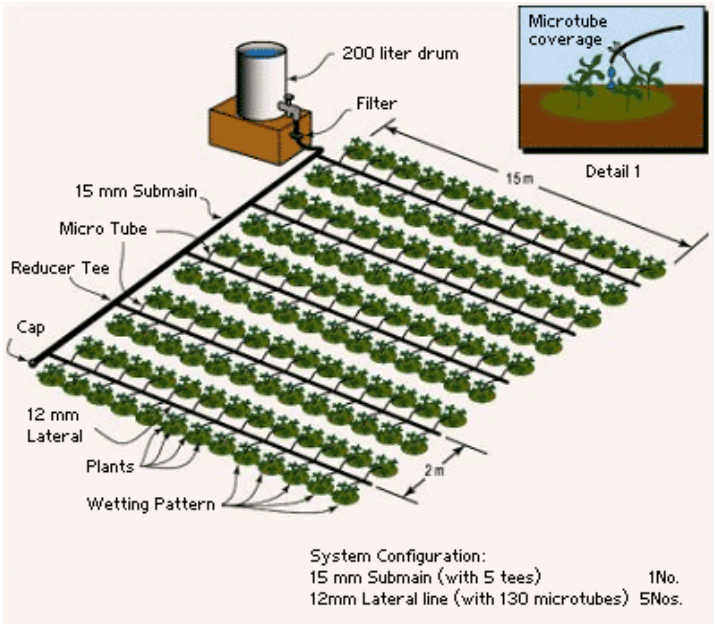

Figure 16. A typical set-up of an IDE drip-irrigation kit. Source: IDE, 2003a.

The manufacturer, IDE, is a non-profit international NGO run "like a business" (Polak, 2004). The organization designs, markets, and disseminates solutions for the rural poor worldwide. Many of their technologies, including the drip irrigation set-up, focus on the access to and use of water as a requirement for escaping the cycle of poverty (IDE, 2003b). Each design is intended to meet the founder's philosophy of high-volume technology dissemination for development. As he summarized his objective in a recent lecture, "Can I sell a million of these?" (Polak, 2004).

The mass manufacturability of solutions for development cannot be applied to everything, everywhere. But the needs of enough communities in enough regions are sufficiently similar that the approach can be used for some of the basic needs with technology manufactured from local, basic, materials available worldwide. Most of IDE's local manufacturing centers to date are in Southeast Asia and in Africa, but they have been moving into South America. In these regions, they have been able to successfully market appropriate and affordable technologies to the rural poor.

South America, and in particular Brazil, is an ideal market for disseminating similar technologies. It is also a region with extensive knowledge of plastics and strong manufacturing capabilities at low prices as a result of 100 years of development through mechanization. If the water technologies can be as successful in Brazil as they have been in other parts of the world, like they have proven to be in Tocantins, it may be an ideal direction for expansion.

Application: Drip irrigation

Between November and March, it rains every day in Tocantins, softening the clay needed to make *pote-no-pote* and other ceramics; but the *cerrado* experiences extremes in precipitation over the course of the year. In July and August there is almost no precipitation, and all the months from April to October are dry enough that keeping crops watered is a challenge. Druing the dry season, arduous labor is required to extract water from wells and drag it across the property to any actively cultivated areas on the settlement. It may be surprising that an inexpensive drip irrigation kit could be useful in Tocantins, just one state away from the renowned rain forests of Amazonas.

For families in the *aldeia* Canuanã and in the settlements, a planned area of crops is common. Depending on the family's size, wealth, and occupation, the plot can range from three to ten square meters (Ramos, 2004). Typical plants include manioc (also known as cassava or yucca), watermelon, beans, and corn. All of these plants require additional water during the dry season, and the irrigation kit is large enough to meet those needs.

At the time MIT visited Canuanã, a few irrigation kits were installed for tests. This was in the start of the rainy season, so the irrigation has not yet come to its most difficult challenges. The GSR students and those in the settlements we visited found the irrigation kits easy to figure out, install, and prepare for irrigation, using the included instructions (Figure 17).

Figure 17. Students from the Escola de Canuanã practice setting up an irrigation kit on campus before taking it to the settlements.

Not only does the IDE irrigation kit turn out to be appropriate for the drier months in Canuanã, it is also affordable. The irrigation system can cost as little as R$11 (US$4) (IDE, 2003a). The only drawback will be the known limited useful lifetime of the kit, as the plastics degrade under the hot Brazilian sun. At such a low capital cost for replacement, and with the added incentive of being able to return the used kit for credit towards a new one, irrigation is affordable even to those of limited means and no regular income. If the market turned out to be large enough to warrant a regional distribution or manufacturing center, additional opportunities could be created. So at a very different manufacturing scale from the *pote-no-pote*, the mass-producible irrigation kit can meet another important community need.

Learning about local technology

Local solutions to daily problems are developed all over the world. Many of them were created to solve one problem in one small location, but could be applied to communities all over the world that are bound by similar constraints. As a good community partner, the Grupo de Saúde Rural (GSR) not only worked with MIT to implement solutions from other parts of the world into their daily lives, they also shared their locally developed solutions. The GSR had two areas in particular for which they had been developing new technology: water extraction and ventilation.

Water extraction

In the settlements, taking water from the ground is arduous work. Many families still use unlined wells and carry water up by the bucketful to drag across their land to points of use. The GSR saw this as an opportunity to create a locally designed solution for a local problem, and try to implement it in their community. So far, they have designed two locally appropriate water extraction devices. Both of them use locally available parts to get water from wells that are between ten and twenty meters deep (Ramos, 2005b).

The first technology works like a pulley, but brings the requisite amount of water much faster than carrying individual buckets up the well. The only necessary materials are

- A length of PVC pipe
- Plastic bottle-cap-like shapes of the same diameter as the pipe's inner diameter
- Thin rope
- Wood (two by fours)

- A water storage tank
- A pulley or pulley-like shape, often a bicycle wheel
- A crank or axle.

With these few parts, hours of work can be saved each day. A wooden structure is built up over the well to hold the water storage tank (Figure 18). The higher the tank, the more potential the water has and the further it can be piped along to reach gardens, feeding troughs, and kitchens. The PVC pipe is run from where the water level will be at its lowest throughout the year. (For Tocantins, the water level varies significantly throughout the year. For six months out of the year, it rains heavily every day. For the other six months of the year, there is almost no rain at all, and water tables are significantly lower.) At the top, the pipe feeds into the water storage container. The rope is looped up the pipe, into the water storage container, over the pulley, and back down. Before looping the rope, though, knots are put at regular distances and between each pair of knots is a cap. A second pipe connected to the storage tank can be used to bring water back down to faucets or hose connections at ground level.

Figure 18. GSR students demonstrate the water extraction device they built in the settlements.

To operate it, instead of lifting one bucket over and over, the user just pulls downward on the rope. The rope comes up through the pipe, bringing the caps with it. Each cap pushes water into the pipe, and carries it up to the storage tank. The GSR's current model can extract fifteen liters of water in one minute.

A second water extraction device was developed by the GSR to allow automatic water extraction and feed to desired points of use. A rubber hose links the water source and a storage container. Along the hose are three valves that control the upward flow of the water. From the storage container, a second hose delivers water from storage to whatever location it will be used at. It works like a siphon pump, so once pressure is built up, water will continue to be extracted from the source until the pressure drops too low to counter the weight of the water. The objective was to design a system that would keep running automatically once it had been started, as long as the valves were open. The water pressure in the hose keeps the pump running by creating a suction which pulls more water along with it. Gravity then pulls the water down to be used.

Right now, this device is still in its prototype stage. The GSR students have been working with people in the nearby settlements to make it more usable for them, but have encountered a few obstacles which will need to be met before the project can advance further. For one, the connections at the valves must be airtight, and with the materials available, this has been difficult. Having imperfect seals allows water to escape and reduces the water pressure in the hose. Water pressure can be increased by having a bigger storage container. The kind that they are using right now forms airtight

connections easier than others, but is more expensive than the people in the *assentamentos* could afford. Taking the design back for refinement will eventually lead to a water extraction device that meets the technical specifications as well as the constraints of the community.

Ventilation

The student dormitories at the Escola de Canaunã are nice, though simple. One of the students' common complaints, however, is how hot they get on the inside throughout the year. The GSR took this as an idea of another challenge in their daily lives that they may be able to find a solution for.

The normal dorms are made of cement, with open windows, a plain door, and corrugated roofs. What the GSR hopes to do is cut larger squares near the roof of the building and add ceiling fans in the center of the room. Hot air would rise in the dorm, and leave through the sides after being pushed towards the edge of the building by the ceiling fan (Figure 19).

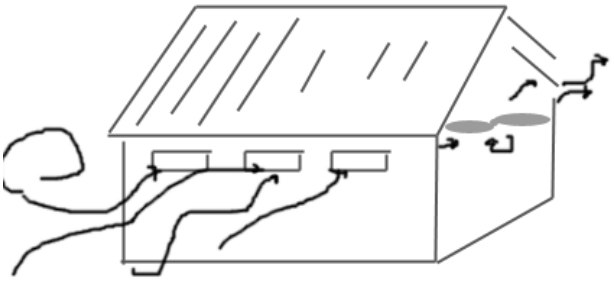

Figure 19. A cut-away rendition of a ventilated dorm typically made of clay brick with corrugated tin roofing. A ceiling fan and open spots in side walls would induce air exchange with the outside.

It follows basic scientific principles, and the idea has also been applied in other cultures and other eras. This is a perfect example of how technology around the world can be reinvented to meet the needs of a different age and environment. In this case, a similar kind of ventilation has been traditionally used to ventilate mosques. Known as wind towers, or badgirs, there are two main kinds (Figure 20). One catches any wind and carries it through the lower levels of the building. The second works by sucking hot air from lower levels and expelling it out the top of the building as it is replaced by cooler air from lower levels.

Figure 20. Wind Tower (Badgir) at The Aqazadeh's house - Abarghu, Yazd

Their proposed solution differs because of the type of building, the natural environment, and the size and height of the open spaces. The GSR's ventilated dorm is still in prototype phase, at a 1:6 model. The students hope to be able to build a model of it the next time the school adds a building or improves any of the current dorms.

Each of these technologies solves a problem in the daily life in Tocantins. Although this is only a small region, their daily challenges are similar to those encountered by millions (even billions) of people around the world. MIT's knowing about their locally developed solutions makes it possible to share them with others around the country or even the world. A large-scale development plan could make significant savings in time and budget by learning about new technologies at each project site and encouraging the application of local solutions to other domestic locations.

Future work

The development in these partner communities does not end here. Fortunately, neither do the projects that have been started nor does the relationship that has been founded between MIT, its students, colleagues in Brazil, and the partner communities. Although in the coming years the faces may change over time, the work will continue.

MIT

Much of this project originated with an MIT class, and then grew from there. The advantage is clear: in a field where projects all too often have the tendency to start and then end before being finished, with no plans for economic or technical sustainability, the long-term relationship between MIT, Canuanã, the *assentamentos*, and the *favelas*, enables projects to continue and grow at MIT before being implemented in Brazil. The wide range of technical expertise here can also be applied to new projects that are now known challenges with defined constraints.

D-Lab

D-Lab, the course that these projects started with, has a continuing relationship with the Fundação Bradesco and the Escola de Canuanã. MIT students will be returning there each year to work with the GSR and local communities. As MIT develops new technologies or learns about solutions from other places around the world, more technologies can be adapted to meet the needs faced by people everyday in Tocantins. Two of the projects that may be introduced in the coming year include solar water bacterial disinfection by exposing water in polyethylene bags to sunlight and bringing

pedal-powered machines to Tocantins, increasing the usefulness of their bicycles and simplifying tasks like corn milling.

Source2Sink

This spring, I am working with a group of MIT students which is continuing with the challenge of providing clean water to the settlements. These three mechanical engineering undergraduates will be devoting their time through a design class, summer field work, and their undergraduate theses for 2006. Their design integrates improved water extraction methods with an experimental prototype for water purification through sand filters integrated with other built parts of the settlement. Rainwater harvesting, though common in other parts of the world, is not yet done in Tocantins. Their water will be collected by rainwater harvesting from the roofs of homes, then stored and run through a slow sand filter. Slow sand filters have layers of sand, charcoal, and gravel that can improve water quality by removing turbid solids and bacteria like *coliform*.

The prototype, including water collection, purification, and transport to points of use, will be tested in the Tocantins settlements over the summer 2005. Between the engineering skills from MIT and the practical and regional knowlege of the students at Escola de Canuanã, an improved (and fully functioning) version will be working in the field by next fall.

Remaining written challenges

Within Canuanã, the *assentamentos*, and the *favelas* that were part of this project, dozens of challenges remain for acquisition of new technological capability from existing sources, social organizations, or opportunities for new designs. The projects that are not currently being worked have been compiled with information like:

- Objective to be met
- Resources available and needed
- Target community, relevant stakeholders, and their involvement
- Relevant design constraints and obstacles
- Potential advantages and risks, for determining most appropriate projects
- Visual documentation

These design challenges will be available to future students working in this community and others who may work in areas with similar needs and constraints. The objective of the design challenge is to make it possible for more people to collaborate MIT-side with partner communities in Brazil. Based on the specifications in the design challenge, future projects could reach the prototype stage and be developed enough to get support from different stakeholder groups inside and outside of MIT.

Brazil

By working with other organizations in Brazil, technical design will be able to continue in the field at Canuanã and São Paulo. With colleagues from the Universidade de São Paulo, one day it will be feasible to apply technical skills within Brazil's universities to the challenges faced everyday by people in the interior and in urban communities. Many Brazilians at university have never explored these other faces of their country. Regional

development experience may benefit them as much as the community partners they work with. Projects like those started by MIT and USP now and in future years will have a life beyond the university's field work. Ensuring the sustainability of the technologies and programs started goes a long way towards making the community's growth sustainable.

Patient Recordkeeping Project

One of the remaining challenges recorded by MIT is a patient recordkeeping system customized to meet the needs at two very different locations: within the school Escola de Canuanã, and also for when the school doctor, Cicero, travels through the settlements volunteering his services. Both sites require a flexible system with additional information that is not available in off-the-shelf systems. Additionally, the financial situation of rural Brazil makes the purchase of specialized, proprietary software systems low priority in the scheme of health care planning.

Thigao Moreira, a USP undergraduate from the computer science department, is incorporating design specifications from the doctor and administrators. Meeting their needs is the critical step in creating a useful system for them. For the designer, it is a way increase project value at the university by incorporating service learning and a real client. In addition, the beta version will be the first technology developed at USP as part of a new focus on regional development programs.

USP class

Further academic and practical developments on regional development are likely to come about for other students at USP from these experiences. Much of the work presented here originated in an MIT class, and colleagues at the engineering school of the Universidade de São Paulo are interested in how a similar project-based development class could be beneficial to the undergraduates in that university. The objective will be to use a similar theoretical grounding in development to frame the national needs of Brazil. Brazil's diversity in geography, resources, community, and culture will be an ideal setting to understand the challenges of technology in development.

Transition of CID

Transition of the CID management and mentoring duties to the teachers in Canuanã is going well. Within the next two months (i.e. by June 2005), primary responsibility will be entirely within the village. As the relationship between Canuanã and MIT grows, we will continue to visit the CID and possibly play a role in any new programs that will be developed at the center.

Conclusions: A New Brazilian miracle

Industrialization and overall development has not come smoothly to Brazil, but rather in fits and starts. Particularly in the twentieth century, since the 1930s, government administrations of all persuasions have tried their hand at turning the former colonial coffee power and rubber monopoly into a modern industry of manufacturers and service providers. Brazil is once again in the macroeconomically stable position of being able to dedicate its policies and funding to continued national development. This time, though, blind over-industrialization like that undertaken in the twentieth century will not suffice. The nation needs to address its regional inequalities, rampant poverty, income inequality, and need for continued sustainable development.

Projects established by MIT and USP in conjunction with community partners in Tocantins demonstrate the potential for the application of technology to solve local problems. Increased community participation and ownership of development projects can subsequently ensure their suitability for a particular region and their sustainability beyond the initially funded timescale. This is true both for organizational solutions, like the CID or a farmers' cooperative, or for technical solutions, like the pot-in-pot or drip irrigation kits. Both types of projects are meant to meet local needs and provide opportunities for education or employment.

In order for small-scale and diverse, decentralized projects to be favorable on a large scale, though, the political environment must make them attractive for community participants, outside agencies, and government branches. The likelihood of coordinating

such a new paradigm depends on addressing the requirements of very different kinds of stakeholders that are all needed for its success.

The policy recommendations made here emphasize the need to narrow the gap between the lower and middle classes for continued economic growth. In combination with policies addressing the challenge of integrating Brazil into the new knowledge-based international economy, the nation's overall economic position and its domestic unity can be increased by investing in human power rather than increased mechanization.

What it is time for is a New Brazilian Miracle. The economic surge in 1969-1973 was based on huge tax breaks to megacorporations and the growing attractiveness of Brazil to foreign direct investment. The New Brazilian Miracle, arising from the democratic state, will focus on growing small businesses and creating new economic opportunities for those sectors of society that have been passed over in previous decades. This goes equally for the rural areas as for the city – national development and coordination will be the focus of the programs, and the exact details will vary depending on the needs and constraints of the local communities.

The New Brazilian Miracles will bring Brazil to the forefront of growth again. Under a policy that combines community development of under-served populations with a commitment to knowledge and innovation, Brazil can expect to realize its potential for technological and economic development.

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