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# ANALYSIS OF *Iguana iguana* FARMING SYSTEMS IN NICARAGUA, COSTA RICA AND PANAMA

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Farmers in Central America have limited possibilities to use agricultural production techniques, such as slash and burn agriculture, because suitable unexploited land often is lacking. These production techniques are associated with continuous deforestation and soil erosion (Gradwohl and Greenberg, 1988; Buffa and Werner, 1989; Pérez, 1994; Kaimowitz, 1995). During the dry season, when farmers' plots are fallow, they exploit the surrounding natural forests to support their family, e.g., by hunting wild animals, collecting firewood, and extracting timber, wood and thatch to repair their huts (Gutiérrez, 1996), which leads to forest degradation. Under current economic conditions, these unsustainable practices constitute virtually the only option for resource-poor farmers to make a living. In an effort to stop the process of forest degradation, non-governmental organizations (NGOs) and government institutions in Central America have proposed farming green iguanas (*Iguana iguana*; Reptilia, Iguanidae) as an alternative. The benefits were expected to be: providing extra income for small-

holder farmers, stimulating nature conservation attitudes of the rural population, producing animal protein, increasing the number of trees and augmenting the farmers' knowledge about nature (Pérez *et al.*, 1993a; Madrigal and Solís, 1994; Ruiz and Ascher, 1996). Appropriate ecological and economic conditions, however, are required. To be attractive to smallholders, the iguana farming system should have low initial costs, use locally available feed and be labor extensive.

#### *Iguana and its possible exploitation*

Iguana farming should be attempted only in its natural habitat, extending from southern Mexico to Brazil and some Caribbean islands, at altitudes below 1000m. Iguanas live in forest borders, prefer river margins, and can adapt to live in vegetation on compounds or in tree lines, such as those used for fences or erosion prevention. Iguanas can be bred in captivity, improving juveniles' survival rate to 80-95% (Werner, 1991), while it is only 5% in nature (Van Devender, 1982). Ideally, to provide an habitat for the founder ani-

mals on a farm, trees have to be planted, and existing vegetation, especially trees near rivers and forest edges, should be protected, thereby protecting associated streams, springs and natural areas (NRC, 1991).

By rearing iguanas in trees, it is argued that profit can be made even before the trees produce fruits or are of a harvestable size (NRC, 1991). Iguanas eat leaves and fruits, and thus can survive, grow, and reproduce without expensive feed such as concentrates. People in Central America eat iguanas and their eggs (NRC, 1991), and use the hides to produce leather goods. More recently, a market has developed for juvenile iguanas as pets.

Existing laws and regulations stipulate the requirements for obtaining permission to farm and trade iguanas. Nicaragua, Costa Rica and Panama have ratified the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and therefore must implement its edicts in their national legislation. *Iguana iguana* is listed in Appendix II of CITES, meaning that regulated trade of iguanas or its products is possible.

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**KEYWORDS / Green Iguana / *Iguana iguana* / Nicaragua / Costa Rica / Panama / Farming Systems /**

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The present study evaluates existing iguana farming systems in Nicaragua, Costa Rica and Panama. The study aimed to assess the extent to which existing iguana farming systems had met expectations, emphasizing economic, ecological and legislative aspects.

## Materials and Methods

### Research area

In Nicaragua, most iguana farms are located in the west of the country, which has a tropical savanna climate with well-defined wet and dry seasons (Huysegems, 1998). In Costa Rica, iguana farms are located in the western part of the Nicoya Peninsula, Province of Guanacaste (Northwest), and in the Limon (Southeast) and Alajuela (Central West) provinces. The Nicoya Peninsula and Alajuela have a tropical savanna climate with well-defined wet and dry seasons, whereas Limon has a tropical rainforest climate with rain year-round (Daling, 1996). In Panama, iguana farms are located in the provinces of Herrera, Cocle and Panama (the Central Provinces), on the islands of Bocas del Toro and in the Province of Darien. Herrera, Cocle and part of Panama Province have a tropical savanna climate with well-defined wet and dry seasons. The rest of Panama, Bocas del Toro and Darien have a tropical rainforest climate with rain year-round (Mark, 1974).

### Data collection

The basic hierarchical community level in which the iguana farming system operates is the household. Information on iguana farming was collected from 49 households: 26 (53%) in Nicaragua, 6 (12%) in Costa Rica and 17 (35%) in Panama (Table I). The sample comprised 24 iguana farms, 21 neighboring households and 4 former iguana farms that had recently stopped iguana farming. In Nicaragua, 34% of all iguana farms (11 of 32) were surveyed, in Costa Rica 40% (2 of 5), and in Panama 61% (11 of 18). In Nicaragua, all small iguana farmers except one were interviewed; the other farmers were commercial iguana exporters, obliged by law to breed iguanas. In Costa Rica, 2 smallholder iguana farmers were interviewed, while the other farms had research and education objectives. In Panama, 3 of the 11 iguana farms visited were research farms.

Heads of households were interviewed with a questionnaire consisting of 62 open-ended questions on economic and ecological aspects of iguana farms. Economic aspects included: 1) Land:

TABLE I  
NUMBER OF RESPONDENTS INTERVIEWED BY COUNTRY AND FARM TYPE

Farm type	N	Nicaragua	Costa Rica	Panama
Iguana farm	24	11	2	11
Neighbor	21	12	3	6
Former iguana farm	4	3	1	0
Total number of farms visited	49	26	6	17
Total number of iguana farms existing in 1997	55	32	5	18

TABLE II  
NUMBER OF RESPONDENTS WITH RESOURCE-POOR FARMS  
THAT HAVE  $\leq 10$ ha AND  $\leq 3$  HEADS OF CATTLE

Resource-poor farms	N	Nicaragua	Costa Rica	Panama	P
Total farms <sup>1</sup>	21	13	3	5	0.38
Iguana farms <sup>2</sup>	11	7	1	3	0.23

<sup>1</sup> Total number of farms visited was 49

<sup>2</sup> Total number of iguana farms visited was 24

Total area available and its use, and land used for iguana farming; 2) Initial investment: Starting capital needed for a farming system, to buy founder animals and to buy materials to construct cages; 3) Markets: Respondent's opinion about the future for iguana farming, number of iguana farms in the future, demand for iguana products in local markets, consumption of iguana products, and numbers of iguanas and eggs sold; and 4) Labor requirements: The daily chores of iguana farming and tending young iguanas. Ecological aspects included: 1) Nature conservation attitude: Opinion on endangered animals, number of trees planted, and ranking of nature conservation objectives on the farm; 2) Local resources: Iguana feeds and trees available on the farm; 3) Predators: Predator incidence and type; and 4) Knowledge about nature: Knowledge about iguanas and courses taken on iguana and agricultural production. Answers to questions about knowledge of iguanas were coded as 'good' or 'sufficient', depending on their correctness and completeness.

In addition, 8 iguana-farming experts from NGOs promoting iguana farming on smallholder farms were asked in semi-structured interviews about their goals and the prospects of promoting iguana farming. The NGOs stimulated iguana farming by offering courses, providing founder animals and credits for the purchase of cage materials and feed.

Data on the habitat of iguanas, on laws and rules concerning iguana farming in each country, and on market possibilities were collected from the literature and by interviewing iguana farm-

ing experts and four officials of the government bodies responsible for legislation on and control of iguana farming.

### Data analysis

The STATISTIX analytical software (STATISTIX, 1992) was used. For categorical data,  $\chi^2$  tests for heterogeneity and/or goodness-of-fit were conducted. For measured data, one-way analyses of variance among countries was performed. Significant differences among means were tested with Bonferroni's multiple range test. The statistical analyses were often only indicative, as in many cases the basic assumptions were not met.

## Results

### Iguana farming system

Forty-three percent of all respondents (21 of 49) and 46% of iguana farmers (11 of 24) were resource-poor, with  $\leq 10$ ha and  $\leq 3$  heads of cattle (Table II). Iguana farming was not restricted to resource-poor farmers, because any interested individual may start farming iguanas. Average farm size, land use (average % of total available land per farm), livestock (average number per farm), and land needed to farm iguanas are shown in Table III for each country. The average farm size differed between Nicaragua and Panama. Land use was mainly for pasture in Panama, whereas trees and crops were important in Nicaragua and Costa Rica. While the average number of cattle per farm was largest in Panama, the average number of iguanas,

TABLE III  
AVERAGE FARM SIZE, LAND USE, LIVESTOCK NUMBERS PER FARM AND LAND NEEDED TO FARM IGUANAS, BY COUNTRY

	N <sup>1</sup>	Mean	Nicaragua	Costa Rica	Panama	P*
Average farm size (ha)	49	29.5	13.9 <sup>a</sup>	37.8 <sup>ab</sup>	50.3 <sup>b</sup>	0.02
Land use (average % of total available land per farm) <sup>2</sup>						
Pasture	28	49	36 <sup>a</sup>	26 <sup>a</sup>	75 <sup>b</sup>	0.00
Trees	40	33	32	47	30	0.52
Fruit trees	36	14	15	30	8	0.24
Crops	42	34	44	37	22	0.07
Livestock (average number per farm)						
Iguanas	33	929	1468	1535	269	0.06
Cattle	29	26	11 <sup>a</sup>	11 <sup>a</sup>	59 <sup>b</sup>	0.00
Horses	28	3	3	4	5	0.05
Pigs	19	3	4	4	2	0.16
Poultry	40	19	16	23	23	0.27
Land needed to farm iguanas <sup>3</sup>						
Cages in m <sup>2</sup>	17	405	510	66	285	0.38

<sup>1</sup> N: number of farms included in the analysis

<sup>2</sup> Total does not sum to 100, because different components are based on different number of farms

<sup>3</sup> Estimated

\* P according to the F-test. Means in a row with same superscript do not differ,  $\alpha=0.05$

horses, pigs and poultry did not differ among countries. Average land needed for iguana cages was 405m<sup>2</sup>. Iguana farming was an important on-farm activity in Costa Rica and Nicaragua.

#### Economic aspects

The area of farmland needed to feed iguanas depends on the number of animals to be fed and on available fresh feed and off-farm feed resources used. Most iguana farmers (94%) obtained, from the farm and nearby roadsides, fresh feed consisting of fresh leaves, fruits and flowers (Table IV). Off-farm feeds, consisting mainly of concentrates, were bought by 88% of the farmers.

To start iguana farming a farmer must buy materials to build cages, other supplies and founder animals (Table V). Cages were the most expensive items, with prices varying greatly among farms (US\$ 42 to 3000 per cage). To obtain founder animals, some farmers captured wild iguanas from the forests. Because of the reduced availability, most farmers had to buy iguanas twice, during each of two nesting seasons or from two or more locations. On average, each farmer bought 166 iguanas at a total cost of US\$ 280. Farmers indicated that the average age of the purchased iguanas was 39 months. In addition to the initial costs, farmers spent on average US\$ 81 per year on concentrates. The average price of founder animals differed greatly among countries, from US\$ 3.54 in Nicaragua

to US\$ 0.22 in Costa Rica, while in Panama iguanas were caught, at no cost, in natural forests after obtaining a permit for US\$ 5.

Only 6 of the 49 respondents considered capital an important precondition to start an iguana farm, probably because of the available credit programs. In Nicaragua, the Food and Agricultural Organization (FAO) offered a program that supplied farmers with the initial capital to buy founder animals and materials for the cages. In Costa Rica, FAO offered a similar program, but instead of supplying credits to buy founder animals, it provided annual loans to purchase concentrates. All organizations supporting iguana farming supplied

farmers with at least part of the required initial investment. Only 3 farmers with above average income were able to finance the farming system with their own capital.

Table VI presents the operation time and characteristics of iguana marketing per farm per country in 1997. Panamanian iguana farmers had the longest experience in the farming system (7.4yr). The number of iguanas sold was small compared with the number exported, because our sample did not include commercial iguana production. In 1997, Nicaragua exported 15230 iguanas, Costa Rica exported 11481 and Panama none (WCMC, 1999). That same year, in Nicaragua it was possible to earn a substantial income (US\$

TABLE IV  
PERCENTAGE OF IGUANA FARMERS USING SPECIFIC FEED FOR IGUANAS

Feed / Supplements	% of farmers <sup>1</sup>
Fresh feeds <sup>2</sup>	94
Leaves	94.1
Fruits	88.2
Flowers	70.6
Off-farm feeds	88
Concentrates	70.6
Market residues	41.2
Medicines	35.3
Vitamins	29.4
Seeds	23.5

<sup>1</sup> N= 17

<sup>2</sup> Leaves included *Ipomoea* sp., beans (*Cajanus cajan*), cabbage (*Brassica oleracea*), Spanish plum (*Spondias purpurea*), lettuce (*Lactuca sativa*), *Gliricidia*, horseradish tree (*Spondias mombin*), and *Cordia* sp. Popular fruits included banana (*Musa* sp.), mango (*Mangifera indica*), papaya (*Carica papaya*), Spanish plum, squash (*Cucurbita* sp.), and melon (*Cucumis sativus*). Flowers included hibiscus (*Hibiscus* sp.) and *Ficus* sp.

TABLE V  
AVERAGE TOTAL INITIAL COSTS (US\$) TO START AN IGUANA FARM AND ANNUAL FEED COSTS PER FARM PER COUNTRY\*

	N <sup>1</sup>	Mean	Nicaragua	Costa Rica	Panama	P
Initial costs						
Materials <sup>2</sup>	16	1944	976	2026	4323	0.17
Other supplies <sup>3</sup>	14	19	10	n.a.	55	0.31
Founder animals	16	280	444	18	0	0.05
Total initial costs		2243	1430	2044	4378	-
Feed costs per year	8	81	92	179	6.5	0.66
Price of a founder animal	17	2.32	3.54 <sup>a</sup>	0.22 <sup>ab</sup>	0 <sup>b</sup>	0.00

<sup>1</sup> N= number of farms included in the analysis

<sup>2</sup> Cages, drinking and feeding troughs, nests, incubators, a net to cover the cage and water supply.

<sup>3</sup> Thermometers, hypodermic syringes, ant poison, diesel fuel, wire, scales, camping gas, plastic bags, canvas bags, water pumps and extended scissors.

\* Except price of a founder animal.

Means in a row with same superscript do not differ,  $\alpha=0.05$

TABLE VI  
OPERATION TIME AND CHARACTERISTICS OF IGUANA MARKETING  
PER FARM PER COUNTRY IN 1997

	N <sup>1</sup>	Mean	Nicaragua	Costa Rica	Panama	P
Operation time of farm (years) <sup>2</sup>	16	3.5	2.4	0.8	7.4	0.01
Sales of iguanas						
Number of iguanas sold per year	10	314	431	1	60	0.22
Income per year (US\$)	10	441	610	5.67	69	0.29
Actual or average price per iguana in 1997 (US\$)						
Adult iguanas	9	6.25	3.84 <sup>a</sup>	21.25 <sup>b</sup>	6.0 <sup>a</sup>	0.00
Replacement animals	4	4.40	3.19	-	8.0	0.17
Young iguanas	11	1.96	1.70 <sup>a</sup>	4.25 <sup>b</sup>	1.86 <sup>a</sup>	0.01
Sales of iguana eggs						
Number of sales	2	1	-	1	1	*
Total number of eggs sold	2	75	-	120	30	*
Total income from eggs (US\$)	2	0.43	-	0.85	0.0	*

<sup>1</sup> N= number of farms included in the analysis

<sup>2</sup> Because of unequal sample sizes Bonferroni's multiple range test could not be applied

\* Not enough degrees of freedom to calculate P

Means in a row with same superscript do not differ,  $\alpha = 0.05$

610) with iguana farming. Variation in income within countries was high, so that no significant difference was found among countries. Only 25% of farmers, with an average operation time of 4.9yr, had reached higher total revenue from the sale of iguanas than their initial investment, whereas the other 75% operated for 3.2yr (P=0.14). Farms that operated for longer periods had a larger income (Figure 1), thus recovering the initial investment.

Of all iguana-breeding farms, 11 (65%) sold iguanas, 2 (12%) gave away young iguanas and 4 (23%) did neither. Those 11 farms that sold iguanas consisted of 9 (53%) that sold young iguanas, mostly as pets; 1 (6%) that sold adult iguanas; and 1 (6%) that sold both. Two farmers (12%) sold or gave away iguana eggs.

In 1997, the actual or estimated prices for adult iguanas were significantly higher in Costa Rica than in Nicaragua or Panama (Table VI). The price respondents received for an iguana depended on its length, age and weight. The price of female iguanas was higher if they were gravid and as the number of seasons they had laid eggs increased.

Farmers not only raised iguanas for sale as pets, founder animals and food, but also for their personal consumption. About 82% of respondents reported eating iguana meat and 65% reported eating iguana eggs. Consumption of iguana meat by respondents and its frequency did not differ among countries. Eggs, however, were eaten more often in Nicaragua, 7 farmers (37%) once a year and 12 (63%) more than once a year, than in Costa Rica, 1 farmer (50%) once a year

and 1 (50%) more than once a year, and in Panama, where 10 (100%) ate them once a year. Reasons for eating iguana eggs and meat included "nice taste", "healthy food" and "it is customary". Most respondents were used to eating iguanas, but either did not eat them as frequently as before or had stopped eating them. Most arguments in favor of eating iguanas or their eggs were still valid, except that numbers of wild iguanas had decreased.

Iguana farmers were asked their opinion as to the future prices for iguana products (pets, meat, hides and eggs). The prices were expected to increase with favorable international markets, increasing tourism, decreasing iguanas in the wild and a favorable local market. The price was expected to decrease with a surplus of iguanas bred in captivity. Overall, the negative and positive opinions of iguana farmers as to future prices counter-balanced.

With regard to the future of iguana farming in general, 37 respondents (76%) thought that the demand for iguana products on the local market would increase and 34 (70%) thought that the number of iguana farms would increase. Iguana farmers were less optimistic about the future of iguana farming than other respondents

were. Market development, governing the possibility to earn an income, was mentioned as a prerequisite for an increase in iguana farms.

Of 21 neighbors and of 8 who were only fattening iguanas, 19 (66%) wanted to breed iguanas in the future, 3 (10%) wanted to breed iguanas only if a good market existed to earn an income, and 7 (24%) did not want to breed them. Motives for wanting to breed iguanas were to earn an income, to protect iguanas, to eat them, to exhibit them and to conserve natural resources. Motives for not wanting to breed iguanas were the amount of labor required and the age of the respondent (too old to start something new).

Neonate iguanas were cared for from May through August, including the first weeks of the wet season, when there are other agricultural activities causing a conflict in labor requirements (Gutiérrez, 1996). Daily chores, such as cleaning cages, feeding and protecting the iguanas, required from 15min to 10hr a day (mean of 3.5hr), depending on whether animals were fed fresh feed and on whether they were protected continuously or only during daylight.

#### Ecological aspects

Respondents mentioned a total of 108 on-farm tree species that served at least one purpose. The most common purposes were production of timber and fruit. Each of these purposes averaged 4.4 species. Reforestation to simulate a natural forest accounted for 11 species.

Of all respondents, 92% had planted trees on their farms, with an average of 7 species per farm. The activity of planting trees did not differ among iguana farmers, neighbors and former iguana

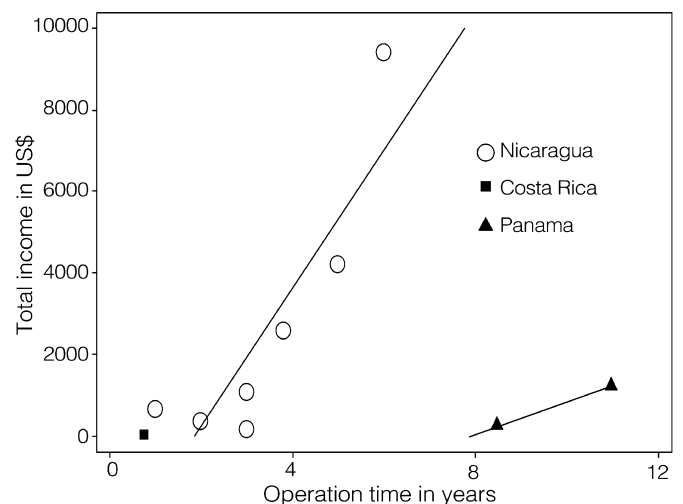


Figure 1. Operation time in iguana farming versus total income earned with iguana farming.

farmers, indicating that tree planting was not stimulated among them by organizations. Former farmers, however, averaged a larger part of their farm (48%) planted with trees than neighbors (5%;  $P=0.00$ ), whereas current iguana farmers were intermediate (22%).

Locally available fresh feed, such as fresh leaves, fruits and flowers represented low feed costs, and was used by 94% of the iguana farmers (Table IV). Furthermore, 88% of the farmers added off-farm feed and supplements, such as concentrates, which averaged US\$ 81 per year (Table V), market residues and medicines. Farmers who did not feed concentrates (the most expensive off-farm feed), kept on average only 156 iguanas (12 to 410), far fewer than the overall mean of 929 (Table III). Most farmers feeding concentrates did so to complement the diet, which consisted largely of fresh feed. As the number of iguanas increased, however, most farmers shifted to more off-farm feed, such as market residues.

For 35% of respondents, their reaction to the word "iguana" brought to mind "protection of an endangered species" and "part of nature", or nature conservation. This reaction did not differ among farm types but did differ ( $P=0.01$ ) among countries: nature conservation was mentioned by 65% in Panama, 50% in Costa Rica and 12% in Nicaragua.

Respondents were asked to name the objectives of their farm and to rank them in order of importance ('1' being most important). Objectives related to nature conservation were protection of animal species, protection against deforestation, stimulation of wood production and protection of habitat, nature and earth. Iguana farmers mentioned nature conservation objectives frequently (24% of objectives) and ranked them as important (2.5). Neighbors mentioned nature conservation objectives less frequently (9%), and did not rank them as important (3.7). Although iguana farmers practiced nature conservation on their own farms, neighbors were aware of the need for it but found it less important than other objectives, such as being self-sufficient, earning an income, and producing milk or meat.

Respondents considered nature conservation important because they had knowledge about nature. The latter was measured through their knowledge about iguanas, and whether they had obtained it by following courses. Knowledge about iguanas differed ( $P=0.03$ ) among types of farms, but not among countries. Predictably, iguana farmers gave more correct and complete ("good") answers (Eilers *et al.*, 2001) about birth (50%) and habitat of iguanas (25%) than neighbors (33% about birth and

0% about habitat) and former iguana farmers (0% about birth and habitat). The level of agricultural education by following courses also differed ( $P=0.03$ ) among types of farms, but not among countries. Iguana farmers were more educated in agriculture (96%), as compared with former iguana farmers (75%) and neighbors (43%). They participated in more ( $P=0.04$ ) courses (3.4) than their neighbors (1.8) or former iguana farmers (2.3).

The number of days respondents participated in iguana courses differed ( $P=0.02$ ) among types of farms, but not among countries. Iguana farmers took about 18 days of iguana courses, neighbors 5 days, and former iguana farmers about 3 days. Benefits to respondents of taking an iguana course included acquiring basic knowledge about iguanas (50%), preventing their extinction (17%), acquiring general knowledge (13%), and learning about iguana feed and about incubation of eggs (8%).

Predators form part of the natural environment in which iguana farms operate. Predators (in decreasing order of importance) consisted of birds, snakes, cats, foxes, people, adult green iguanas and black iguanas (*Ctenosaura similis*), ants, rats and dogs. Predators entered 47% of the iguana farms once or twice a year and to 53% of the farms more than twice a year. About 76% of the iguana farmers said they had problems with predators. Incidence of predators did not differ among countries. Predator attacks caused death of adult iguanas (according to 1 farmer), death of young iguanas (3 farmers) and failure of eggs to hatch (2 farmers).

The methods used to deter predators were sleeping near the iguanas (67%), covering cages with netting (42%), killing predators (17%), using garlic to deter snakes (8%) and using chlorine to kill ants (8%). Some farmers had learnt to deter predators without harming them. Comments about not harming them included "Predators have the right to live" and "They not only kill young iguanas, but also the rats and mice that attack our crops, so they keep nature in balance".

#### Legislative aspects

CITES regulates trade in wildlife species. *Iguana iguana* is included in Appendix II, which includes all species that, although not necessarily threatened with extinction, may become extinct unless trade is strictly regulated (CITES, 1973). In Nicaragua, Costa Rica and Panama, CITES was implemented in the national legislation.

Each year, a fixed percentage of the initial founder stock obtained from natural forests and a fixed per-

centage of new animals born on-farm (in Panama they are 10% and 5% respectively; INRENARE, 1990) have to be returned to their natural environment to help maintain natural populations. Each year also, the scientific authority of each exporting country determines a quota for the number of iguanas that may be exported. The quota for Costa Rica in 1997, for example, was 85000 live wild iguanas (CITES, 1997). In Nicaragua, there were 21 farmer/traders with permission to export iguanas, while in Costa Rica there was only one. In Panama, 3 farmers had applied for permission to commercialize iguanas nationally.

For all three countries, CITES constitutes the basic framework within which the government must operate to decide what conditions have to be fulfilled before iguana exports are allowed. Farmers have to acquire several permits and certificates before they may begin obtaining founder animals. Poorly educated farmers are at disadvantage, as the procedure requires a project proposal that needs knowledge of natural resource management and writing ability. Thus, farmers have to get professional assistance in natural resources to formulate their project proposal.

#### Discussion

The iguana farming system varied among countries (Tables I, II, and III). In Panama, cattle was the main activity and iguana farming a side activity, whereas in Nicaragua and Costa Rica, iguana farming was an important activity.

#### Economic aspects

*Low feed costs and available land.* On smallholder farms, iguanas may be reared free ranging within tree lines, and thus be combined with cattle production, arable farming (with trees used as fences) and wood production (Table III). The land needed for iguana farming consists of areas for cages and for growing feed, or an area for free ranging. One hectare containing tree species appropriate for iguanas can support about 100 free ranging iguanas without additional feed (Pérez *et al.*, 1993a). A border of 20 to 50m between trees and certain crops, however, is needed to keep free ranging iguanas out of agricultural plots (Werner *et al.*, 1993). In Costa Rica and Panama, adult iguanas were free ranging in tree fences and forest edges. In Nicaragua, however, where farm size averaged 13.9ha, iguanas could not be free ranging because the farm was too small to separate the iguanas from agricultural plots. Iguanas, therefore, were reared in cages to prevent crop loss

(NRC, 1991; Werner *et al.*, 1993). Iguanas kept in cages were fed with feed grown on the farm or collected from nearby roadsides. At present, land availability does not appear to be a constraint for iguana production. In the future, however, when several iguana farms might be close together, there may be competition for feed along roadsides, implying that more feed will have to be grown on each farm, demanding more land per farm.

If a farmer rears more than about 400 iguanas, then it is difficult to meet their feed requirements with on-farm and roadside feed resources. This is due to the high labor requirements to collect fresh feed and to the insufficient supply of fresh leaves, fruits and flowers. Farms with large numbers of iguanas, consequently, must also rely on off-farm feed. Most farmers added concentrates to the diet of locally available feed, increasing feed costs. Iguana farmers considered concentrates to be high in cost and in some regions to be difficult to obtain.

*Low initial costs.* Low initial costs are a precondition for the adoption of iguana farming by resource-poor farmers. Due to expensive materials and founder animals (especially in Nicaragua, Table V), initial costs were high and difficult to obtain without credit for resource-poor farmers. The most expensive items were cages. There are possibilities to save money in the construction of cages by using local materials or by simplifying cage designs.

The price of founder animals was higher in Nicaragua than in Costa Rica and Panama (Table V), presumably because of sharply decreased numbers of iguanas in the wild and because middlemen drove prices up. Wild iguana numbers fell because they were being poached for food during the dry season and were being smuggled into El Salvador and Honduras for sale on the national or international market (Fitch *et al.*, 1982; Gutiérrez, 1996).

In Costa Rica and Panama, the price for a founder animal (Table V) was lower than the price for an adult iguana produced on-farm (Table VI). In Costa Rica, a possible reason for the low price for founder animals was that they were available near the farm and only a "catch wage" had to be paid. A possible reason for the high price for adult iguanas produced on-farm was that only a few farms were permitted to market them. In Panama, founder animals were almost cost free, as they could still be caught in the wild (with permission). Adults produced on-farm were relatively expensive, possibly because of the "black market" for their meat.

TABLE VII  
A SUMMARY OF THE VARIOUS ASPECTS OF IGUANA FARMING IN NICARAGUA, COSTA RICA AND PANAMA

	Nicaragua	Costa Rica	Panama	Overall
Economic <sup>a</sup>				
Land	-	+/-	+	+/-
Labor	-	-	-	-
Initial investment	-	-	-	-
Providing income	-	+	-	+/-
Providing protein	+/-	+/-	+/-	+/-
Ecological				
Feed	+/-	+/-	+/-	+/-
Trees	+	+	+	+
Predators	+/-	+/-	+/-	+/-
Nature conservation	+	+	+	+
Legislative				
Protection	+	+	+	+
Smallholders' possibilities	-	-	-	-
Implementation	-	+	+/-	+/-

<sup>a</sup> "+" means that the aspect is favorable, "-" means that the aspect is unfavorable

*Extra income.* Income from iguana farming depends on costs and retail prices, future price trends and initial investment. About 59% of farmers earn extra income selling young iguanas. We will focus, therefore, on cost and retail prices for young iguanas. The cost is calculated with that for materials and feed, plus opportunity costs for land, and labor. Opportunity costs for land can be ignored when iguanas are free ranged, although the reduced production of the trees has to be taken as an extra cost (Sandlund *et al.*, 1993). Opportunity costs for labor also can be ignored (Pérez *et al.*, 1993a). Respondents, however, indicated that opportunity costs for labor should be taken into account, due to competition between labor needed for iguana farming and for agriculture.

In Costa Rica, the cost for producing 7 month old iguanas was US\$ 2.48, including opportunity costs for labor (Pérez *et al.*, 1993a). Retail prices for young iguanas in Nicaragua ranged from US\$ 1.5 to US\$ 2.25 (Gutiérrez, 1996). Average retail prices in the present study are in Table VI. If the cost of US\$ 2.48 in Costa Rica is extrapolated to Nicaragua and Panama, then selling young iguanas would be profitable only in Costa Rica. Extrapolation of the cost to Panama is justified because of a comparable GNP, US\$ 2640 in Costa Rica and US\$ 3080 in Panama (World Bank, 1997). Extrapolations of the cost to Nicaragua is justified because of the cost of US\$ 1.2 for young iguanas, excluding labor and land opportunity costs (Paniagua, 1995). Although Nicaraguan farmers were able to export young iguanas as pets,

they did not earn extra income if opportunity costs for labor were taken into account.

Adult iguanas were sold by 12% of iguana farmers. In Costa Rica, the cost to produce two-year-old iguanas was about US\$ 8, including opportunity costs for labor (Pérez *et al.*, 1993a). In Panama, adult iguanas were sold for meat at US\$ 4 per kg. Extrapolation of the Costa Rican cost price of US\$ 8 to Nicaragua and Panama, indicates that selling adult iguanas would be profitable only in Costa Rica (Table VI).

Obtaining extra income from iguana farming depends not only on costs and retail prices but also on future price trends. In Nicaragua, farmers supply young iguanas mainly to the pet market, which is small. Prices fluctuate from profitable to clearly unprofitable (Sandlund *et al.*, 1993). According to experts, prices for young iguanas are decreasing in Nicaragua because of competition on the international market from Colombia, El Salvador, Guatemala, Suriname, Peru and Guyana.

Iguana farmers were less optimistic about the feasibility of earning an income from iguana farming than other respondents, perhaps because the interview itself made other respondents more optimistic. Of neighbors, 66% said they wanted to breed iguanas in the future, and their motives for doing so corresponded with the benefits explained by the NGOs.

Farmers who succeeded to amortize their initial investment for iguana farming appeared to have longer operational periods than farmers who did

not (Figure 1). Nicaraguan farmers were able to earn more income due to the export possibilities. Iguana farmers receiving assistance from NGOs were able to endure the initial period of low production due to lack of experience, and of unknown market possibilities due to lack of knowledge, and could obtain the necessary experience before being left alone to earn extra income. Farmers who did not receive such assistance stopped iguana farming because they were unable to sell their products.

*Production of animal protein.* Only 12% of iguana farms sold adult iguanas, most as founder animals. A small proportion of the adults sold was consumed; thus, producing animal protein was not yet an important production goal. There are possibilities for market development for the consumption of iguana products: 21% of households in Costa Rica had eaten iguana meat, of which 94% liked it. These consumers form a solid basis for marketing iguana meat (Pérez *et al.*, 1993b). In our survey, 82% of respondents consumed iguana meat, and 65% consumed eggs. These results support the possibility of creating new markets for iguana meat and eggs. The development of such markets will encourage poaching and probably pose a serious threat to wild iguana populations. If local people supply local and national markets with legally produced iguanas, illegal exploitation of wild populations might become unprofitable (Sandlund *et al.*, 1993). With the high cost for iguanas reared in captivity, however, exploitation of wild populations of iguanas will probably stop only when iguanas are near extinction, making hunting unprofitable.

*Labor requirements.* Opportunity costs for labor can be ignored, because of the lack of alternative employment (Pérez *et al.*, 1993a). Ignoring opportunity costs for labor applies when there is a surplus of labor, but actually the iguana farmers mentioned a shortage of labor. Farmers did not have the time to take care of young iguanas, e.g., to protect them, during the wet season, when priority for labor was given to producing food crops. It was time consuming to protect iguanas against predators by "sleeping near the iguanas" or "killing predators".

#### *Ecological aspects*

*Increased number of trees.* Iguana farmers and former iguana farmers had a larger area of their farm planted with trees than their neighbors. There were three reasons for this result: 1) NGOs promoted iguana farming among farmers who had already planted trees or

who were interested in planting more trees. 2) The larger area with planted trees could be a spin-off from the contact farmers had with NGOs: iguana farmers knew how and where to find financial resources to plant trees. FAO in Nicaragua encouraged tree planting by providing credit. 3) Farmers learned in courses about the importance of protecting existing trees and planting new ones. Planting activity, however, did not differ among farm types. Iguana farming, therefore, did not directly promote planting, but rather encouraged conservation of existing trees.

*Improved attitudes of nature conservation and increased knowledge and awareness of nature.* Iguana farmers were more involved in implementing nature conservation objectives on-farm than their neighbors. This supports the contention that iguana farming stimulates nature conservation attitudes that are formed by knowledge and awareness of nature. The latter was measured by the reaction of respondents to the word "iguanas". Differences in reactions among countries reflect differences in information about iguana farming. In Panama, for example, entire villages were informed about the introduction of iguana farming and its goals. More people learned that rearing iguanas meant that their habitat had to be preserved. This knowledge, therefore, improved nature conservation attitudes. In contrast to the entire village, individual iguana farmers, however, taking more intensive courses increased their knowledge about nature more than their neighbors and former iguana farmers did.

Knowledge about predators also influenced the farmers' attitudes. If farmers knew about the role of predators in nature, they deterred predators without harming them. If farmers did not know about the role of predators, they killed them. Exchanging experiences about predators and enhancing the farmers' knowledge of predators could discourage farmers from killing predators, an attitude contrary to nature conservation.

*Increased use of locally available feed.* Concentrates were used to complement the diet of locally available feed, especially in the dry season when more time is required by the farmer to collect sufficient fresh leaves, fruits and flowers. As the number of iguanas increased, the reliance of the farmer on locally available feed supplies will presumably shift to off-farm feed supplies, such as market residues and concentrates.

#### *Legislative aspects*

In most countries of Central America, large companies are le-

gally prevented from engaging in large-scale iguana farming and, thereby, from driving smallholder farmers out of the market. In El Salvador and Guatemala, however, large-scale iguana farming does impact smallholder farmers. Large-scale farmers largely obtain their stock of iguanas from natural forests of Nicaragua and Honduras, so as to offset losses that are suffered during breeding (Fitch *et al.*, 1982; Menghi and Werner, 1994). Legislation and regulations concerning iguana farming and trade provide governments a means to control the number of farms and the number of iguanas produced, and a means to protect smallholder farms. Current laws and regulations, however, are so complicated and rigid that they deter smallholders from starting iguana farming.

To apply for permission to keep and breed iguanas, for example, the farmer has to submit a project proposal that requires the assistance of a professional in natural resources. In Panama, the application has to be approved officially by a lawyer. After analysis of the project proposal, inspection of the farm, and implementation of any recommendations from the management authority, the latter may grant a permit to capture adult iguanas from natural forests and begin farming. In Costa Rica, for example, only four farms met the requirements; two are research and education farms managed by professionals. The legislative limitations are not a problem for the smallholder farmers, however, and legislation can be advantageous, as the production of trees is tax deductible (Palacios, 1994). Permission to export iguanas is granted after five conditions are met: the regulations of CITES are fulfilled, a fee is paid to the government, the scientific authority gives its approval, the registration of the iguana farm is demonstrated and the international norms on transport of iguanas are complied with.

#### **Conclusions**

In 1997, iguana farms in Nicaragua, Costa Rica and Panama could be classified as either resource-poor farms or resource-rich farms. The initial investment was a major economic constraint to iguana farming in all three countries. This was especially true when banks did not provide credit programs and smallholders depended on credit provided only by NGOs. If the initial costs and the absence of credit are taken into account, it is clear that an unassisted resource-poor farmer cannot start iguana farming.

On most farms, iguana farming activities did not generate additional income, because most farmers were

struggling to recover their initial investments and because if labor costs were taken into account, the sale of iguanas was profitable only in Costa Rica. The labor requirements, such as protection of young iguanas and the feeding and cleaning of cages, was considered a constraint during the wet season, when producing food crops had priority. Presently, the production of animal protein appears not to be important, because most adult iguanas were sold as founder animals, not as food. Production of iguana meat, however, seems to be a feasible alternative to production for the pet and founder animal markets. Fresh iguana feed is available locally and used on most farms. Most farmers, however, add concentrates to improve growth rates of the iguanas, thus reducing the labor required, but increasing costs.

The ecological benefits of iguana farming are tenable: incorporating nature conservation as an objective leads to a positive attitude towards nature conservation. Providing added value to trees on the farm stimulates the conservation of existing trees. A farmer can rely totally on local feed resources only if he has a small number of iguanas. Courses and experience increased farmers' knowledge about nature. Farmers saw predators as a threat, but their attitudes changed with increasing appreciation of the role of predators in nature.

The restrictive legislation intended to protect *Iguana iguana* may also serve to protect smallholder iguana farms from being driven out of the market by large-scale farms. Presently, however, such regulations represent an obstacle for the smallholders to start iguana farming and to trade their products.

A summary of the various aspects of iguana farming in Nicaragua, Costa Rica and Panama is in Table VII. The prospects for the farming system depend on the weight attached to these aspects. From the point of view of smallholders, unstable and risky economic prospects and the negative impact of legislation on starting iguana farming are important. From the point of view of nature conservation organizations, however, the ecological benefits and the protective influence of the legislation are very important. If iguana farming is to be introduced successfully, all parties must be satisfied. "If resources do not represent anything beneficial for the people and if their conservation provides no additional benefits for the communities, it cannot be expected that they will conserve them" (Kaimowitz, 1995). The iguana farming system, therefore, must be adapted to satisfy the major actors, the farmers, by increasing their

profits and by giving them professional help to meet statutory requirements.

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