LAND USE IN CUBA BEFORE AND AFTER THE REVOLUTION: ECONOMIC AND ENVIRONMENTAL IMPLICATIONS

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It is generally concluded that Cuba's poor performance in the agricultural sector since the early 1990s is the result of two primary, complementary reasons. Cuban agricultural production has faltered because of:

- a dearth of agricultural inputs since the collapse of the socialist world, and
- the adverse impact of economic policies that interfere with the sector's performance due to structural rigidities and by eliminating production incentives.

According to the first and most common line of reasoning, with the end of Soviet subsidies, Cuban agriculture has been unable to maintain 1980s production levels because the government has not been able to obtain needed imported agricultural inputs. The agricultural development model Cuba pursued since the 1960s was heavily dependent on capital and chemical inputs. These inputs were either provided by the former Soviet Union and its Eastern European allies under one subsidized scheme or another, or were purchased in international markets with the limited hard currency Cuba earned from sugar and petroleum (also provided by the Soviet Union) sales in international markets.

While most analysts embrace this reasoning, they also accept the argument that attributes the problems of Cuban agriculture to socialist economic policies. There is a wealth of documentation relating to Cuba — as well as to other countries of the former socialist community — indicating that the socialist economic framework had disastrous production consequences, for reasons generally well understood. Aside from the systemic flaws associated with a command economy and the poor incentive framework with which it is associated, agricultural production is hampered under socialism by several dominant features of the economic system. Among the most salient are its proclivity to rely on large scale, mostly inefficient production units; undue reliance on extensive cultivation practices; excessive emphasis on mechanization; an unbounded but often unwarranted faith on technological interventions; and excessive use of agricultural inputs (for reviews see, Pryor 1992; Díaz-Briquets and Pérez-López 1998; Díaz-Briquets and Pérez-López 2000:10-13). Despite reliance on this agricultural development model, including heavy capital investments, Alvarez and Puerta (1994) have documented that productivity was considerable higher in the few small, private land holdings remaining in Cuba after 1959 than in state farms. Remarkably, this productivity advantage was achieved despite the fact that many of the agricultural inputs abundant in the state sector were not accessible to small private farmers. Furthermore, Sáenz (1994, 1995, 1997a, and 1997b) in several papers has shown that small landholders relied on agricultural practices far more favorable to environmental preservation than large-scale farms in the state sector.

While the flaws related to the characteristics of the model already represented a drag on Cuban agricultural production before the Special Period, their effects were somewhat masked by what appears to have

been an ever-growing reliance on capital intensive agricultural inputs during the 1970s and 1980s. This can be seen by analyzing trends in the use of farm machinery, fertilizers, and pesticides from the 1960s to the late 1980s (see Tables 1 and 2). Between the early 1960s and 1990, for example, the stock of agricultural tractors rose by close to 300 percent. Many of the bulldozers, harvesting combines, and a substantial number of tractors, constitute heavy farm machinery, not the most appropriate for working fragile tropical soils. There were also equally impressive increases in the use of pesticides and herbicides, whether measured by physical weight or purchase value. The increase in herbicide and pesticide use, as measured in Cuban pesos, for example, rose from about 5 million in 1965 to more than 80 million in 1989, or by 1,450 percent. While extreme, this percent increase is not inconsistent with other rising trends in fertilizer and pesticide imports depicted in Table 2. To these estimates must be added agricultural inputs produced domestically, as the socialist government also made considerable investments to increase domestic production capacity, including two large nitrogen fertilizer plants built during the 1970s at Cienfuegos and Nuevitas (Díaz-Briquets and Pérez-López 2000:198).

IS THERE AN ENVIRONMENTAL CONNECTION?

While the two factors discussed above seem to be sufficient to account for the decline in Cuban agricultural production, it is surprising that hardly any attention has been directed to assess the potential effect of environmental factors in the production collapse. The work of Sáenz and others (for an overview, see Díaz-Briquets and Pérez-López 2000), as well as official Cuban sources, including those that provide agricultural statistics, suggest that an important determinant of the current situation may well be a substantial degradation of Cuba's natural resource base. The link between environmental degradation and the agricultural development policies that began to be implemented in the 1960s, leading to a radical transformation of the Cuban countryside by the late 1980s, can be readily established. To begin to appreciate the significance of the environmental underpinnings of the current agricultural situation, it is convenient to review developments in land use practices before and after the revolution. Through such comparison, it is possible to reach a preliminary judgment of how changes in land use practices and environmental degradation, together with other factors, are associated with the agricultural sector's poor performance in the 1990s.

This can be done by looking at 1946 agricultural census data (with a 1945 reference date) and statistics on land use released in the last full-blown statistical compendia made public before the Special Period, the *1989 Anuario Estadístico de Cuba*. This approach has the obvious flaw of not been capable of isolating the important changes in Cuban agriculture that began after the Second World War (Grupo Cubano 1963), and that were well underway by 1959. Thus, the comparison exaggerates to a limited but indeterminate extent the effects land use changes may have had on environmental degradation and, ultimately, on agricultural production. The comparison is also contaminated by differences in definitions. The 1946 agricultural census included a large residual land use category (20.7% of the total land area) labeled "not in farms," as well as a "other uses" category (14.4% of the total land area). The 1989 data are presented inclusive of these other land use categories. While recognizing that this approach can only yield a partial and imperfect understanding of changes since the early 1960s — and some of their consequences — the comparison provides a macro glimpse of the enormous transformations experienced by the Cuban countryside under the socialist regime.

LAND USE CHANGES BETWEEN THE EARLY 1960s AND THE LATE 1980s

The data presented and discussed in this section are largely drawn from previous work by the author and Jorge Pérez-López (Díaz-Briquets and Pérez-López 2000:84-88), but enhanced by the presentation of several detailed tables that will allow the reader to analyze more closely specific trends. According to the 1946 agricultural census, farms occupied four-fifths (79.3%) of the land area (Table 3). These farms, numbering some 160,000, had an average size of 56.7 hectares. Crops accounted for 21.7% of the farm area, while 42.9% and 14%, respectively, were

Table 1. Stock of Agricultural Tractors and Mechanized Agricultural Equipment *(units)*

	1970	1975	1980	1985	1986	1987	1988	1989
Bulldozers	—	—	—	1678	1633	1678	1720	1918
Tread tractors	3862	4151	4670	5694	6362	6752	6837	7216
Heavy wheel tractors	2760	3776	2289	2981	2713	2765	2901	3175
Light wheel tractors	37699	43118	53133	55217	59753	59969	60336	61571
Special tractors	7247	3806	8202	4693	4911	4917	4845	4821
Sugar combines	1092	1143	2776	3472	3819	3981	4014	4049
Rice harvesting combines	1153	1124	879	664	671	590	603	626
Planters				1510	1746	2031	2037	2175

Source: Comité Estatal de Estadísticas (1989, p. 214).

Table 2. Cuban Imports of Fertilizers and Pesticides, 1970-89

		1970	1975	1980	1985	1986	1987	1988	1989
Manufactured Fertilizers	(000 pesos)	44562	88582	81449	136083	138747	130832	120191	157752
Ammonium nitrate	(000 pesos)	350	2401						
	(Tons)	6672	25868						
Urea	(000 pesos)	5316	13861	19619	37053	32772	3843	38596	53135
	(Tons)	82710	110009	151334	244354	214000	2252000	257000	351000
Simple superphosphate	(000 pesos)	2281	6418	12971	18359	21470	23191	20308	22232
	(Tons)	77429	129194	243515	255466	299000	324000	283000	311000
Triple superphosphate	(000 pesos)	3379	16150	7124	7316	7000	6899	4221	5114
	(Tons)	51185	61043	37195	40000	37000	37000	16000	26000
Ammonium sulphate	(000 pesos)	9796	24397	23128	26211	26970	17187	14042	18730
	(Tons)	301451	317723	417052	381796	393000	249000	201000	272000
Potassium chloride	(000 pesos)	4198	11695	15764	36624	34252	33404	30278	36856
	(Tons)	130321	213492	295815	390593	367000	352000	323000	394000
Potassium sulfate	(000 pesos)	1206	2578	1887	2820	2683	3584	3109	3188
	(Tons)	25859	33677	24757	24281	18000	22000	20000	20000
Mixed fertilizers	(000 pesos)	18036	11082						
	(Tons)	299598	50000						
Herbicides & pesticides	(000 pesos)	23903	52733	60476	64483	53300	76866	68768	80807
Herbicides	(000 pesos)	15324	34737	39113	35936	26285	51713	47066	55629
	(Tons)	7800	14009	15135	17500	10290	14218	12688	17151
Pesticides	(000 pesos)	5895	17996	21318	28437	26823	24846	21532	25178
	(Tons)	5914	11530	11164	14396	11952	10231	8054	9740

Source: Comité Estatal de Estadísticas (1989, pp. 282-83, 262 and earlier issues).

occupied by pastures or covered by trees. The remaining farm surface was covered by various weeds, fallow, or used by roads, buildings, etc. These same data, incorporating the land area not in farms, are presented in Table 4. In 1945, 53.8% of the country's total land surface, or 6.2 million hectares, were used for agricultural purposes. This was about 400 thousand hectares less than the country's agricultural land ceiling, as estimated through an agricultural production potential typology of Cuban soils developed during the 1980s with Soviet assistance (as described by Atienza Ambou et. al., 1992, briefly reviewed by Díaz-Briquets and Pérez-López 2000:82-83). .

Table 3. Land Distribution in 1945 *(in hectares)*

Total Land Area	Hectares	Percent
	11,452,400	100.0
In farms	(9,077,086)	(79.3)
Cultivated	1,969,728	21.7
Pasture	3,894,070	42.9
Woods	1,261,715	13.9
Marabú	272,313	3.0
Other uses	1,652,030	18.2
Fallow	27,230	0.3
Not in farms	(2,375,314)	(20.7)
Number of farms	159,958	
Average size of farms (in hectares)	56.7	

Source: World Bank (1951, Table 15, p. 87).

Table 4. Land Distribution by Type of Use, 1945 *(in thousands of hectares)*

Total	Thousands of hectares	Percent
	11,452	100.0
Agricultural	(6,614)	(53.8)
Cultivated	1,970	17.2
Not cultivated	4,194	36.6
Pastures	3,894	34.0
Fallow	300	2.6
Non-agricultural	(5,289)	(46.1)
Forests	1,262	11.0
Not in farms	2,375	20.7
Other uses	1,652	14.4

Source: World Bank (1951, Table 15, p. 87).

Land use data for 1989 are shown in Table 5. Nearly 62% of the nation's land was in agricultural and 38% in non-agricultural uses. Out of the nearly 6.8 million hectares devoted to agriculture, about 4.4 million hectares (40.1% of total land) were cultivated (including 1.082 million hectares of cultivated pastures), while 2.4 million hectares (21.4%) were natural pastures or fallow. Non-agricultural land was distributed among forests (23.7%), settlements (6.3%), not usable (5.5%), or covered by water (3%). The total amount of agricultural land in 1989 (whether cultivated or not) exceeded by nearly 200 thousand hectares the ceiling of potential agricultural soils. As can be seen in Table 6, where comparative land use data for both periods are presented, by 1989 the total amount of land being used for agriculture (61.5%) exceeded by nearly one percentage point the amount of soils considered suitable for agriculture (60.6%). More noteworthy is that the total land area cultivated had increased by nearly 23% between 1945 and 1989, whereas pastures (excluding cultivated pastures, which in 1989 accounted for 9.8 % of the total land area) had declined by half (from 34% in 1945 to 17% in 1989).

The increase in cultivated land and the decline in pastures were not as sharp when considering cultivated and natural pastures together, the total land in pasture declining by only 7% during the 1945-89 interval. Still, the amount of cultivated land (other than cultivated pastures) increased by nearly a third between 1945 and 1989. The number of hectares in fallow increased substantially, but from a much lower base. Major increases in the land area cultivated were largely achieved by bringing under the plow formerly non-agricultural land either because it was being held in reserve (e.g., by the large sugar mills), or because it was considered as agriculturally marginal. Table 7 provides more detailed information on how the ex-

Table 5. Land Distribution by Type of Use, 1989 *(in thousands of hectares)*

Total	Thousands of hectares	Percent
	11,016	100.0
Agricultural	6,772	61.5
Cultivated	4,410	40.1
Permanent	(3,620)	(32.9)
Sugar cane	1,980	18.0
Coffee	147	1.3
Cacao	10	.1
Plantain	114	1.0
Citrus	150	1.4
Fruit Trees	96	.9
Pastures	1,082	9.8
Other	41	.4
Temporary	(784)	(7.1)
Rice	206	1.9
Various	456	4.1
Tobacco	57	.5
Pastures	20	.2
Other	46	.4
Vivery	(6)	(0)
Not cultivated	2,357	21.4
Natural pastures	1,883	(17.1)
Fallow	474	(4.3)
Non-Agricultural	4,241	38.5
Forested	2,611	23.7
Not useable	606	5.5
Water	330	3.0
Settlements	694	6.3

Source: Comité Estatal de Estadísticas (1989, Tables VIII.3. VIII.4 and VIII.6, pp. 185-6).

Table 6. Comparative Land Use Pattern in 1945 and 1989 *(in percent)*

Total	1945	1989	Difference 1989/1945
	100.0	100.0	—
Agricultural Land	53.8	61.5	+7.7
Cultivated	17.2	40.0	+22.8
Pastures	34.0	17.2	-16.8
Fallow	2.6	4.3	+1.7
Forested/non-agricultural	31.7	32.2	+0.5
Settlements/other uses	14.4	6.3	-8.1

Source: Tables 4 and 5.

panded acreage in agricultural land was distributed. Between 1945 and 1989, the cultivated land area (the sum of land in permanent and temporary crops) increased by 1,321 hectares, or by 66.6%, from 1,982 to 3,303 thousand hectares. Of the total amount of additional land being cultivated, sugar cane accounted for 66.4%, or 877 thousand hectares. In relation to land under permanent crops, the increase attributed to sugar cane was even more pronounced, amounting to 72.8%. The increase in the amount of land dedicated to citrus plantations was minor relative to the increase in land in sugar cane plantations. Although the amount of land planted with citrus increased eight-fold between 1945 and 1989, by the latter date citrus plantations only occupied 150 thousand hectares, or 2.4% of all agricultural land, as compared to the 1,980 thousand hectares planted with sugar cane (31.5% of all agricultural land). Other notable changes were a considerable expansion in the amount of land devoted to coffee, fruit trees, and rice, and a contraction in the land area dedicated to tobacco and the residual category of "other temporary crops."

Table 7. Agricultural Land Use in 1945 and 1989

	Thousands of Hectares		Percent	
	1945	1989	1945	1989
Total Agricultural Land	5,879	6,288	100.0	100.0
Permanent Crops	1,333	2,538	22.7	40.3
Sugar Cane	1,103	1,980	18.8	31.5
Coffee	89	147	1.5	2.3
Cacao	7	10	.1	.2
Plantain	81	114	1.4	1.8
Citrus	15	150	.3	2.4
Fruit Trees	20	96	.3	1.5
Other	18	41	.3	.6
Temporary Crops	649	765	11.0	12.1
Rice	58	206	1.0	3.3
Various	330	456	5.6	7.2
Tobacco	66	57	1.1	.9
Other	195	46	3.3	.7
Pastures	3,897	2,985	66.3	47.5

Source: Ministerio de Agricultura (1951, various pages); and Comité Estatal de Estadísticas (1989, Tables VIII.3, VIII.4, and VIII.6, pp. 185-6).

A more detailed assessment of changes in land use by type of crop can be made by examining the data on Table 8. This table provides data on non-sugar land planted in 1946 and 1989 by type of crop (including existing and new plantings for perennial crops, and plantings for annual crops). The data suggest that the overall acreage planted in tubers declined between 1945 and 1989, even though potato plantings nearly doubled and boniato plantings remained almost unchanged. A major decline of 61% was recorded in the

Table 8. Non-sugar Cane Land Planted in 1945 and 1989 by Crop
(in thousands of hectares)

		1989		
	1945	Total	State	Non-state
TOTAL	871.0	927.9	630.8	297.1
Tubers	161.8	148.7	91.0	57.7
Potato	8.5	15.9	13.1	2.8
Boniato	53.3	53.4	35.5	17.9
Malanga	32.8	12.7	6.4	6.3
Ñame	6.7	—	—	—
Yucca	60.5	—	—	—
Vegetables	98.4	155.6	74.6	81.0
Tomatoes	72.3	42.5	17.7	24.8
Onions	.5	5.8	3.8	2.0
Peppers	1.5	5.6	1.5	4.1
Pumpkins	22.7	—	—	—
Garlic	1.4	—	—	—
Cereals	252.2	257.6	188.9	68.7
Rice	57.5	167.3	141.6	24.7
Corn	180.0	89.3	45.3	44.0
Millet	14.7	—	—	—
Leguminous	69.7	55.1	32.2	22.9
Beans	56.8	54.0	31.0	23.0
Peanuts	12.9	—	—	—
Tobacco	66.2	50.4	14.7	35.7
Henequen/Kenaf	11.2	4.6	4.6	—
Bananas	80.6	43.1	26.0	17.1
Fruit	22.6	13.1	7.4	5.7
Plantain	58.0	30.0	18.6	11.4
Citrus	14.8	5.3	4.8	.5
Orange	13.5	2.1	1.8	.3
Grapefruit	.8	2.3	2.1	.2
Lemon	.5	.7	.6	.1
Other Fruits	20.0	8.9	6.1	2.8
Mango	—	.7	.5	.2
Guava	—	.8	.6	.2
Papaya	1.1	4.8	3.1	1.7
Coconut	4.5	—	—	—
Pineapple	14.4	—	—	—
Coffee	88.9	7.5	5.5	2.0
Cacao	7.2	.6	.3	.3
Cultivated pastures	—	163.8	155.6	8.2

Source: Ministerio de Agricultura (1951, various pages); and Comité Estatal de Estadísticas (1989, Tables VIII.13, VIII.14 and VIII.15, pp. 191-3).

number of hectares planted with malanga, the data also suggesting a significant contraction in the land area planted with yuca and ñame.

Land devoted to the production of vegetables, other than tomatoes, appears to have increased considerably, with major increases in the amount of land planted with onions and peppers. A striking difference in the planting trends for rice and corn can be noted. Whereas the amount of land devoted to rice production increased three times between 1945 and 1989, the acreage devoted to corn declined by half. These divergent trends are consistent with Cuba's policy to increase domestic rice production (even before the 1959 revolution) and with the country's dependence on Soviet supplies of feed grains for livestock and poultry production. Millet, an important crop in 1945, is not even listed separately in 1989. The data suggest, finally, that the number of hectares planted with beans between 1945 and 1989 remained essentially unchanged.

In 1989, as a result of the damming of many of the country's rivers, inland water bodies accounted for 3% of the territory, while swamps did so for a further 4% to 5%. The amount of forested lands between 1945 and 1989 remained about the same, 18%, although between 1945 and 1959 it had declined to some 14%. Both estimates have little to say regarding the stock of fruit and shade trees, although it is safe to conclude that many small stands of these trees were lost during the socialist period as the capital intensive, large-scale farm model was introduced. To make up for the removal of traditional fruit tree groves, the government embarked on a program to developed fruit tree, coffee and cacao plantations, the citrus plantations being the best known. Resources were assigned to develop mango and guava tree plantations, as well as to expand coffee and cacao plantations in mountain areas, often as part of agroforestry projects.

LAND USE CHANGES BETWEEN 1959 AND 1989: SUMMARY

Despite comparability problems, several conclusions can be drawn from the data reviewed above and from other well-known information pertaining to Cuba's agricultural economic policies during the socialist period. The first is that the total amount of agricultural land increased substantially, by as much as 8%, between 1945 and 1989, mostly by bringing marginal farm land into production. Average farm size also increased appreciably. The implementation of the socialist agricultural development model depended on the utilization of large-scale farms to facilitate mechanization of agricultural operations and intensive application of chemical inputs. These tendencies were further accentuated by:

- concentration on the production of a relatively small number of agricultural export commodities (sugar, citrus fruits);
- increasing domestic capacity to produce staple crops (rice, potatoes);
- depending on commodity imports (feed grains) to satisfy certain national needs; and,
- in some cases, neglecting the nation's capacity to produce traditional staple crops (e.g., malanga).

These decisions were reached within the framework provided by the Council for Mutual Economic Assistance (CMEA) that regulated trade relations within the socialist bloc and that assigned to Cuba a predominant role as supplier of agricultural (and mineral) commodities to the former Soviet Union and other socialist countries.

Another very important land use change was a major expansion in the amount of flooded land as hundreds of large and small reservoirs were filled behind numerous dams built during the 1970s and 1980s. Irrigation on a vast scale was an intrinsic component of the socialist approach to agricultural development. By flooding some of the most fertile soils of the country, particularly along the relatively flat western and central regions, the reservoirs removed many thousands of hectares from production.

CHANGES IN LAND USE, LAND DEGRADATION AND DECLINE IN AGRICULTURAL PRODUCTION

That the agricultural developments described above — due to land use and production practices — had adverse environmental effects is unquestionable.

Data culled by Sáez (1997) from various Cuban sources provide convincing evidence that the damage is substantial and potentially difficult and costly to reverse. According to these data, of Cuba's total agricultural land area of 6.6 million hectares, 4.2 million hectares (or 64% of the total) are eroded to one degree or another; 2.7 million hectares (or 41%) have poor drainage; soil compaction, due to excessive heavy farm machinery use, affects 1.6 million hectares (24%); 1.1 million hectares (17%) suffer from acidification; and 780 thousand hectares (12%) have been degraded by salinization.

The toll that soil degradation can take on agricultural production is well documented. I limit myself here to summarize some of its most obvious consequences. Soil erosion can have multiple consequences depending on the type of soil, but it is generally believed to have a cumulative impact. Furthermore, different soil erosion processes are usually correlated with one another. Regardless of why it occurs, the consequences of soil erosion are fairly predictable: it usually results in lower yields or in higher costs per yield when corrective measures are introduced (Pagiola 1994:22). This relationship appears to be particularly germane to Cuba's experience. The fertilizer use trend data reviewed in this paper suggests that Cuba may have been able to arrest declining yield problems during the 1980s thanks to the ever-increasing use of fertilizers and other agricultural inputs. As the availability of abundant and inexpensive imports dried out after 1989 leading to a contraction in fertilizer use, Cuban soils were no longer able to sustain their former productivity. This hypothesis merits further examination. It seems to explain the priority assigned by the Cuban agricultural authorities to the development of domestically produced organic fertilizers to substitute for the chemical fertilizers formerly acquired abroad.

The effect of poor water drainage of irrigated soils on agricultural output is well documented. Despite vast agricultural investments, Cuba's central planners gave relatively low priority to the development of a national drainage infrastructure, although the country has an abundance of flood-prone areas and the land under irrigation increased several-fold. The World Bank, in fact, has identified poor drainage as one of the most serious problems affecting countries that embraced agricultural development policies highly dependent on large-scale irrigation projects. These projects often neglect the development of a drainage infrastructure to preserve the soils. Many drainage problems are caused by the poor maintenance of canals and other irrigation facilities and more generally by inadequate attention given to the need to address drainage issues in agricultural development plans (Umali 1993:29-41). This is a fitting description of some of the issues that have affected Cuban agriculture over the last 40 years and that are likely to be having a bearing on the sector's poor performance.

In some regions of the country, salinization has become a major environmental issue. It is acknowledged to be critical in rice production areas, which were expanded by the socialist government, particularly along southwestern Cuba and in the Cauto River Basin. Important irrigation projects, involving the development of artificial water reservoirs and excessive pumping of underground water stores, together with poor drainage practices, accompanied the expansion of cultivation of rice and other crops. These tendencies are aggravated even further by the known contamination of many of Cuba's coastal aquifers, a process that appears to have been at least partly induced by perverse hydraulic development initiatives. In the southwestern section of Pinar del Río province, for example, some independent observers (Agencia Ambiental Entorno Cubano 1999) are claiming that damage is so severe that a process of desertification is underway: levels of salt concentrations are so high that few plants can survive. Even when salinization levels have not reached critical levels, it is known that "the tolerance of different plants to salinity vary greatly, but all suffer from increased salinity"(Goudie 1994:148). Thus, it seems reasonable to assert that as some of Cuban soils have become more saline, their capability to sustain former agricultural yields has been compromised. In some places the damage may be so severe so as to be virtually irreversible. Reclamation efforts (salt removal, converting more harmful salts into less harmful ones, miscellaneous control measures) in other regions may be too

expensive and beyond Cuba's present day ability to pay for them (Goudie 1994:149-50).

The extent of soil compaction is also a serious concern since it can seriously damage its structure. Soil compaction, according to Goudie (1994:152-53), "tends to increase the resistance of soil to penetration by roots and emerging seedlings, and limits oxygen and carbon dioxide exchange between the root zone and the atmosphere. Moreover, it reduces the rate of water infiltration into the soil, which may change the soil moisture status and accelerate runoff and soil erosion." Goudie goes on to note that most notable effects of soil compaction can be seen on the soil's infiltration capacity, with the most damage being seen in row crops accompanied by poor rotation. Before the Special Period, these were characteristic features of Cuban socialist agriculture: the planting and harvesting of many row crops was fully mechanized and the ancient land preservation practice of crop rotation was woefully neglected. The burning of sugar cane to facilitate mechanical harvesting and frequent application of chemical fertilizers and pesticides contributed to the removal of organic matter from the soil further intensifying pressures on its fertility. The extent of the compaction damage alone suggests it must have had a noticeable impact on agricultural output.

CONCLUSION

In summary, the evidence reviewed in this paper indicates that the poor performance of the Cuban agricultural sector during the 1990s — and very likely into the future as well — responds to environmental causes, as much as it does to a shortage of imported inputs and inadequate economic policies. This conclusion is important and carries potential grave significance since soil degradation processes are expensive and difficult to reverse, and often require a long time before producing expected results. Environmental degradation, therefore, could well prove to be a major brake on Cuba's eventual economic recovery.

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