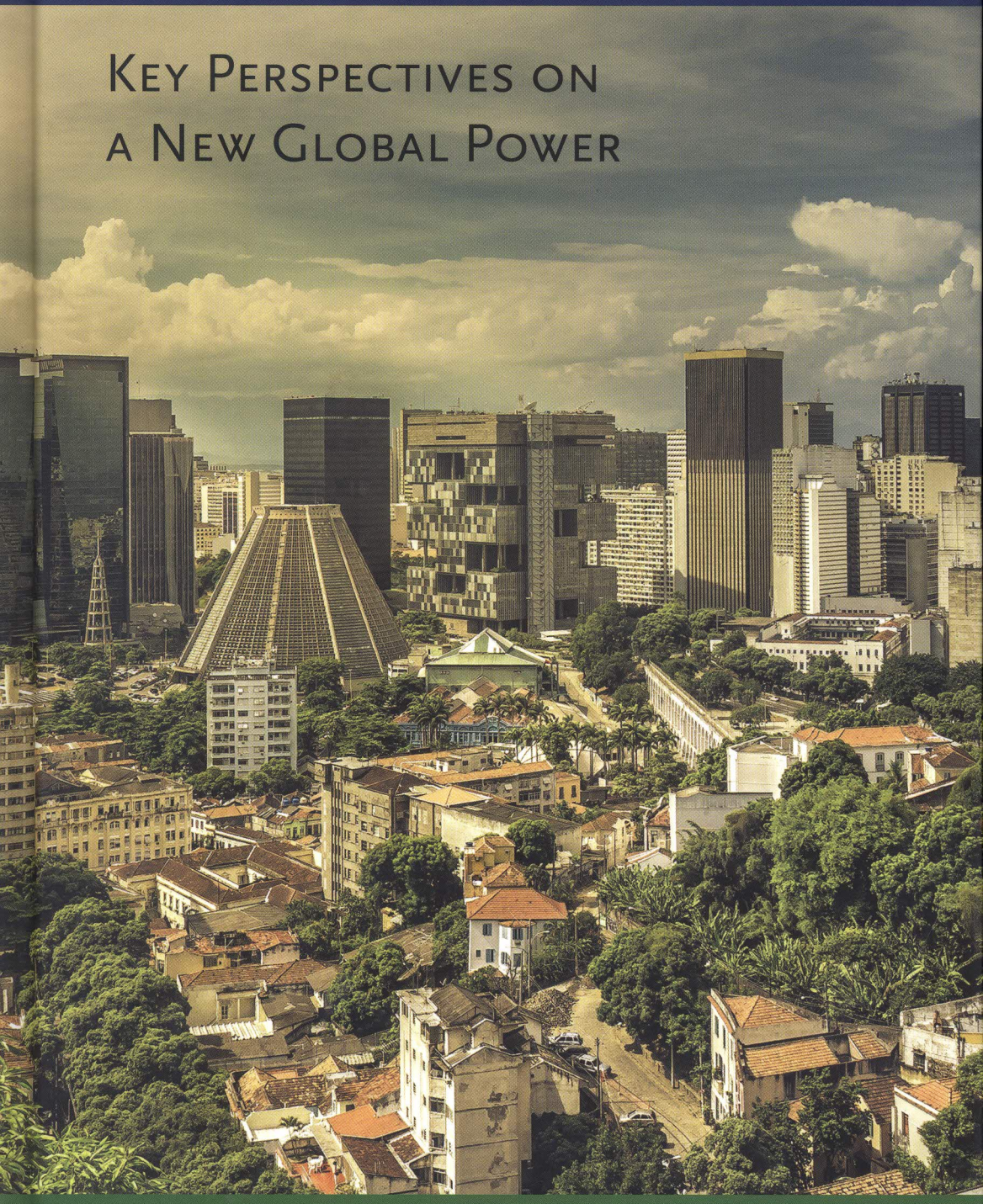
Emergent Brazil

Key Perspectives on a New Global Power



Edited by Jeffrey D. Needell

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Environmental Governance and Technological Innovations for Sustainable Development in the Amazon

JUDSON F. VALENTIM

Global and National Importance of the Amazon

The Amazon Basin covers nearly 2.6 million square miles of part of the territories of Bolivia, Brazil, Colombia, Ecuador, Guiana, Peru, Suriname, Venezuela, and French Guiana. It holds 10 percent of the world's known biodiversity and is home to more than 30 million people, among them 350 indigenous groups. The Amazon River flows for more than 2,500 miles and accounts for 15–16 percent of the world's total river discharge into the oceans. The region's rain forest contains 90–140 billion metric tons of carbon,[1] and it is vital for maintenance of the global atmospheric fluxes, biodiversity, and terrestrial carbon storage.[2]

The Amazon contains some of the world's most biodiverse communities of plants and animals. Tree species larger than ten centimeters in diameter can reach up to three hundred species in an area of one hectare.[3] The region has a long history of human influence, dating back 11,200 years.[4] Human actions have influenced as much as 60 percent of the different forest typologies in the Amazon.[5] Plant species like the peach palm (*Bactris gasipaes*) and cassava (*Manihot esculenta*) were domesticated during the Archaic Period (10,000–2,500 years ago).[6] Several plant species of great world economic importance are indigenous to this region, such as the rubber tree, cacao, and cassava.[7]

Brazil takes up 60 percent of Amazonia, a territory bigger than western Europe. This part of Amazonia, often referred to as the Legal Brazilian Amazon, was legally established in the mid-1960s to support federal governmental policies aiming at promoting development and integrating the Amazon to the other Brazilian regions. It occupies 2 million square miles, 59 percent of Brazilian territory.[8] The region covers nine states (Acre, Amazonas, Amapá, Pará, Tocantins, Rondônia, Roraima, and parts of Maranhão and Mato Grosso) and 775 counties.[9] It has 12.5 percent of the Brazilian population (23.9 million people) and 56 percent of the country's indigenous population.[10]

According to the government of Brazil, in 2005 up to 77 percent of the national greenhouse gas (GHG) emissions came from deforestation and land use change, with Amazon deforestation accounting for 67 percent of those emissions.[11] Therefore, tackling deforestation is at the center of Brazil's strategy to combat global climate change.

Becker notes a tremendous conflict between the expansion of soy, beef, and wood production chains and forest conservation as proposed by small-scale farmers, environmentalists, and several groups of scientists.[12] It is imperative to change the development model that prevailed in the Amazon between 1960 and 1980 and to promote the sustainable use of the region's natural resources and the knowledge accumulated by its traditional communities.

A Changing Vision

Brazil's military leaders of 1964–1985 viewed the Amazon as an empty space where national sovereignty was threatened and as a region that contributed little to the national economy. It was thought that its minerals, agricultural land, forests, and rivers could be made to contribute to national economic development and that its space could offer a solution for the needed resettlement of landless families from other regions of Brazil. In the 1960s and 1970s, federal and state policies were intended to occupy the Amazon and integrate it with the more developed regions of Brazil. The main pillars of these policies were the expansion and improvement of the federal highway network (BR-010, the Belém-Brasília Highway; the Transamazon Highway, BR-364; and BR-317); fiscal incentives and subsidized credit for mineral, industrial, agricultural, and cattle-ranching projects; construction of large

hydroelectric dams to provide low-cost energy to support industrial projects; and colonization projects for resettlement of the landless.[13]

However, the 1980s brought a change in the perception of the global development process. Sustainability gradually became critical to judging the productive and industrial processes, the economy, and power relations.[14] In the same period, with the transition from the military regime to democracy, the Brazilian Constitution of 1988 established that governance in areas such as health, education, the environment, and agriculture should be decentralized and shared with the states and municipalities. The new constitution began a growing process of empowerment and participation in Brazil's decision making.

The growing consciousness of global warming's threat and the human impacts in this process occurred simultaneously with the birth of the environmental movement at the global and national levels. In Amazonia, the organization of traditional community and indigenous social movements led to their struggles to preserve their cultures as forest communities. At the same time, the global and national perceptions regarding the role of the Amazon in the process of development changed drastically. Amazonia was at the center of the global debate regarding deforestation, the agricultural frontier, global warming, biodiversity conservation, and indigenous rights. The need to reconcile the objectives of economic growth, social welfare, and environmental conservation became clear in the ideal of sustainable development.

Environmental and Socioeconomic Contrasts

Since 1970, government policies implemented in the Legal Brazilian Amazon have resulted in rapid and profound changes; some promoted great socioeconomic benefits. Even these, though, throughout most of this period, were unevenly distributed among people, with the majority of the poor in urban areas and with small farmers in rural areas getting only a small share. More important, this process had very high environmental costs, and unlike the benefits, these were widely distributed. The costs were shared by everyone at the local, national, and global levels.

Population in Amazonia grew 225 percent between 1970 and 2010, from 7.8 million to 25.5 million, through dramatic migration and urbanization.[15] Federal programs settled more than 597,000 families on

Table 12.1. Accumulated deforestation in the Legal Brazilian Amazon, 1977–2011

State	Total area (hectares)	Deforested area (hectares)	Proportion of total area deforested (%)
Acre	15,887,100	2,038,530	12.83
Amapá	14,992,000	292,560	1.95
Amazonas	160,189,000	3,557,550	2.22
Maranhão	33,580,200	10,519,480	31.33
Mato Grosso	90,482,700	20,729,720	22.91
Pará	124,949,700	25,108,280	20.10
Rondônia	24,038,000	8,611,500	35.82
Roraima	22,622,400	965,640	4.27
Tocantins	27,893,200	3,028,750	10.86
Total	514,634,300	74,852,010	14.54

Source: Prepared by the author with data from the Instituto Nacional de Pesquisas Espaciais (INPE), "Estimativas anuais desde 1988 até 2011: Taxa de desmatamento anual—km2/ano," 2013, http://www.obt.inpe.br/prodes/prodes_1988_2011.htm.

84 million hectares of land; most of the settlers came from a landless population from other regions of Brazil.[16] Accumulated deforestation reached 14.5 percent of the Brazilian Amazon in 2011, an area of 74.8 million hectares (table 12.1) that was converted mainly to pastures and agriculture. Deforestation was more intensive in Rondônia, Maranhão, Mato Grosso, and Pará, surpassing 20 percent of their total territory. These four states, commonly characterized as the Deforestation Arc (figure 12.1), accounted for 53 percent of the total territory and 86.8 percent of the deforestation in the Legal Brazilian Amazon. The states of Acre, Amapá, Amazonas, and Tocantins, with 47 percent of the total area, accounted for 13.2 percent of the deforested area.[17]

At the same time, the Legal Brazilian Amazon increasingly participated in agricultural production. Between 1975 and 2006, its share of the total area of Brazilian pastures rose from 12 percent to 36 percent.[18] In 2010, land use of the deforested areas comprised pastures (62.1 percent), secondary forest (22.3 percent), cropland (5.4 percent), and "other uses" (10.1 percent).[19] In 2011 the Legal Brazilian Amazon accounted for 37 percent of the national cattle herd, and its share of total beef production rose from 14 percent in 1988 to 38 percent in 2011.[20] Between 1974 and 2011, its share of Brazilian dairy produc-

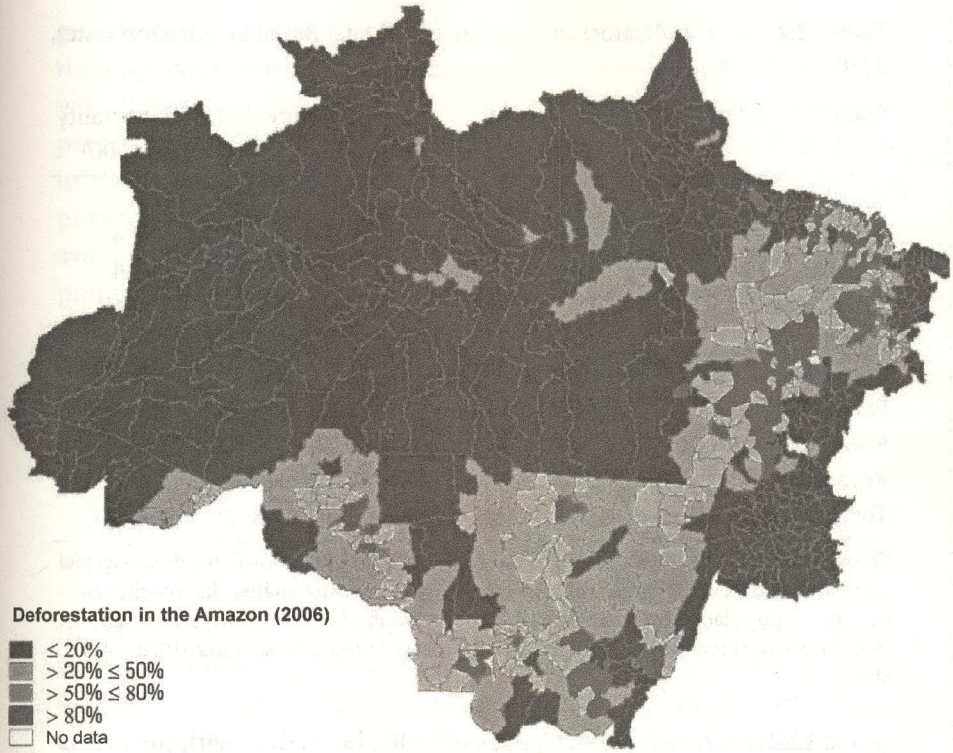

Figure 12.1. Deforestation arc in the Legal Brazilian Amazon, 2006. Map produced by Sérgio Rivero, Oriana Almeida, Saulo Ávila, and Wesley Oliveira, "Pecuária e desmatamento: Uma análise das principais causas diretas do desmatamento na Amazônia," *Nova Economia* 19, no. 1 (2009): 41–66, http://dx.doi.org/10.1590/S0103-63512009000100003, reproduced by permission of *Nova Economia*.

tion rose from 13 percent to 24 percent.[21] Between 1990 and 2011, its share of the area harvested with grain crops (encompassing beans, corn, oats, rice, sorghum, soybean, sunflower, and wheat) rose from 13.2 percent to 25.7 percent, while its share of the national production of these crops rose from 11.2 percent to 23.8 percent.[22]

However, inadequate management of cropland and pastureland and the predominance of low-technology agricultural and cattle-production systems have led to widespread degradation of the deforested areas in the Legal Brazilian Amazon.[23] Water resources are becoming scarce in urban and rural areas, and water contamination is becoming a problem in the urban areas of the Amazon.[24]

There are other problems as well. An analysis of the social indicators

Table 12.2. Social indicators in Brazil and the Legal Brazilian Amazon states, 2010

State	Extreme poverty (%)	Adult illiteracy (%)	Child mortality (per 1,000)
Brazil	6.3	9.6	16
Acre	12.6	16.5	20.4
Amapá	8.6	8.4	25.4
Amazonas	13.3	9.6	20.6
Maranhão	20.6	20.9	21.9
Mato Grosso	2.7	8.5	19.6
Pará	14.4	11.7	21.5
Rondônia	4.8	8.7	18.9
Roraima	8.8	10.3	18
Tocantins	8.3	13.1	20.5

Source: Prepared by the author with data from the Instituto Brasileiro de Geografia e Estatística (IBGE), "Síntese dos indicadores sociais: Uma análise das condições de vida da população brasileira 2010," http://www.ibge.gov.br/home/estatistica/populacao/condicaodevida/indicadoresminimos/sinteseindicsociais2010/default.shtm.

(table 12.2) of the Brazilian Census of 2010 shows that, with the exception of Mato Grosso and Rondônia, all the states in the Legal Brazilian Amazon were marked by a higher proportion of their populations in extreme poverty (70 reais, or approximately $1.25, per capita per day) than the national average (6.3 percent).[25] Adult illiteracy was higher than the Brazilian average in all states with the exception of Amapá, Mato Grosso, Rondônia, and Amazonas. In 2010, child mortality in all states of the region was higher than the national average.[26]

It is true that since 2000 there has been a dramatic change in socioeconomic indicators at the family level, in particular for those social groups traditionally excluded from the benefits of development. This has been both the result of higher average national economic growth and, especially, a result of federal and state policies such as the Family Scholarship Program (Programa Bolsa Família) aimed at providing food security, health care, and education for the poor.

These gains have been documented. Neri's recent research has found that between 2001 and 2009, poverty in Brazil was reduced by 52 percent.[27] The income of groups traditionally excluded grew more in the twenty-first century. The accumulated rate of per capita income

growth between 2001 and 2009 was 69 percent for the 50 percent of the population with lower income and 13 percent for the 10 percent with higher income. That means that the income of the poorest 50 percent grew 318 percent higher than that of the richest 10 percent in the Brazilian population over this period. Rural areas with more poverty and smaller cities experienced higher income growth than the average for Brazil. Between 2003 and 2009 the middle class grew 15 points more in rural areas than in the total Brazilian population. In the same period the middle class grew 34.3 percent, from 37.6 percent to 50.45 percent in the total Brazilian population, while in rural areas it grew 71.8 percent, from 20.6 percent to 35.6 percent of the population. This is equivalent to 3.7 million Brazilians integrating into the middle class.[28]

Nonetheless, despite these gains for the nation as a whole, the rural inhabitants of the Amazon are still faced with a unique situation. They have the guardianship of the greatest single environmental resource in the world, and simultaneously they are deprived of most of the technological and socioeconomic benefits of the twenty-first century. Together with the rural population of Northeast Brazil, Amazonians suffer the worst social indicators and diseases in the nation, evident in dramatically distinct child mortality and reduced life expectancy.

Governance and Innovation to Reduce Deforestation and Increase Productivity

The Brazilian Forest Code, approved in 2012,[29] restricts conversion of native vegetation in the different Brazilian ecosystems to agricultural and cattle production activities.[30] It establishes strong economic sanctions for farmers who do not comply with the law, preventing their access to credit and restricting access to markets. The possibility of Amazonian deforestation is dwindling as a result of these policies and of the increase in their effective government oversight and implementation.

In the past thirty years Brazil has emphasized investment in a state-of-the-art environmental monitoring system linking satellites with a nationwide computerized network coordinated by INPE (Instituto Nacional de Pesquisas Espaciais, the National Institute for Space Research).[31] This system provides environmental agencies with daily reports on fires, allowing immediate action to control them and penalize

those responsible. It provides monthly and annual reports of deforestation for the different biomes at the state and county levels; these allow the government to plan and carry out actions to prevent, control, and penalize illegal deforestation. This system has been particularly effective in the Legal Brazilian Amazon, with its low population density and difficult rural access. With such intelligence data the environmental agencies can concentrate on target areas under higher deforestation pressure to increase effective control. However, a big challenge ahead is to increase system capability to detect small patches of deforestation, below six hectares, because slash-and-burn agriculture persists as the predominant practice among hundreds of thousands of small-scale farmers and extractive and Indian communities in the Amazon.

The discussion regarding the role of agriculture and ranching as drivers of deforestation in the Legal Brazilian Amazon has been focused on the direct conversion of forests for the production of commodity grains, mainly soy and corn, and the establishment of cultivated pastures for ranching for beef and dairy production. Gibbs et al. find that deforestation of tropical forests was one of the main sources of new areas used for agriculture and cattle ranching in the world from 1980 to 2000.[32] However, as environmental governance has increased and farmers have their land rights legally assured, there has been a trend toward reduction of deforestation in the Legal Brazilian Amazon. At the same time, as infrastructure for transportation and access to regional, national, and international markets has improved, there is a trend toward intensification and integration of agricultural, livestock, and forestry production systems.

In the past forty years the Brazilian Corporation for Agricultural Research (Embrapa) established nine research centers in the Legal Brazilian Amazon. The goal has been to develop technologies, processes, and products and contribute to the national and regional policymaking process. The hope is to promote innovation for management and conservation of the 85.54 percent of forest areas remaining and agriculture intensification and integrated systems of agricultural, livestock, and forest production in the 14.46 percent of the areas already deforested.[33]

One of the biggest challenges was to make sustainable forest management profitable and competitive with agriculture and ranching to ensure the maintenance of the remaining forest.[34] Embrapa developed

and disseminated technologies for sustainable and precision forest management for wood production by small-scale farmers and extractive communities as well as for large-scale enterprises.[35] The Brazil nut (*Bertholettia excelsa*) is an extractive product of great socioeconomic and environmental importance for more than fifty thousand Amazonian extractive families and Indian communities. For that reason, Embrapa and its national and international governmental and private partners developed and disseminated an effective and sustainable management system to reduce aflatoxins,[36] a form of biological contamination, in Brazil-nut production.[37] It produced a technical manual for cultivation of the rubber tree in the state of Acre that will support Acre's reforestation program,[38] with the goal of planting 10,000 hectares in agroforestry systems and in pure stands using grafted plants resistant to South American leaf blight (*Microcyclus ulei*).[39] Management systems for the native *açaí* palm (*Euterpe oleracea*) were developed and disseminated in the states of Pará and Amapá as well.[40]

Another challenge was to develop and disseminate technologies, services, and products to promote reclamation of degraded lands and sustainable intensification of agriculture and livestock production systems in Amazonia's deforested areas. Embrapa has developed and disseminated cultivars of grasses and legumes, grain crops (cassava, corn, beans, rice, and soy), and fruit crops (*açaí* palm, banana, *cupuaçu*, lemon, orange, and pineapple) resistant to pests and diseases and adapted to the different environmental conditions of the Amazon as well as technical information for the main agricultural and livestock production systems in the Legal Brazilian Amazon.[41] Embrapa's 2012 economic, environmental, and social assessment shows that technological innovations in the Amazon reached an area of 264,000 hectares and resulted in economic benefits of $90 million.[42]

However, Alves et al. note that data from the Brazilian Censo Agropecuário (Agriculture Census) 2006 show a strong concentration of agricultural production measured as the gross income received by the farmers.[43] The researchers observed that 500,000 farms accounted for 87 percent of agricultural gross income in Brazil. Another 3.9 million farms, consisting mostly of small-scale farmers, accounted for only 3.3 percent of the total gross income, and 2.9 million of these farms had a gross income equivalent to only 50 percent of the Brazilian monthly minimum wage, with the farm families living in extreme poverty, on

less than $1.23 per day. These conditions are even more dramatic in Amazonia and Northeast Brazil. Only education and modernization of agriculture can rescue this rural population from poverty. Many of these families will have to be supported by economic and social policies.

Agricultural Impacts of Technology Adoption

According to the Intergovernmental Panel on Climate Change,[44] burning of fossil fuel is the main source of carbon dioxide emissions, while agriculture and cattle ranching are the main sources of methane and nitrous oxide emissions. Consequently, technological innovation in agriculture and cattle production systems should significantly affect man-made emissions of greenhouse gases.

In fact, Burney, Davis, and Lobell conclude that the intensification of world agriculture through an increase in crop productivity compared favorably with other proposed strategies to mitigate greenhouse gas emissions.[45] They analyzed emission impacts caused by global agricultural intensification between 1961 and 2005 and found that while emissions from factors such as fertilizer production and application increased, the net effect of yield increases had avoided emission of up to 161 billion tons of carbon since 1961. They estimated that each dollar invested in yield increase resulted in the reduction of 68 kilograms of carbon, thus avoiding emission of 63.6 billion tons of carbon per year in relation to the 1961 technology level.

Recent trends in Brazil are similar. According to the Brazilian government's annual municipal agricultural survey, between 1990 and 2011 the total area harvested with grain crops (beans, corn, oats, rice, sorghum, soy, sunflower, and wheat) increased by 35 percent (from 34.6 million to 46.8 million hectares) in Brazil and 163 percent (from 4.6 million to 12 million hectares) in the Legal Brazilian Amazon alone, while production increased by 186 percent (from 54.4 million to 155.5 million tons) and 508 percent (from 6.1 million to 37 million tons), respectively.[46] This was the result of average productivity gains in these crops of 111 percent (from 1.6 to 3.3 tons per hectare) in Brazil and 131 percent (from 1.3 to 3.1 tons per hectare) in the Legal Brazilian Amazon (figure 12.2).

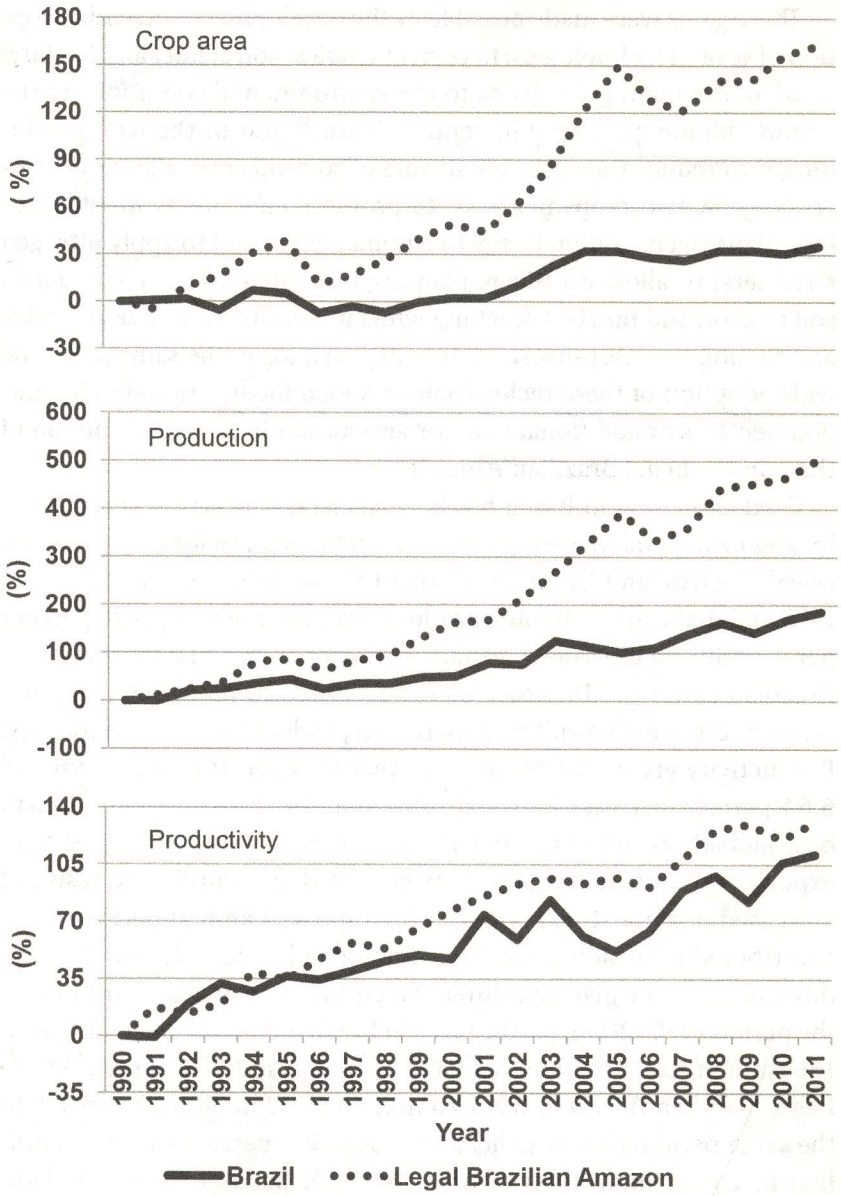

Figure 12.2. Crop area, production, and productivity of annual grain crops in Brazil and in the Legal Brazilian Amazon, 1990–2011. Source: Prepared by the author with data from Instituto Brasileiro de Geografia e Estatística (IBGE), "Produção agrícola municipal," Rio de Janeiro, 2013, http://www.sidra.ibge.gov.br/bda/acervo/acervo2.asp?e=v&p=PA&z=t&o=11.

These gains were made possible by the development and wide adoption of several technologies: to correct tropical soil acidity and fertility; to adapt the main grain crops to the environmental conditions of the *cerrado* biome, primarily in central Brazil,[47] and of the Amazon biome;[48] to reduce the cycle of cultivars of soy and corn, allowing farmers to grow two crops per year; to promote effective symbiotic biological nitrogen fixation in soy to eliminate the need to apply nitrogen fertilizers; to allow no-tillage planting of annual crops that reduced soil erosion and nutrient leaching while increasing soil carbon stocks; and to integrate crop-livestock-forestry systems in the same area. The wide adoption of these technologies avoided incorporation of 52 million hectares of additional land for agriculture in Brazil, 16 million of them in the Legal Brazilian Amazon.

Cattle ranching in Brazil has been criticized for its low productivity and its dependency on Amazonian deforestation for new pastures. Martha, Alves, and Contini note that this was true between 1950 and 1975 and that cattle-ranching productivity increased only 0.28 percent per year during the same period.[49] However, in the past four decades, Brazilian cattle-production systems experienced notable technological progress, which resulted in increased productivity and profitability. Productivity grew 3.62 percent per year between 1975 and 1996 and 6.64 percent per year between 1996 and 2006. This made Brazilian beef globally competitive and Brazil one of the world's biggest beef exporters. Productivity gains between 1950 and 2006, as a result of increased pasture stocking rates and improved animal performance, contributed to avoiding incorporation of 525 million hectares of additional land to expand pastures. Valentim and Andrade find that in the period 1975–2006, pasture area in Brazil increased 4 percent, from 166 million to 172 million hectares in Brazil, and 203 percent in the Legal Brazilian Amazon, from 20 million to 62 million hectares.[50] In the same period, the cattle herd increased 102 percent, from 102 million to 200 million head, in Brazil and 901 percent, from 7 million to 70 million head, in the Legal Brazilian Amazon (figure 12.3). As a result, in this period pasture stocking rates increased 85 percent, from 0.51 to 0.94 animal unit (1 AU = 450 kilograms of animal live weight), in Brazil and 203 percent, from 0.3 to 0.91 AU, in the Legal Brazilian Amazon (figure 12.4). Productivity gains due to increased pasture stocking rates in this period avoided incorporation of 213 million and

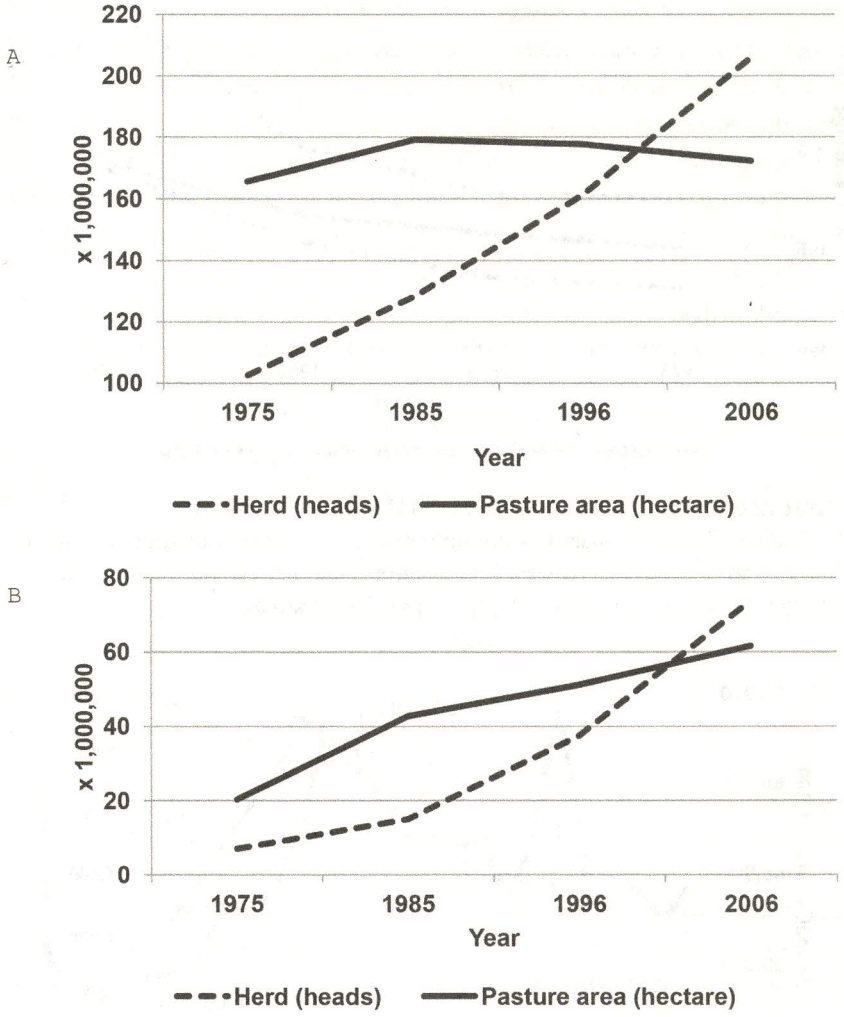

Figure 12.3. Evolution of the cattle herd and pasture area in Brazil (A) and the Legal Brazilian Amazon (B), 1975–2006. Source: Prepared by the author with data from Instituto Brasileiro de Geografia e Estatística (IBGE), "Censo agropecuário" (Rio de Janeiro: IBGE, 2013), http://www.sidra.ibge.gov.br/bda/acervo/acervo2.asp?e=v&p=CA&z=t&o=3.

148 million hectares of new area in Brazil and in the Legal Brazilian Amazon, respectively.

Data from INPE, Brazil's National Space Research Institute, show that between 2004 and 2011, annual deforestation in the Legal Brazilian Amazon decreased by 77 percent, from 2.8 million hectares to

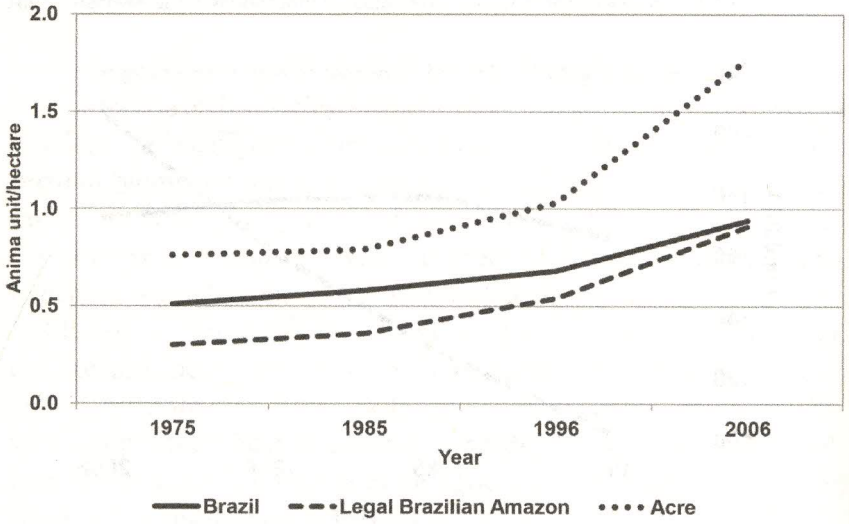

Figure 12.4. Stocking rates in Brazil, the Legal Brazilian Amazon, and Acre, 1975–2006. Source: Prepared by the author with data from the Instituto Brasileiro de Geografia e Estatística (IBGE), "Censo agropecuário 2006," http://www.sidra.ibge.gov.br/bda/acervo/acervo2.asp?e=v&p=CA&z=t&o=3.

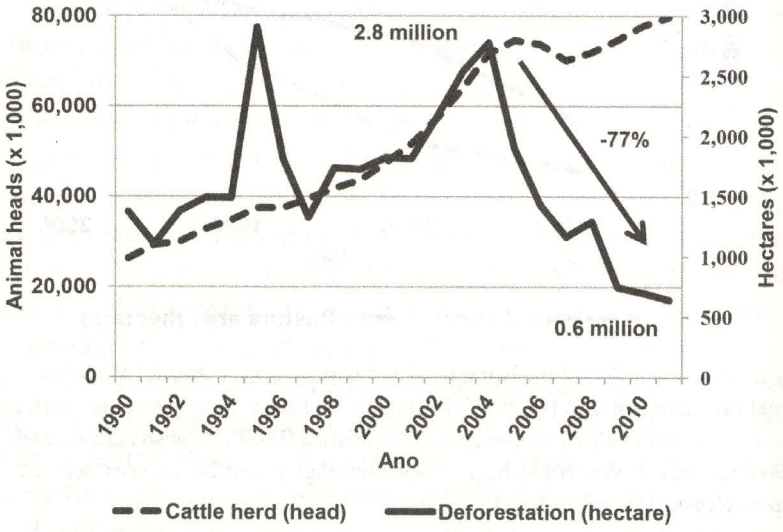

Figure 12.5. Cattle herd and annual deforestation in the Legal Brazilian Amazon, 1990–2011. Sources: Prepared by the author with data from the Instituto Brasileiro de Geografia e Estatística (IBGE), "Censo agropecuário" (Rio de Janeiro: IBGE, 2013), http://www.sidra.ibge.gov.br/bda/acervo/acervo2.asp?e=v&p=CA&z=t&o=3, and from the Instituto Nacional de Pesquisas Espaciais (INPE), "Estimativas anuais desde 1988 ate 2011: Taxa de desmatamento anual (km2/ano)," http://www.obt.inpe.br/prodes/prodes_1988_2011.htm.

642,000 hectares.[51] Covering the same period, data from IBGE, the Brazilian Institute of Geography and Statistics, show that the cattle herd of the region grew 8.7 percent, from 71.6 million to 77.8 million head (figure 12.5).[52] This decoupling of agriculture and cattle ranching from deforestation in the Legal Brazilian Amazon is a consequence of productivity gains due to technological innovation and the increased technological capability and effectiveness of environmental agencies.

One of the biggest challenges remaining to reduce deforestation is the gradual replacement of small-farm slash-and-burn agriculture by using technologies adapted to local cultural, social, economic, and environmental conditions. The small-scale farmers' low level of education constitutes one of the main obstacles to innovation and to their access to public resources, particularly subsidized credit. Therefore, programs aimed at reducing deforestation and poverty through innovation in the agricultural sector should also focus on the hundreds of thousands of small-scale farmers in the Legal Brazilian Amazon. These programs will require great investments, and their success will depend on governmental competence and effectiveness at all levels.

The Emerging Global Role

There is an emerging vision that the environmental services provided by the Amazon, such as maintenance of carbon stocks, biodiversity, and water production, will become a vital part of the new century's green economy. This creates new income opportunities for forest communities and private forest owners and is a very important financial focus for governments with policy commitments to sustainable development.

In Brazil, the state of Acre has led in capturing such opportunities. Acre has successfully established a climate-change policy, the Institute of Climate Change and Environmental Services Regulation, the System of Incentives for Environmental Services, and the State Commission for Validation and Monitoring. Acre established a partnership with the United Kingdom's Sky News and WWF Brazil as part of the Rainforest Rescue Initiative, in the amount of $12.2 million, with the aim of helping 1,000 extractive and small-farm families save around 3 million hectares of forest from deforestation.[53] Acre established a partnership with the German Development Bank (KFW), in the amount of $24.9

million, as part of the Early Movers' Program, which compensates Acre for reductions of carbon emissions due to deforestation and forest degradation.[54]

Recommended Pathways for Sustainable Development in the Amazon

Even though there have been significant policy changes promoting Amazonian sustainable development, there is still a lack of policies to improve commercial relations within the agricultural, livestock, and forest production chains involved in such development. There is a need to establish economic incentives for price differentiation to distinguish and support the products of sustainable development by using markers of quality control and certification of origin. The federal government needs to regulate the mechanisms in the new Brazilian Forest Code to provide economic incentives for farmers to promote environmental reclamation of degraded areas and adoption of best production practices in agricultural, livestock, and forest production systems and for industrial and commercial chains to be supplied with products with environmental certification.

Brazil has been increasingly successful in reconciling economic growth with improving human welfare and reducing deforestation in the Amazon. At the same time, this success is leading to regional integration with the nine neighboring nations that share Amazonia. There is an increasing international scientific, commercial, and touristic flux into the Amazon. This process brings many social and economic benefits but also poses serious environmental threats in areas with less governance. It already is leading to a spillover effect on development in Amazonia as a whole. Brazil and its neighbors must establish an operational and effective international learning community to share the lessons learned in the Amazon development path over the past five decades. In order to effectively mitigate the spillover effects of development, this international community should prioritize strengthening environmental organizations and environmental monitoring systems, including international integration and data sharing; promoting establishment of common environmental policies leading to integrated watershed management; building human capacity; and developing and disseminating technology.

The increasing scientific capability in the Amazon associated with the rapid growth of Brazilian and international research networks will accelerate scientific advances regarding the potential for sustainable use of Amazonia's natural resources. However, Brazil and the neighboring countries that share the Amazon, with the support of the larger international community, should make a commitment to invest significantly in expanding and strengthening the region's universities, technical schools, and research over the next forty years.

It is of capital importance that governments establish effective policies and mechanisms to ensure that small-scale farmers and extractive and Indian communities have access to the technologies they need to be the guardians but also the beneficiaries of the economic and social services the Amazon provides to the world. The expansion and improved quality of rural basic education, increased availability of technical training, improved health services, and better transportation can have a dramatic impact on agricultural productivity and the welfare of these small-scale farmers and communities and reduce migration to the cities.

It is essential to establish effective links among organizations of science and technology, the private sector, and governments to promote policy change and innovation toward sustainable development in the Amazon. The beneficial aspects of technological innovation can be used for sustainable intensification and integration of agricultural, livestock, and forestry production systems. This will result in sustainable production growth, increasing economy of scale, creation of opportunities for local or regional processing, and greater value of Amazonian products. With quality control and social and environmental certification, such products will have better acceptance in the world market. This will increase profits throughout the production chain while ensuring consumer safety. Furthermore, well-organized and regulated agroindustrial production chains can contribute to the larger goal central to this chapter—the reconciliation of economic growth, improved human welfare, and environmental conservation in the Amazon.

Notes

1. World Wildlife Fund, *Amazon*, http://worldwildlife.org/places/amazon.
2. William F. Laurance, Mark A. Cochrane, Scott Bergen, Philip M. Fearnside,

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