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Agriculture on the Steep Slopes of Tropical America: Current Situation and Prospects for the Year 2000*

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Summary. – We examine agricultural and social indicators of the tropical American steep slopes. For the whole region, these areas currently produce between 20 and 40% of total agricultural output, have 20–50% of total agricultural land in annual crops, contain 30–50% of the farming population, and have the worst poverty. A similar situation appears likely for the year 2000. Viable development strategies for the steep sloped areas will involve increased agricultural productivity and off-farm employment to reduce poverty, economic incentives to preserve the resource base, and research into sustainable production systems for the part-time small farmers who are common there.

1. INTRODUCTION

In this paper, we consider three questions. First, what is the contribution to national agricultural output of the steep slopes of tropical America (Mexico, Central America, the Andean countries and the Caribbean)? Second, what is the economic status of the people who live there? Third, what are the prospects for the area in the year 2000?

These questions arose when we attempted to estimate the agricultural production on the steep slopes, and the income and environmental degradation which this production generates. While many authors have recognized that farming on steep sloped areas is important in agricultural output and employment (Rankine, 1976; IBRD, 1978a, pp. 1–5, 1978b, pp. 15 and 23, 1978d, pp. 17–18), few estimates of these contributions are available. Therefore, using data from a variety of sources we have estimated the proportion of agricultural output produced on the steep slopes, the proportion of the population who live there and their economic status. Diverse opinions also exist regarding the degree of environmental degradation in the region. For example, some analysts (Eckholm, 1975, 1976; CEPAL, 1976; Shapiro, 1978; Le Baron and Bond, 1979; Murray, 1980) have emphasized the ecological fragility of the steep slopes, and the severe erosion which currently exists there. They warn that this trend is accelerating.[1] By contrast, others [such as Wilken (1972, 1974), Rhoades and Thompson (1975), Orlove (1976), Mayer (1979) and Denevan (1980)] have argued that traditional systems of resource use in these areas are adaptive and have changed in ways that thave sustained the productive potential of the environment.

Both of these issues, the lack of data on the contribution of the steep sloped areas and the diverse opinions about their degree of degradation, are linked. Without reliable data on relevant social and economic indicators, research workers have often generalized from

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Table 1. *Estimated area, arable land and population on steep slopes of tropical America**

Country (1)	Per cent of national area (2)	Per cent of arable land† (3)	Per cent of national population (4)	Per cent of agricultural population (5)
Mexico	45	20	15	45
Guatemala	75	30	40	65
El Salvador	75	40	30	50
Honduras	80	15	15	20
Costa Rica	70	25	20	30
Panama	80	10	15	30
Jamaica	60	50	15	30
Haiti	80	70	50	65
Dominican Republic	80	15	15	30
Colombia	40	25	15	50
Ecuador	65	25	25	40
Peru	50	25	25	50

* The data in this table are based on USAID, FAO and World Bank sources, discussion with specialists, and personal estimates. See note 5.
† Arable land includes only the land used for annual crops. It is cropped and/or fallow land in the normal rotation. It includes land in sugar cane, cotton and other annual crops, but excludes perennial crops such as coffee and bananas and permanent pasture.

Table 2. *Contribution of steep slopes to total agricultural output of tropical America for selected years*

Country (1)	Contribution to total agricultural production* Including coffee (%) (2)	Excluding coffee (%) (3)	Years (4)
Ecuador	42	33	1973–1974
Colombia	38	26	1976–1977
Peru†	24	21	1968–1970
	22	19	1975
Guatemala	45	26	1974–1976
El Salvador	75	18	1976–1978
Honduras‡	38	19	1975–1977
Haiti §	50	30	1973–1975
Dominican Republic†	28	20	1970–1972
	43	31	1974–1976

Sources: Ecuador – (a) *El Sector Agropecuario del Ecuador* (1979), Table 6, p. 19; Annex 2, p. 101; Annex 11, p. 110. (b) IBRD (1977a), Annex 2, Table 2. (c) IBRD (1977c), Table 2.4. (d) IBRD (1979c), Vol. 2, Tables 7.2, 7.47. Colombia – (a) IBRD (1979b), Tables 7.1, 7.10. (b) IDB (1979), Table A-3, p. 46. Peru – IBRD (1979e), Vol. 2, Table 96; Vol. 3, Tables 7.16, 7.20, 7.44. Guatemala – IBRD (1977b), Table 8.1. Honduras – IBRD (1978a), Tables 3.5, 7.1, 8.1. Haiti – IBRD (1978c), Table 7.2. Dominican Republic – Beach and Murphrey (1973), p. 26. IBRD (1978b), Annex 1, Table 4.
* Includes crops, livestock and timber.
† Excludes timber.
‡ Excludes livestock.
§ Crops only.

particular (usually alarming) situations. These generalizations have influenced both planners and policy-makers so that four views (reflected in both plans and policies) are common. These are: the sloped areas have little agricultural potential; the people who live there are degrading the environment and creating problems at lower elevations (such as silting and flooding); given other opportunities farmers will abandon their hillside plots; and population pressure can be eased on the steep slopes by the colonization of new areas.[2]

Recent work [Posner (1981) and later] has challenged these views by showing that the steep sloped areas currently make a large contribution to agricultural production and, under foreseeable circumstances, will continue to do so. Environmental degradation is not generalized but confined to particular locations where the economic and social factors have encouraged the use of the physical resource base beyond its sustainable productive capacity. Rather than leave, most farmers have adapted to hill farming by supplementing their income with off-farm activities. And, colonization schemes have been costly and of limited success (Schuurman, 1980; Bromley, 1980).

This paper has the following format. In Section 2, we examine the current economic and demographic situation on the steep slopes of most countries in tropical America and project their likely contribution to national output and social welfare for the year 2000. Section 3 discusses the social, economic and political implications of our results for the countries of the study area. Section 4 concludes the paper with observations on development priorities for the steep slopes.

2. CURRENT AND PROJECTED SITUATION ON THE STEEP SLOPES

(a) *Current situation*

Tables 1–4 contain data on the resource base (land), the main factor of production (labour), the output created by the principal economic activity of the population (agricultural production), and the low level of income generated by this activity (poverty) on the steep slopes. Table I gives estimates of the total national area, the arable land, and the national and agricultural population on the steep slopes of 12 countries in tropical America. A high proportion of the total area of all countries is on steep slopes [column (2)].[3] The range is 40% in Colombia to 75% in Central America and the Caribbean. The estimated shares of the total arable area on steep slopes [column (3)] were derived from land distribution data by assuming that 50–75% of the farms below 5 ha in size were hill farms and that these had approximately 70% of their area in annual crops.[4] In tropical America, generally more than 25% of steep sloped land is in anual crops. (In North America and Europe annual cropping is unusual on slopes over 12% and probably no cultivation occurs on slopes over 20%.) Finally, for all countries over 15% of the national population [column (4)] and 30% of the agricultural families [column (5)] live in the steeped sloped areas.

Table 2 reports the contribution of the steep slopes to total agricultural output (crops, livestock and timber) of eight countries for selected years. We derived these estimates by assuming that hill production included all forestry products, all coffee, and 50% of the livestock. We consulted local agronomists and used census data to determine the proportion of other crops, such as beans, maize and cassava, produced on hill farms.[5] Column (2) gives the contribution including coffee. The data vary from 28% in the Dominican Republic (1970–1972) to 75% in El Salvador (1976–1978) but most are close to 40%. When coffee is excluded, the range is 18% in El Salvador (1976–1978) to 33% in Ecuador (1973–1974). These contributions to total agricultural output of the steep slopes are large. As is evident from note 5, *for staple food crops* these contributions are even larger, being between 50 and 75%.

But, despite the aggregate contribution of the steep slopes to agricultural output, the farmers on the steep slopes are poor relative to both the urban population [USAID/Ecuador (1980), p. 2; USAID (1978), p. 123, Table 3, column 6] and to agricultural producers on the flat lands.[6] According to World Bank data, most of the 40–60% of the rural population in tropical America which it classifies as being 'absolutely poor'[7] lives on the steep slopes (IBRD, 1977b, p. 19, 1978c, p. 63, 1979b, Vol. 1, p. 7, 1979d, p. 20, 1979f, Annex 4, Table 2, p. 19, 1980, p. 8; USAID/Ecuador, 1980, p. 4; USAID/Peru, 1980, p. 1). One explanation of this poverty is that farmers lack resources, particularly land. For instance Esman (1978), p. 7a, estimated that approximately 75% of the rural families in tropical America were 'landless and near-landless'.[8] Other reasons for their poverty include high population growth rates; limited capital resources; physical, economic and (both private and government) institutional isolation; and lack of public-sector assistance (USAID/Peru, 1980, pp. 12ff).[9]

Table 3. *Distribution of land in selected countries of tropical America*

(1)	(2)	(3)	(4)	(5)
	Per cent of rural population			
	Landless	Microfincas (under 0.7 ha)	Small farms (0.7– ha)	Family farms (over 4 ha)
Central America – 1970				
Guatemala	26	15	42	17
El Salvador	26	24	36	14
Honduras	31	10	24	35
Costa Rica	26	31	13	30
		Per cent of farm holders		
		0–1 acres	1–5 acres	Family farms over 5 acres
Caribbean				
Nevis		33	61	6
Dominica		35	35	30
Haiti		30	60	10
Barbados		98	–	2
Jamaica			81*	19
		Per cent of farm holders		
	Rural landless per cent of rural population	Under 1 ha	1–5 ha	Family farms over 5 ha
Andes				
Colombia	17	23	33	44
Ecuador (total)	11		67†	33
Sierra		35	43	22
Peru (total)	14		66‡	34
Sierra		37	47	16
Bolivia (total)	21	–	–	–
Sierra		17	42	41

Sources: Central America: Cited in IBRD (1977b), p. 72.
Caribbean:
Nevis and Dominica: Finkel (1964), p. 164.
Haiti: USAID (1978).
Barbados: FAO (1978).
Jamaica: IBRD (1974).
Andes:
Rural landless estimates: Esman (1978), Tables 3, 4, pp. 7, 8.
Colombia: IDB (1979), Table A-1.
Ecuador: *El Sector Agropecuario del Ecuador* (1979), Annex 14.
Peru: IBRD (1979e), Table 7.75, p. 862.
Estimates for Sierra part of Andean Pact countries: JUNEC (1978), p. 68.

* Under 5 acres.
† Under 5 ha.
‡ Under 3 ha.

Table 3 shows some of the dimensions of landlessness and near-landlessness on the steep slopes in selected countries. In most cases, more than two-thirds of the farmers in Central America and the Andean countries have farms of less than 5 ha. In Ecuador, Peru and Bolivia the majority of these small farms are concentrated in the Sierra of the Andes. In the Caribbean, the majority of farms are less than 5 acres (approximately 2 ha). Recent evidence suggests that land areas of less than these limits (5 acres and 2 ha) cannot support a farm family.[10] As a

Table 4. *Trends in the size and number of small farms (less than 5 ha) in selected countries of tropical America*

Country (1)	Year of comparison (2)	Average farm size (ha) (3)	Per cent reduction in farm size (4)	Per cent of farm population (5)	Absolute No. of farms (thousand) (6)
Panama	1960	2.2	18	46	44
	1970	1.8		48	41
Haiti*	1950	0.7	11	39	227
	1970	0.6		71	438
Ecuador	1954	1.7	6	73	252
	1974	1.6		67	347
Colombia	1960	1.8	17	62	681
	1970	1.5		60	700
El Salvador	1950	1.4	14	–	140
	1970	1.2		–	237

Sources: Panama: USAID/Panama (1979), Agricultural Census 1950, 1960, 1970.
Haiti: USAID (1978), Tables 3.8, 3.9, pp. 93, 94.
Ecuador: *El Sector Agropecuario del Ecuador* (1979), Annex 14.
Colombia: IDB (1979), Table 1-A.
El Salvador: Peck (1978), Table 5.

* Data in column (5) refer to the farm population with less than 1 *carreau* (1.3 ha). In column (3), the data refer to the average size of farms with less than 1 *carreau*.

result, most of these farmers supplement their family income with off-farm employment (Deere and Wasserstrom, 1980).[11]

Over recent decades, the average size of small farms has declined (Table 4) and, except for Panama, the number of small farms has increased [columns (3) and (6)]. This is a disquieting development since staple crop yields have also stagnated in these areas.[12] These data imply that *a larger number of farm families has been attempting to subsist on farms that, over time, have become progressively smaller without becoming more productive.*

Nevertheless, this conclusion should not divert attention from the existing contributions of the steep sloped areas to agricultural output, especially food production, nor the potential for a sustained contribution. In the few instances where agricultural researchers have focused on the problems of steep sloped farmers, the results have often been dramatic. For example, in Caquezo and Rio Negro (Colombia) corn and potato yields, respectively, increased by 200 and 90% on hillside farms that adopted improved technology (Sepulveda, 1980). In Jamaica, the use of hillside ditches and contour mounds produced sustainable yields of yams of 38 tonnes/ha while traditionally cultivated plots, after 4 years, yielded 26 tonnes/ha. These structures also had the advantage of reducing erosion. Soil losses under the traditional technology averaged 134 tonnes/ha per annum. With ditches and contour mounds, soil losses were only 27 tonnes/ha per annum [Sheng and Michaelson (1973), cited in Wilson (1976), pp. 461–462]. Michaelson (1980) noted the high net returns of a reforestation project in Northern Honduras which was designed for firewood and orange production on contour ditches intercropped with corn and cassava. Livestock productivity has also increased rapidly when appropriate management and breeding practices have been followed. Vincente-Chandler (1976) noted that cattle weight gains on well-managed ultisols with 35% slope were similar to those obtained on level ultisols. Finally, as Wennergren and Whitaker (1977) reported, improved management of genetically upgraded sheep in Bolivia had high pay-offs. These results are inconsistent with the common opinion that the steep slopes lack agricultural potential.

Yet, while this potential for higher production exists, few of the countries in tropical America have made significant progress in their capacity to produce food domestically from either flat or steep land. In the cases where agricultural output has increased rapidly, it has been the result of improved production of coffee, sugarcane, cotton, citrus and beef for export. Table 5 shows an index of average food production per person, a calorie supply index, the growth of agricultural production, and debt service relative to exports for selected years to provide some perspective on these points. Columns (2) and (3) show, respectively, food pro-

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Table 5. *Selected food production and import potential data, countries of tropical America*

Country (1)	Food production per person 1976–1978 (1969–1971 = 100) (2)	Calorie supply per person – per cent of need 1977 (3)	Annual average growth of agriculture 1970–1978 (4)	Debt service as per cent of exports (5) 1970	1978
Mexico	99	114	2.1	24	60
El Salvador	111	90	2.7	4	3
Guatemala	108	98	5.3	7	2
Honduras	84	89	0.8	3	8
Nicaragua	102	109	5.4	11	13
Costa Rica	114	114	2.5	10	23
Panama	103	101	2.4	8	39
Haiti	91	93	2.6	8	6
Dominican Republic	93	93	3.3	5	9
Jamaica	98	119	1.4	3	18
Trinidad and Tobago	94	111	−0.1	3	1
Cuba	96	118	–	–	–
Venezuela	97	99	3.5	3	7
Colombia	114	102	4.9	12	10
Ecuador	103	92	4.6	9	12
Peru	90	97	0.7	12	31
Bolivia	111	83	3.6	11	49

Source: *World Development Report*, 1980 (Washington, D.C.: World Bank, 1980), Tables 1, 2, 10, 13, 17, 22.

duction per person and average per person calorie supply relative to (recommended) needs. Food production per person fell in nine countries. Of these, five (Haiti, Honduras, Peru, the Dominican Republic and Venezuela) already had inadequate per person calorie supplies [column (3)]. Slow agricultural growth aggravated this situation in Honduras and Peru [column (4)]. Food imports have historically been used to offset the effects of slow expansion of domestic agriculture. But since the rapid increases in oil prices, this option has become less viable. The (sometimes dramatic) increases in debt service as a proportion of exports [columns (5) and (6)] have reduced the ability of most countries to finance discretionary food imports. These trends underscore the point that domestic agriculture in the countries of tropical America will have to provide a larger share of their future food and fibre needs. The steep sloped areas will be vital to this effort.

(b) *Projected situation in the year* 2000

The data in the previous section provide a base for us to project the situation on the steep slopes of tropical America in the year 2000. They showed that

(i) the steep slopes make a significant contribution to agricultural output;
(ii) they support a large proportion of the agricultural population;
(iii) a large portion of each country's arable area is farmed on steep slopes;
(iv) the number of small farms on steep slopes has been increasing;
(v) the size of these farms has been declining, while their physical productivity has stagnated;
(vi) the people on the steep slopes are among the poorest in each country;
(vii) because of diminished import capacity, most countries of tropical America will have to increasingly rely on their domestic agriculture for their basic food and fibre supplies.

We believe that these trends are likely to continue for two reasons. First, colonization schemes in Central America and the Andean countries have only had a small effect on reducing the growth of population in the steep sloped areas. Given the cost of these schemes, e.g. $6000 per family in Bolivia (Curtis, 1979, p. 27), they will continue to have a small effect.[13] Second, the rural populations of all of the countries in the study area (with the exception of Jamaica) are expected to increase at

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Table 6. *Estimated increase in the rural population by the year 2000 – all countries*

Country (1)	Rural economically active population (million) 1980 (2)	2000 (3)	Per cent increase (4)
Bolivia	1.0	1.4	41
Colombia	2.5	2.6	4
Ecuador	1.3	2.1	55
Peru	1.7	2.0	16
Venezuela	0.9	0.9	6
Costa Rica	0.4	0.5	22
El Salvador	0.9	1.4	59
Guatemala	1.3	2.1	57
Honduras	0.6	1.0	54
Nicaragua	0.3	0.5	43
Panama	0.3	0.3	21
Cuba	1.1	1.1	6
Haiti	2.3	3.2	41
Mexico	6.0	7.4	24
Dominican Republic	1.1	1.4	27
Jamaica	–	–	−13
Trinidad and Tobago	–	–	5

Sources: Except Trinidad, Tobago and Jamaica: CELADE (1979).
Trinidad, Tobago and Jamaica: United Nations (1975), pp. 67–70.
(Note in these countries, increases are based on total rural population.)

least until the year 2000 (Table 6). These increases vary from less than 10% in Colombia, Venezuela, Cuba and Trinidad and Tobago to over 50% in Ecuador, El Salvador, Guatemala and Honduras. Some of the highest population growth is expected to occur in countries such as Haiti, Honduras and Guatemala where pressure on the resource base is already high.[14]

Therefore, we conclude that the steep slopes will continue to support an increasing number of people over the next two decades in the countries of the study area. In the absence of technological breakthroughs and adoption of this technology, this trend will exacerbate the poverty of the people who live there and further increase the pressure on the steep sloped environment.[15] The increase in the absolute number of farmers will expand the cultivation of the more marginal lands, shorten fallow rotations, and reduce the amount of land per farm family.

3. SOCIAL, ECONOMIC AND POLITICAL IMPLICATIONS

What implications do the above conclusions have for national and agricultural policy-makers, scientists interested in the problems of agricultural production on the steep slopes of tropical America, and the people who live there?

In our view, national policy-makers could usefully focus their attention and resources on efforts to reduce the poverty of the people who live and farm on the steep slopes. A reduction in poverty of this group has at least three economic effects. First, it will help to preserve the productivity of the resource base on the steep slopes. Farmers who are less poor have less need to 'mine' their farm land by emphasizing present consumption over future consumption. Second, being less poor, farmers will also have more resources, including labour time, to adopt soil conservation practices and invest in productivity-improving technology.[16] This will sustain (and perhaps increase) the production of staple food crops on the steep slopes. A direct benefit of increased soil conservation is a reduction in the cost of erosion-induced silting and flooding at lower elevations. Third, reducing the poverty of people who live on the steep slopes reduces the need for (expensive) colonization schemes to relocate people from denuded slopes. A question which could prove useful as policy-makers contemplate an expansion of the colonization schemes is: would the same resources have a larger (social and economic) payoff if

spent in the (already settled) steep sloped areas?

The continued poverty of the people on the steep slopes has direct political implications which are probably only significant in countries where this group is a large proportion of the total rural population, such as in Guatemala, El Salvador and Haiti [cf. Table 1, column (4)]. Yet, in all countries there are indirect political implications as poverty continues to undermine rural social systems, promoting rural–urban migration and leading to the concentration of formerly rural poor in the urban areas. Given the projected population growth rates (Table 6), the problem of poverty on the steep slopes will not solve itself. Indeed, policy-makers can expect that neither the problem nor the people affected will 'go away'.[17]

A constructive focus for agricultural policy-makers is to determine ways of obtaining the maximum *sustainable* output of crop, livestock and forestry products from the steep sloped areas. One way is to provide incentives to encourage production activities which are consistent with the physical potential of the resource base. For example, in eroded areas, advisable strategies are the increased production of perennial crops, permanent pasture and forest, and the reduction of annual cropping on the steepest slopes. In addition, relative input and product prices, land use regulations and research priorities are often disincentives to sustained use of the resource base within its physical limits. A useful starting point is to understand the key elements of sustainable steep slope production systems in various areas. In some cases, terraces, hedgerows and other physical barriers as well as relay cropping, rotations and other agronomic practices provide the basis for successful intensive farming systems. But, in others, these features and practices are inappropriate. Thus, policy-makers would be assisted in their efforts if they recognized the variety of conservation and production strategies and designed flexible incentives and regulations to encourage their expanded use.

Scientists interested in the problems of the steep sloped areas have a direct interest in the promotion of research which is relevant to the production systems of the people who live there. So far, agricultural research has had a flat-land research bias[18] and a focus on the problems of export crops such as sugar, bananas, cotton and beef and products consumed in the urban areas, e.g. pigs, poultry and milk. Important subsistence crops on the steep slopes such as intercropped maize, beans, potatoes and barley have received less research attention. So has the question of finding ways to improve the productivity of plots of land which are both decreasing in size and being farmed by a part-time family labour force.

4. CONCLUDING OBSERVATIONS

The data presented in this paper contain few surprises. They confirm what is widely recognized among agricultural planners, policy-makers, research scientists and others that the steep slopes make a major contribution to agricultural production in tropical America. (Indeed, when these data were first presented at a conference at CATIE in Costa Rica, the consensus of the conferees was that the estimates were conservative.) But, this recognition has not been translated into effective policies which promote the welfare of the farmers on the steep slopes and research programmes to work on their problems. To date, the tendency has been to seek solutions to the problem of the steep slopes both indirectly and in other locations. For example, one rationale for the promotion of import-substituting industrialization has been to absorb the 'surplus labor' which has been presumed to exist in the 'backward' steep sloped agricultural areas. The implicit assumption underlying this effort is that industrialization has a greater potential to promote economic growth (and national welfare) than an expansion in agriculture on the steep slopes. A second example is the existence of colonization schemes to relocate people away from the steep sloped areas.

We urge a reorientation of development priorities to reflect the increasing evidence that the steep-sloped areas of tropical America have significant agricultural potential, that staple food production on the steep slopes is a vital and permanent feature of agriculture in the region, and that agricultural research on the problems of the farmers on the steep slopes is a socially useful enterprise. What we urge is that national and agricultural policy-makers and research scientists co-operate, through their policies, financial support and work, to encourage the farmers on the steep slopes to simultaneously increase agricultural output and adopt measures to preserve the resource base. Success in this effort is one way of reducing poverty and environmental degradation throughout tropical America.

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NOTES

1. We have found it difficult to place the degree of environmental degradation, its location and economic significance in the regions in perspective. For example, Baldwin (1954), p. 159, reported that, based on FAO and Conservation Foundation maps, 42% of Mexico had 'accelerated' erosion. The Instituto Geografico Augustin Codazzi estimated that, in 1973, 93% of Colombia's soils that had been mapped were not suitable for agricultural use because of their erodability (IDB, 1973, Table A-8). Low (1967) estimated that 87% of the land in Peru was losing more than 10 tons/ha per annum of top soil. Eckholm (1976) reported a Conservation Foundation estimate that 77% of El Salvador had severe erosion. Finally, Saouma, the Director-General of FAO, stated that 80% of Cuba was affected by erosion (*Granma*, 14 September 1980, p. 3). These suggestions of generalized erosion are hard to reconcile with the observations of one of us (Posner) while working and travelling in the region.

2. These views are evident in each government's actions. For example, in a personal communication Haajes and Dourojeanni cited World Bank estimates that 90–95% of public investment in agriculture since World War II in Mexico and Peru has been in irrigated agriculture. Little of this investment was for watershed management. Schuurman (1980) argued that major reasons for colonization schemes in the Amazon region of Colombia, Ecuador and Peru were to increase agricultural production and reduce rural–urban migration without causing social disruption through land reform. This focus on colonization has diverted attention from the needs of the hill areas which are the source of the colonists and rural–urban migrants. A final example (also mentioned in note 18) is that agricultural research has a flat-land bias. Research stations in tropical America are located on flat lands. Most land classification systems place a ceiling of 10–15% slope for annual cropping (Posner, 1981). As a result, research attention is systematically diverted from the problems of steep slopes.

3. We define the steep slopes as land with a slope of greater than 8% (Posner *et al.*, 1980). The majority of agricultural production discussed in this paper occurs on slopes of 15–25%.

4. Our estimates are consistent with other work. For example, Plath estimated that approximately 65% of class I–V land in Central America is on steep slopes (BID, 1977, Table 2, p. 21). Baldwin (1954) noted that 75% of the arable land in the Andes of Venezuela has slopes exceeding 25%. Dr Jesus Arras estimated that 80% of the farm land in Colombia is on class V–VII soils (personal communication). Finally, Rankine (1976) reported that 50% of Jamaica's arable land is on steep slopes.

5. The percentages are summarized in Appendix Table A1. (Our worksheets are available on request.)

6. Farms on the steep slopes are physically less productive than farms on flat land. For instance, in Ecuador, farmers with less than 10 ha have average yields 20% below the average yields of farmers with 10–50 ha. The majority of these small farms are on steep slopes (IBRD, 1979c, Table 1.23, p. 627). In Peru, small farmers in the Sierra with less than 5 ha have yields of 30–60% of their counterparts on the coast (IBRD, 1979e, Table 7.26, p. 786). For Ecuador and Guatemala, Dr Kass and Ing Lalama estimated that grain yields of farmers on steep slopes were only 60% of yields for the same crops on flat lands (personal communication). The corresponding datum for maize in the Oaxaca Valley in Mexico was 33% (Kirkby, 1975, p. 63).

7. The World Bank defines 'absolute poverty' as the income level which is not sufficient to purchase 'a minimal nutritionally adequate diet plus essential non-food items' (IBRD, 1979d, p. 20).

8. Esman (1978), p. 2, defined 'landless . . . workers' (both agricultural and non-agricultural) as those who reside in rural areas, have 'little or no ownership rights to land' and who earn their livelihoods 'primarily from the proceeds of their labour'. 'Near-landless' workers include 'marginal tenants' and 'marginal farmers'. The former 'farm parcels owned by others and pay rent in cash or kind'. The latter 'have title to or customary tenure of holdings that are of inadequate size or quality to provide a subsistence livelihood'.

9. Yet another explanation is that a majority of these poor farmers on the steep slopes are of Indian descent, a group that has been systematically exploited and ignored throughout tropical America. In 1977, Indians as a proportion of the rural population were 0.95 in Bolivia, 0.82 in Guatemala, 0.73 in Peru, 0.58 in Ecuador, and 0.36 in Mexico (III, 1979, Table 1, pp. 14–15).

10. In Guatemala the minimum size of farm needed to generate a sufficient income from the full employment of a farm family was 4–7 ha (IBRD, 1977b, p. 72). A minimum 'economic' sized farm in Peru is 5 ha (USAID/Peru, 1980, p. 8). Brush (1980), p. 8, estimated that at least 4 ha per family were required for the 7-year cropping cycle in the Peruvian Andes. For the Caribbean, Wright (1979), p. 8, estimated that 3–5 acres would provide an adequate income for a family if its cropping pattern included high-value crops such as nutmeg. Cifuentes (1979), p. 25, estimated that 4.2 ha was the 'minimum area necessary for an adequate diet of a farm family' in the hill areas of Puebla, Mexico.

11. Their review of studies of Mexico, Peru and Bolivia shows that small farmers – defined as having less than 2 ha – earned between 50 and 75% of their household incomes in non-farm activities.

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12. Blasco (1979) showed that in Colombia average yields for potatoes have declined over the last decade. Wheat yields have remained at 1.3 tonnes/ha during the same period. In Peru and Ecuador, there was no improvement in the productivity of basic food crops between 1960 and 1974 (CEPAL, 1976).

13. The cost of these schemes is increased by the limited supply of adequate land. Nelson (1973) cited FAO estimates that only 11% of the 30 million ha in the east Andean foothills of Colombia, Ecuador, Peru and Bolivia is suitable for annual cropping. Lack of transport, health facilities and schools are major drawbacks to the development of these areas. Bolivia's colonization schemes have relocated 230,000 people since the mid-1950s (Henkel, 1978, Table 1). Kirkby (1978), Table 4, noted that 440,000 people had moved into eastern Colombia by 1972. These population movements represent less than 5% of the rural population of each country.

14. One index of this pressure is given by FAO (1979) data. Economically active agricultural population per square kilometre of arable land in 1977 was 307 in Honduras, 95 in Dominican Republic, 70 in Guatemala, 61 in Peru, 57 in Colombia, 28 in Ecuador, and 25 in Bolivia. Between 1975 and 2000, the amount of farm land per rural inhabitant is expected to decline by 30% in Mexico, 40% in Bolivia and 31% in Peru (Eckstein *et al.*, 1978).

15. To show the consequences of increasing population pressure on the steep slopes, Marten and Sancholuz (1980) used a simulation model to demonstrate that, in the Jalapa region of Mexico, the maintenance of food self-sufficiency in the absence of additional investment in agricultural infrastructure will increase total erosion 12-fold between 1978 and 2000. Siltation rates in the Panama Canal watershed will increase by 80% by the year 2000 if forest cutting, and annual cropping and overgrazing on steep slopes are not strictly controlled (D. Walker – personal communication).

16. With an increased amount invested in the production of high-value crops, farmers also have more reason to adopt conservation practices. For example, Murray (1980) noted how Haitian farmers began to use terraces to prevent the loss of fertilizer.

17. One index of the expectations of a diverse group of individuals that agricultural production on steep slopes is a permanent feature of tropical America is land values. Some estimates are shown in Appendix Table A2. While land has uses besides agricultural production, such as a hedge against inflation or for purposes of status and power (from which economic benefits are derived), reasonable people do not pay increasing real prices for an asset that is expected to deteriorate in the foreseeable future.

18. Indeed, the majority of agricultural research stations in tropical America are located at low elevations on flat land. For example, the six Central American countries have 32 agricultural research stations (IBRD, 1979a, p. 25) while the five Andean-pact countries have 63 (Blasco, 1979, p. 159). Few of these stations include steep sloping land where field experiments can be conducted to study cropping systems under varying soil and water conservation practices. There is also a low elevation bias in the location of these stations. In the Andean countries over three-quarters of the stations are at elevations of less than 2500 m. In Central America, where the elevation bias is less pronounced, a research emphasis on genetics and plant improvement (65% of the effort) dominates. Only minimal attention is given to the concerns of the small farmer on steep slopes, namely weed control, irrigation and soil conservation (3% of the effort) (IBRD, 1979a, p. 19).

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GLOSSARY

BID = Banco Interamericano de Desarrollo (or IDB).
CATIE = Centro Agronomico Tropical de Investigacion y Ensenanza.
CELADE = Centro Latinamericano de Demografia.
CEPAL = Comision Economica para America Latina.
CIP = Centro Internacionale de la Papa.
FAO = Food and Agricultural Organization (United Nations).
HIID = Harvard Institute for International Development.
IBRD = International Bank for Reconstruction and Development.
IDB = Inter-American Development Bank (or BID).
III = Instituto Indigenista InterAmericana.
JUNEC = Andean Pact Countries.
SRN = Secretaria de Recursos Naturales.
UN = United Nations.
USAID = United States Agency for International Development.

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APPENDIX

Table A1. *Estimated contribution to agricultural production (%) of farms on steep slopes*

(1)	Honduras (2)	El Salvador (3)	Haiti (4)	Dominican Republic (5)	Guatemala (6)	Peru (7)	Ecuador (8)	Colombia (9)
Cereals								
Corn	40	50	70	40	50	20	50	50
Wheat	–	–	–	–	50	60	30	50
Barley	–	–	–	–	–	80	70	70
Sorghum	80	80	–	–	–	–	–	–
Millet	–	–	70	–	–	–	–	–
Rice	–	–	–	–	–	–	–	–
Pulses	40	50	70	50	50	–	50	50
Root and tubers								
Potato	100	–	70	50	75	50	70	70
Yuca	30	–	70	50	–	40	30	25
Peanuts	–	–	–	75	–	–	–	–
Sweet potato	–	–	70	25	–	–	–	–
Other		40						
Sisal	–	–	80	–	–	–	–	–
Platano	30	–	–	–	–	40	25	50
Panela	–	–	–	–	–	–	–	75
Vegetables	–	–	–	–	50	–	–	50
Coffee	100	100	100	100	100	100	100	100
Livestock	n.c.	50	n.c.	50	50			
Beef						60	50	50
Sheep/goats						100	100	
Pigs						40	50	
Forestry	100	100	n.c.	n.c.	100	n.c.	100	100

n.c.: Not calculated.
– : Data unavailable or no production on steep slopes.

Table A2.

Country	Value ($thousand/ha)	Description	Source
Ecuador			
Riobamba	4.2–6.5	Moderate slope	Cornick*
Imburra	3	Hill land without irrigation	Tripp*
	5	Hill land with irrigation	
Colombia			
Rio Negro	2	Steep slope cropland	Tobon*
	10	Moderately sloping cropland	
Sasiama	10	Good coffee land	
Guatemala			
Chimaltenago	6	Flat land	Kass*
	2.0–2.5	Sloping land	
Mexico			
Zacapoaxtla	1	Hill land	Cifuentes (1979), p. 32

* Personal communication.