CARIBBEAN FOOD CROPS SOCIETY

Sociedad Caribeña de Cultivos Alimenticios
Association Caraïbe des Plantes Alimentaires

Vol. XX

PROCEEDINGS

OF THE 20th ANNUAL MEETING – ST. CROIX, U.S. VIRGIN ISLANDS – OCTOBER 21-26, 1984

Published by
THE EASTERN CARIBBEAN CENTER, COLLEGE OF THE VIRGIN ISLANDS *and* THE CARIBBEAN FOOD CROPS SOCIETY

The Decline of Agriculture and Projection of the Number of Farm Units in the United States Virgin Islands

Frank L. Mills
College of the Virgin Islands

The collapse of the sugar industry in the Virgin Islands in 1966 ushered in a period of decline in agriculture which has persisted till the present. Despite the government's efforts to increase production, the agrarian domain has been under relentless siege by competing industrial, commercial and social interests. The paper is presented in three sections. The first gives, and discusses, basic quantitative parameters of the decline in agriculture over the last 20 years. The second makes use of a stochastic model – absorbing Markov chains – to project the decline in the distribution and the total number of farm units over the next 20 years. The third section details those causative factors that may explain the decreasing performance in agriculture. These latter include the impact of the abandonment of sugar production, the development of tourism, the increase in industrial and commercial activities, competition from imported foodstuffs, the policies of government, the unavailability of land, the lack of trained personnel, the shortage of labor, inadequate supplies of water, and insufficient marketing facilities. The paper concludes with a call for a conscious policy commitment by the government.

There is hardly any doubt that in the minds of the majority of the residents of the Virgin Islands, agricultural activity should constitute one of the major components of the economy of the territory. Until the recent past, *i.e.*, about twenty years ago, most native Virgin Islanders had known little more than the monoculture of sugar cane that had dominated the economy from colonial days. And for many other residents of the Caribbean, agriculture had always featured prominently in their island economies. The period that begins about 1960 can be described as a watershed in agricultural production in the Virgin Islands, for despite recent efforts to restore agrarian-based activities to a higher level than it has been in the last decade, there appear to be signs of an irreversible trend to a decreasing role for agriculture. This tendency to a reduced performance of agriculture can be broadly ascribed to three initial and interrelated factors: the collapse of the sugar industry in 1966, the impact of tourism and heavy industry, the population pressure on limited space.

The Virgin Islands Company (VICO) that was created by the Federal Government in 1934 was done with the express purpose of stimulating the economy by the operation of a sugar, rum and hotel business. Its successor in 1949 was the Virgin Islands Corporation (VICORP), which the Congress prohibited from any further production of rum. The production of sugar proved to be unprofitable, and VICORP sold off or conveyed its assets to the local government. This ensured the demise of the sugar industry in 1966. The early 1960s was marked by a rapid increase in tourism, and many hotels and tourist recreation facilities were built on land that was previously in the agricultural domain, including an 18-hold golf course and a condominium complex in St. Thomas, and two golf courses in St. Croix. The net result was that many agricultural workers drifted into the tourist industry as unskilled workers, and the demand for more cheap labor persisted for more than a decade.

The supply of labor for the increasing number of tourist facilities and for the burgeoning construction industry was met largely through migrant labor from the Eastern Caribbean and from the U.S. mainland. The demand for housing grew concomitantly, and inroads into abandoned rural farm land or agricultural lands adjacent to urban areas were readily given over to public housing complexes and other expressions of residential housing needs.

Hence it is quite clear that agrarian land has been under persistent siege by competing commercial and social interests, and this continues to be the case in the mid-1980s. The objective of this work is, therefore, to explore two issues. The first is an examination of the major characteristics of farming in the territory through an analysis of agricultural census data. The second is a projection of the number of farming units in five-year periods till the year 2000. The approach that is taken below is to discuss, first, some of the attributes of Virgin Islands agriculture which will lay the groundwork for the succeeding section. The second step is to present the salient features of the stochastic model – absorbing Markov chains – that is used in the projection of the distribution of farm units. After a presentation of the future pattern of decline, an attempt will be made to provide reasonable answers to why farming is on a continual decline in the Virgin Islands.

Attributes of Virgin Islands Agriculture

The most appropriate point of departure for a discussion of recent performance in agriculture appears to be the hiatus in activity of the early 1960s. Prior to that time, sugar and cotton production, raising livestock, and truck farming were the primary enterprises in farming, with the latter confined principally to St. Thomas. The artificially sound VICORP collapsed when it could no longer produce rum, and thus the sugar industry was the major casualty in 1966. This, therefore, led to the abandonment of large tracts of agricultural land and the retirement from this industry of hundreds of acres of prime land. The evidence for this may be seen in the Census of Agriculture data for 1960 and 1970, which show not only a decrease in the number of farms, but also in the number of acres that remained productive. The 1982 Census of Agriculture in the Virgin Islands defines a 'farm' "as a 'place' of three acres or more on which any field or forage crops were harvested or vegetables were harvested for sale during the 12-month period between July 1, 1982 and June 30, 1983, or on

TABLE 1. Selected characteristics of Virgin Islands farming: 1960 to 1982.

Year	Farm Units: No.	Farm Units: % Change	Farm Units: Growth Factor	Productive Acreage	% Farms Producing for Sale
1960	501			44062	60.3
1964	466	-7.0	0.93	39539	49.1
1970	212	-54.5	0.45	20470	48.6
1975	327	54.2	1.54	24703	54.1
1978	378	15.6	1.16	24397	46.6
1982	303	-19.8	0.80	20824	71.6
	Average rate of change	-10.6%	-9.6%	-16.2%	

Note. The data in column 2 are respectively from the U.S. Census of Agriculture, Virgin Islands of the United States, U.S. Bureau of the Census.

TABLE 2. Percentage of Virgin Islands farms by size: 1964 to 1982.

Size of farms (in acres)	1964	1970	1975	1978	1982
Less than 3	10.3	31.1	33.3	24.1	24.8
3 to 9	42.0	25.9	28.8	38.9	37.6
10 to 19	16.1	11.3	10.7	14.3	10.6
20 to 49	10.5	11.8	10.1	9.0	11.2
50 to 99	6.8	7.6	5.8	5.0	5.9
100 to 174	5.2	3.3	4.0	2.1	4.0
175 to 259	2.2	1.4	2.1	2.1	1.6
260 to 499	3.0	3.3	2.5	2.4	2.0
500 to 999	2.4	1.9	0.9	0.8	1.3
1000 or over	1.5	2.4	1.8	1.3	1.0
	100.0% (466)	100.0% (212)	100.0% (327)	100.0% (378)	100.0% (303)

which there was a combined total of ten or more fruit or nut trees or plants, any livestock, or ten or more poultry at the time of enumeration. Places of less than three acres were counted as farms if their sales of agricultural products . . . amounted to at least $100, or if they could normally be expected to produce agricultural products in sufficient quantity to provide sales amounting to at least $100 . . . The definition of a farm for 1982 was the same as in all previous census, except the one for 1950" (U.S. Bureau of the Census, 1983, p. iv). In fact, Table 1 shows that the total number of farms in 1964, 466, was reduced to less than half in 1970 when only 212 remained. And concomitantly, the total productive acreage recorded the largest decline in the last 25 years, a change of − 52.7% or a growth factor of 0.473.

The pattern of change that is reflected by the data of Table 1 is one of decline, but this has not been consistent from one quinquennium to the next. First, it is noted that overall there is a 10.6% rate of decrease per period between 1960 and 1982, in the number of farm units in the territory. The table also shows that the decline has not been constant: the third and fourth columns of percent changes and growth factors respectively express uneven rates of decrease and increase. The average period-to-period percent change is therefore − 9.6%. The acreage devoted to farming is related to the number of units under production, and the data thus reflect the same type of increase and decrease. Overall, the average rate of decrease between periods is 16.2%.

The most recent census records the largest percentage since 1960 of the total number of farms that produce for sale, versus those that produce for home consumption only. Whereas about six out of ten farms were producing for sale in 1960, the rate in 1982 was seven out of ten.

Census documents group most of the farm data by size categories. It is therefore useful to examine, by comparison, the frequency distributions of the last five quinquennial censuses to determine if the number of farm units in each of the categories remains basically the same from one census year to the next, or if they increase or decrease. The last decennial census of agriculture in the Virgin Islands was taken in 1960. The first quinquennial census of agriculture was taken in 1964. For the 1969 quinquennial census, the data were collected in 1970 to coincide with the decennial Census of Population and Housing. In 1976 Congress authorized censuses for 1978 and 1982 "to adjust the data reference year to coincide with the 1982 Economic Censuses . . . after 1982, the agriculture census will revert to a 5-year cycle" (U.S. Bureau of the Census, 1983, p. iv.). The data in Table 2 illustrate that, whereas the percentages of the number of farms over 100 acres in size have remained rather constant, the numbers in the smallest category (of less than three acres) have varied remarkably. Among the number of farms over 1,000 acres, there were 1.5% in 1964, and 1.0% in 1982. In 1964, 10.3% of the farms were less than three acres in size, and this number tripled to 31.1% by 1970. The largest percent of 33.3 was recorded in 1975, and the most recent count listed 24.8%. No other category registered this degree of variation in the proportion of farms in intercensal periods. The large increases between 1964 and 1975 may probably be explained by the dismemberment of some of the sugar plantations that ceased sugar cane production in 1966.

It was of further interest to examine the five distributions to determine statistically if it can reasonably be said that, basically, the same distribution of the percentage of farms was maintained in each of the census years from 1964-1982. The chi-square test of homogeneity is utilized to establish if the differences between the distributions can be ascribed to a chance process. The validity of a statistical test of significance on population data may have crossed the reader's mind. However, the attempt is not to generalize here to a larger population; it is merely to rule out the 'chance process' alternative as an explanation for the observed differences. See Blalock (1979, p. 242). The computed chi-square and associated probability of p = .00011 suggest that the populations are neither identical nor homogeneous, and that chance is not responsible for the observed differences. In fact, the test confirms that the largest differences are between 1964 and 1970, and these may be attributed to the agrarian change in sugar production that characterized the period.

Commensurate with the decline in farm unit numbers was a decrease in the number of acres devoted to productive agricultural practices. Table 1 recorded a quinquennial decrease of 16.2% over the period, and Table 3 illustrates the percentage of agrarian land that was distributed among the various size categories. Typical of most farming systems throughout the Caribbean, less than 1% of the total farm acreage in 1982 was found on 25% of the farms under three acres, and for most years, more than half of the total agrarian land was confined to farms over 1,000 acres in size. While the percentage of the acreage on farms of less than three acres tripled from 1964 to 1970, *i.e.*, from 0.2% to 0.6%, the actual amounts were 69 (1964) and 117 acres (1982). However, the percentage in almost all categories from 3 to 999 acres decreased between 1964 and 1970. The category that registered an increase was farms over 1000 acres: from 39.2% in 1964 to 54.7% in 1970. The last census marks the first time in about 15 years that the percentage of farms in the largest category is less than 50%, 45.7% in fact.

TABLE 3. Percent distribution of Virgin Islands farms by acreage: 1964 to 1982.

Size of farms (in acres)	1964	1970	1975	1978	1982
Less than 3	0.2	0.4	0.5	0.5	0.6
3 to 9	2.6	1.3	2.1	3.0	2.9
10 to 19	2.5	1.4	1.8	2.8	2.0
20 to 49	3.8	4.0	3.8	4.4	5.0
50 to 99	5.7	5.3	5.7	5.4	5.7
100 to 174	8.0	4.1	6.4	3.8	6.9
175 to 259	5.3	3.0	6.2	7.1	5.4
260 to 499	13.1	12.7	12.3	12.8	11.1
500 to 999	19.6	13.1	7.9	8.8	14.7
1000 or over	39.2	54.7	53.3	51.4	45.7
	100.0%	100.0%	100.0%	100.0%	100.0%
	(39539)	(20470)	(24703)	(24397)	(20824)

TABLE 4. Percent distribution of Virgin Islands farms by age group: 1964 to 1982.

Age group	1964	1970	1975	1978	1982
Less than 25	0.7	0.9	2.1	1.1	2.0
25 to 34	6.1	9.4	6.1	6.3	4.0
35 to 44	19.3	22.6	16.5	19.0	18.2
45 to 54	28.2	20.3	25.4	22.0	22.8
55 to 64	25.0	27.9	27.0	28.1	28.6
65 and over	20.7	18.9	22.9	23.5	24.4
	100.0%	100.0%	100.0%	100.0%	100.0%
	(466)	(212)	(327)	(378)	(303)
Average age	53.5	51.8	52.4	54.0	55.0

Note. Base data derived respectively from the U.S. Census of Agriculture, Virgin Islands of the United States, U.S. Bureau of the Census.

A chi-square test of homogeneity was conducted on the distributions (of the actual number of acreages) to determine if the population remained homogeneous throughout. The large chi-square value produced an associated p less than .0000. One is fairly certain that the distrubtions have changed substantially over time. The computed adjusted residuals, however, suggests that factors other than the abandonment of sugar production in 1966 may have been responsible for the departures from homogeneity in the system.

It was also of interest to examine the distribution of farm operators by age group, since with the public financial support for young farmers in recent years, one would normally expect the youthful age groups to reflect these entrants. A 'farm operator' is defined as a "person who operates a farm, either by doing the work himself/herself or by directly supervising the work. The operator may be the owner, a member of the owner's household, a hired manager, or a tenant, renter, or sharecropper . . ." (U.S. Bureau of the Census, 1983, p. A-1). First, however, Table 4 reflects that, since 1969, the average age of farm operators is becoming older, not younger. There does not appear to be any substantial movement of youth into farming, and it is to be observed from the table that the percentage of operators over 55 has increased since 1974.

In order to test further the supposition that the age structure of recent years should reflect a change from that of the past, the populations of the last five censuses were tested by a chi-square test of homogeneity to establish if the differences between the observed distributions were due to chance. The computed chi-square and associated probability ($p = .293$) lend strong evidence that there is no substantive departure from homogeneity of the age structure over time, and that the differences observed are most likely due to a chance process. This outcome was indeed surprising, and a possible explanation is explored later in the paper.

A final attribute of the farming pattern is the number of farms that have been recorded which produce for home consumption, and those which produce for sale. The last column in Table 1 indicates that there is no real constancy in the proportion of sale holdings, but it does appear extraordinary that over the years no more than about two out of three holdings are devoted to production for sale, or that more than one-third of the designated farm units produce for home consumption only.

Thus, the major factors that characterize farming in the Virgin Islands present clear evidence that the overall industry is in a state of decline, both in terms of the total number of acres devoted to productive agriculture, and the number of farm units involved in this production. The following section is therefore given over to a discussion of the Markov chain model used in the projection of the total number, and distribution, of farm units in the years ahead.

Projection of Future Size Distributions

Basic Elements of the Markov Chain Process

The areal organization of functional units through time, and the paths they are likely to follow in future time periods, have often attested the interest of the geographer, be they units of settlement, industry, or farms (Collins et al., 1974; and Collins, 1975). In a similar vein, agricultural economists share a common interest, as is evident from the works of Judge and Swanson (1961), Dovring (1962), and Krenz (1964). The application of the Markov chain model to spatially distributed time-varying data is contingent on the definition of a set of mutually exclusive states or categories which comprise the total distribution and the area under study. It also assumes that movements of units between states over time can be considered as a stochastic process, *i.e.*, in any given sequence of events, the outcome of each movement depends on chance. The process can be in only one state at a given time and it moves successively from one state to another. And the probability that the process moves from S_i to S_j depends only on the state S_i that it occupied before the move. For complete details on the estimation of the fundamental matrix and related statistics, see Kemeny and Snell (1976, pp. 43-50).

The states used in this study are the classifications used by the Bureau of the Census:

State	Size of farm (acres)
S_1	Less than 3
S_2	3 to 9
S_3	10 to 19
S_4	20 to 49
S_5	50 to 99
S_6	100 to 174
S_7	175 to 259
S_8	260 to 499
S_9	500 to 999
S_{10}	1000 or over

Within a given set of states, it is generally possible to estimate the probabilities (p_{ij}) of observations moving from one state to another. Such probabilities of movements for a given time period can be summarized in a transition matrix, the elements of which denote the probability of moving from state S_i to S_j in the next

TABLE 5. Estimated transition probabilities of farms from 1978 to 1982.

States	S_0	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
S_0	1	0	0	0	0	0	0	0	0	0	0
S_1	.176	.824	0	0	0	0	0	0	0	0	0
S_2	.224	0	.776	0	0	0	0	0	0	0	0
S_3	.352	0	0	.593	.055	0	0	0	0	0	0
S_4	0	0	0	0	.912	.088	0	0	0	0	0
S_5	0	0	0	0	0	.790	.210	0	0	0	0
S_6	0	0	0	0	0	0	1	0	0	0	0
S_7	.250	0	0	0	0	0	0	.625	.125	0	0
S_8	.333	0	0	0	0	0	0	0	.556	.111	0
S_9	0	0	0	0	0	0	0	0	0	1	0
S_{10}	.400	0	0	0	0	0	0	0	0	0	.600

TABLE 6. The fundamental matrix of mean five-year periods

States	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	Total
S_1	5.69	0	0	0	0	0	0	0	0	0	5.69
S_2	0	4.45	0	0	0	0	0	0	0	0	4.45
S_3	0	0	2.45	1.55	.65	.14	0	0	0	0	4.78
S_4	0	0	0	11.33	4.75	1.00	0	0	0	0	17.08
S_5	0	0	0	0	4.75	1.00	0	0	0	0	5.75
S_6	0	0	0	0	0	1.00	0	0	0	0	1.00
S_7	0	0	0	0	0	0	2.67	.75	.08	0	3.50
S_8	0	0	0	0	0	0	0	2.25	.25	0	2.50
S_9	0	0	0	0	0	0	0	0	1.00	0	1.00
S_{10}	0	0	0	0	0	0	0	0	0	2.50	2.50

step. The transition matrix, in addition to the initial starting state, completely defines the Markov process; *i.e.*, with the foregoing information, it is possible to determine the outcome of the process at the n^{th} step.

Estimation of the Transition Matrix

The efficient estimation of transition probabilities often presents a major technical problem because such estimates depend on the quality of the data available. However, three alternative approaches are possible: statistical estimation from micro-unit data, from aggregate data, and from conceptual considerations (Collins et al., 1974). This study, following Krenz (1964), adopts a conceptual approach to the estimation of transition probabilities. The Bureau of the Census does not provide data on individual farm units in the quinquennial censuses, and only enumerates farms in one of the several categories given above. By making use of detailed information on the life of farms in the Virgin Islands, patterns of behavior are assumed and rules subsequently adopted in order to determine the transition probabilities. In this regard, the following assumptions are made.

First, it is presumed that most farm operators in the Virgin Islands would want to expand their acreage if it is possible to do so. Second, it is more likely that medium to average size farms will expand because of financial resources available, and because of economies of scale, than it is that small farm units will increase their acreage. Third, any increase in farm size is likely to proceed gradually by the acquisition of adjacent property. Such incremental aggregation is likely to be a function of the availability of agriculturally zoned land, and of reasonable financial arrangements for purchasing land. Fourth, individual farms are not likely to decrease their unit size voluntarily, particularly because of the problems of economies of scale. Rather, it is more probable that a farm will go out of business than exist as a reduced entity. It is on the basis of these assumptions that the following two rules are adopted in determining the transition of farms from one state to another.

An increase in the number of farms in any state S_i, from one time period to the next, comes from the next smaller state, S_{i-1}. A decrease in the number of farms in any state indicates a movement to S_0, a state of demise. The application of these rules of behavior to the data at hand produces the transition matrix that is utilized below. One advantage of the transition matrix is that it provides useful insights into the movements of farms that are not readily available from other types of projection models.

The Application of Absorbing Chains

In the movement of farms between states discussed above, it was indicated that states S_0 is that state in which all farms that go out of business eventually end up, and the assumption was that they remain there. Such a state in a Markov chain is defined as an absorbing state if it is impossible to leave it. A chain is therefore absorbing if it has at least one absorbing state and from every state it is possible to go to an absorbing state (Kemeny et al., 1962). With one absorbing state in this study, that of going out of business, the model employed here is an absorbing Markov chain. The application of the theory of absorbing Markov chains thus permits one to generate very useful answers to a number of questions (Kemeny et al., 1962; Bartholomew, 1982).

First, what percentage of farms that are in a given state S_i (or size category) are likely to be amalgamated with farms in a larger size category S_j after five years? This question can be answered by examining the coefficients of the transition matrix. Second, for any farm of a particular size, how long is it likely to stay within its size classification before it amalgamates with another? Such a question can be answered from the elements of a fundamental matrix. Thus, the coefficients of this matrix give the mean number of years (of five-year duration) in each transient state for each possible nonabsorbing starting state.

Third, on average, how long does it take before a farm in a given size category is absorbed or goes out of business? The sum of all the entries in a row of the fundamental matrix will give the total length of (five-year) time periods that a farm is likely to survive before going out of business. Fourth, what, in absolute numbers, is the distribution of farms, according to size categories, likely to be in five years, in ten years, or in n years? Or, how many farms in total will there be in five, ten, or n years? Of the two alternative methods for projecting these numbers, use is made of that which multiplies the distribution of farms in the base year, 1978, by the canonical form of the transition matrix P to generate the projected distribution for one period; then the result is postmultiplied by P for the needed number of periods (Krenz 1964). For complete details on the estimation of the fundamental matrix and related statistics, see Kemeny and Snell (1976, pp. 43-50).

Empirical Results

The frequencies used to estimate the transition matrix were derived from the census data of 1978 and 1982, and by the application of the rules stated previously. The particular quality of the Virgin Islands census data dictated that only the data for 1978 and 1982 could be utilized in the generation of the transition

TABLE 7. Projected numbers and distributions of farms, with 1978 as the transition base.

Year	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	Total	De-cline
1978	91	147	54	34	19	8	8	9	3	5	378	
1982	75	114	32	34	18	12	5	6	4	3	303	75
.....												
1987	62	88	19	33	17	16	3	4	5	2	249	54
1992	51	69	11	31	16	19	2	3	5	1	208	41
1997	42	52	7	29	16	23	1	2	5	1	178	30
2002	35	40	4	27	15	26	1	1	6	0	155	23

Note. Data for 1978 and 1982 are actual census data and are included for comparative purposes.

matrix. This in itself is statistically acceptable since the theory indicates that the outcome or form of a given distribution – that of 1982, say – is dependent only on the outcome or distribution of the immediately preceding one – that of 1978 – and that the dependence is the same at all stages (see Judge and Swanson, 1961, p. 2). The transition probabilities shown in Table 5 permit certain insights into the dynamics of farm movements in the Virgin Islands. The matrix reflects many zero elements, an obvious indication of the lack of data on individual farms from one category to another.

Row S_0 suggests that no new farms have been entering farming, according to the assumptions above, and column S_0, an absorbing state, reveals that from all categories except S_4, S_5, S_6, and S_9 farms are going out of business. The principal diagonal contains relatively large coefficients, which tend to indicate a degree of stability in farm size. The nonzero elements in row S_1 signify that approximately 18% of the farms of less than three acres go out of farming in any five-year period. Of this same group, about 82% will remain in the same size category. Similarly, about 35% of the farms in S_3 (10 to 19 acres) are likely to go out of business in a five-year period, about 59% are likely to stay in the same size group, and about 6% are likely to amalgamate with farms in S_4 (20 to 49 acres). None of the farms in S_4, S_5 and S_6, between 20 to 174 acres, is likely to go out of business; in fact, farms in S_6 show total stability. In addition, all farms between 20 and 500 acres show tendencies to expand (with the exception of those in S_6). On the contrary, the largest farms exhibit the greatest inclination to founder: four out of ten farms over 1,000 acres are likely to fail in any five-year period.

The elements of the fundamental matrix permit additional insights into the behavior patterns of farms: they give the mean number of five-year periods in each size category before going out of business, depending on the starting state. Thus, in Table 6, row S_1 indicates that the mean number of years for a farm of less than three acres to exist before going out of business is about 28 (5.69 × 5) years. Similarly, it is about 22 years that farms between 3 and 10 acres will exist before their demise. For farms between 10 and 20 acres, however, the length of time they are likely to stay in that size category is 12 years before being amalgamated with a larger farm. In its higher size classification, it is likely to stay there for about eight years before amalgamating again, and so on. Thus, the total length of time a farm operation is likely to stay in a given category is provided by the sum of elements of the fundamental matrix. These values are shown in the last column (Table 6). Thus, in the long run, farms in S_6 (100 to 174 acres) and S_9 (500 to 999 acres) will, on the average, exist only for five years before going out of business, while those in S_4 (20 to 49 acres) have the longest life, on the average.

The Projection of Farm Unit Numbers

Information on the projected number and distribution of farms is not only important to present farmers, but also to younger people who may be contemplating, or training for farming as a career, as well as to public administrators in the formulation of agricultural policy. It was pointed out previously that the transition matrix, when pre-multiplied by the base year distribution of farms, produces the projection for the following time period. Continual post-multiplication of the results by the transition matrix gives the projections for as many years as desired. The base year selected for projection is that of 1978, and the projected numbers and distributions are shown in Table 7.

The overall pattern of decline recorded earlier is confirmed by the results of this stochastic model. Of the 303 farm units in operation in 1982, only 249 are projected to be in operation by 1987. About 54 of the current ones will probably cease farm operations. As shown, the small farms between 3 and 10 acres will continue to contain the largest absolute number of farms in any size category. However, because the base data show increases in the number of farms between 1978 and 1982 of sizes 175 to 259 acres, and of 500 to 999 acres, these are the only categories in which increases are suggested over the next 20 years. Nevertheless, these increases occur at a decreasing rate over time. By about the year 2000, almost all of the largest farms would have become extinct, and those between 175 and 500 acres would almost all have gone out of existence. Farms below 175 acres in general will tend to have a much longer life and will persist in the system beyond those over 175 acres. If current trends continue, there is likely to be only about 155 farms altogether in the system by the year 2000, a decline from 754 in 1950, and from an all-time (recent) high of 828 in 1940.

Explanation of the Decline in Farm Numbers

The agrarian tradition in the territory of which older Virgin Islanders speak may be traced in recent times to that period around 1933 when the repeal of prohibition in the United States increased the demand for sugar, molasses and rum, and in 1934 when the Federal Government created the Virgin Islands Company to stimulate the economy through the operation of sugar, rum, and hotel businesses. The initial expansion of agricultural activities led to the creation of a large number of farms in 1940, and increases in acreage under the plough reached its zenith in 1950, but the rate of growth was not sustained for long. Not even another breath of life by the Federal Government in 1949 could insure a sustained level of development based on agriculture. Thus was initiated another spiral of decline in this industry which persists to the present. The foregoing analysis addressed several quantitative dimensions of the decline, and in this section, an effort will be made to provide reasonable answers to *why?* this decline has been taking place. In so doing, an examination will be made of the impact of the abandonment of sugar production, the development of tourism, the increase in industrial and commercial activities, the competition from imported foodstuffs, and the effect that policies or actions of government have had.

When in 1949 VICORP was succeeded by VICO without the blessing of Congress in the continuation of rum production, it was left with the unprofitable sugar plantations, hotel and public utilities (Miller, 1979). By 1965, it was clear that the industry was feeling its death throes, since the single sugar mill in St. Croix had been sold by VICORP to a private concern, and the terms of sale required operation only until the end of the 1965-66 crop. At the close of the season, the owner announced that the factory would cease operations due to the substantial losses that were sustained in the previous year. This implied the elimination of the sugar industry involving over 4,000 acres of cane land, 113 farms, and a gross farm return of more than $600,000 in a single year (Blaut et al., 1965).

An alternative for cane farmers proved problematic for two reasons. First, they had little experience with other crops after generations of monocultural sugar production, and many had neither the capital to convert to new crops nor reliable markets for such crops. Second, demand for land for residential uses was so great that much of their land would have been sold for urban uses if the farmers did not have an alternative replacement of their income loss from the extinct cane industry. Even though it was recommended that "sugar be replaced by other agricultural enterprises," and that ". . . every possible step be taken to retain, and reconstruct, the agriculture of St. Croix, provided only that the reconstructed agricultural industry must prove itself profitable" (Blaut et al., 1965), the abandonment of sugar led to a rapid and irreversible change from a predominantly rural, agricultural landscape to an urbanized or suburbanized one. That the number of farms decreased from 501 in 1960 to 466 in 1970 (Table 1), and produced the largest percent change of −54.5% in the study period, and farm acreage dropped from 35,539 to 20,470 acres, a change of −48.2%, are clear indicators that the stage may have been set for an irrevocable decline.

The unprecedented growth of tourism in the 1960s served to impact on agriculture in at least three ways. It created a huge demand for labor, it induced considerable growth in population, and it exerted pressure on the land resource. As the number of tourist facilities increased to accommodate the rising tide of tourists, economic opportunities multiplied and attracted the seasonally employed sugar workers and the unemployed. Given the social stigma that clings tenaciously to farm work throughout the region, many a farm laborer willingly traded his overalls for a bellboy's garb. Not only was income from sugar associated with low-wage employment, tourism was considered prosperous. This led one government official to observe that "income from tourism over the past five years has more than tripled the combined returns from rum and raw sugar production" (Economic Policy Council, 1979).

The construction industry, spurred by the rising need to accommodate tourists, contributed to the decline of agriculture in two ways. In the first place, it too created its own demand for labor, which served to entice labor from farming. Secondly, the demand was met primarily by immigrant labor. The great influx of these workers increased the need for housing so acutely that there was little alternative but to encroach on agricultural land. This was the case in St. Thomas where public housing complexes and an 18-hole golf course and condominium complex speeded the transition from rural to urban uses. In St. Croix, two golf courses had the same effect. Thus the suburbanization that Blaut et al. (1965) advised against became a reality. In lamenting the epitome of this process, one report noted that since the early 1960's, agricultural land on St. Thomas had dwindled to a mere 1,448 acres. It continued: "The encroachment of residential . . . development has brought this about and is worsening the situation . . . The potentials for any large-scale development on St. Thomas are very low" (Virgin Islands Planning Office, 1977).

In view of the limited land resource in the Virgin Islands, it is fair to say that any plan for agriculture would recognize that one is dealing with an irreplaceable natural resource that is not only scarce but expensive. And that once agrarian land is committed to an alternative use, it is extremely improbable that it will ever be reconverted to productive agrarian use. This is perhaps most likely to be so for land that is used for commercial or industrial uses.

While the major inroads into agrarian land use came from tourist facilities and commercial establishments on St. Thomas and St. John, two major industrial complexes characterized the diminution in St. Croix. Despite the fact that some 18,689 acres are in agricultural use there (U.S. Bureau of the Census, 1982), and it still has potential for expansion of farming activities, grave concerns are being expressed about future development. Trends indicate that "St. Croix is showing signs of a pre-industrialization mood, and that agricultural development may fall off through the leasing or sale of large tracts to industrial companies ((Virgin Islands Planning Office, 1977). In St. Thomas, both commercial and business usage exceed the zoned acreage, and in St. Croix, the increasing industrial base—with a possible additional oil refinery—will necessitate a substantial increase in consumption of the once highly productive agricultural land. Consensus for this view is summarized in this statement: "It is government policy which eventually determines where emphasis should be placed. In the Virgin Islands today business and commercial developments are top-tanking with industrial [*sic*] or even above. Agriculture, on the other hand, is ranked lowest in priority" (Virgin Islands Planning Office, 1977).

An additional set of factors which help to explain the decline of agriculture is what McElroy refers to as the "complex of both internal and external forces" (1979). His delineation includes the traditional high volume export-import orientation embedded in the local economy, together with a combination of relative affluence, urbanization and supermarket tastes. The territorial status of the Virgin Islands and its geographic proximity provide relatively easy access to, and penetration by, a volume of comparatively low-cost suppliers of a variety of foodstuffs, including staple items like eggs, chicken, milk, pork, beef and their derivatives, as well as vegetables (fresh, refrigerated and tinned). Despite the fact that there is no commercial production of vegetables in the islands and 99% of the food consumed is imported (Department of Agriculture, 1980), a visiting trade mission found cause to express concern over the lack of consistent marketing practices ranging from quality control through regular delivery and distribution routines (Economic Policy Council, 1979).

Even though an official agricultural policy document does not exist, there is little question that the impact of government action on agriculture in the territory has been considerable. It is also evident, however, that there is no consistency in policy, for while one branch may proclaim the positive steps by the administration to promote agrarian development, another may at the same time deplore its apparent regressive actions.

In reference to the economic policy which contributed to the alienation of prime agrarian tracts after 1966, to heavy industry and ". . . which indirectly spawned widespread suburban sprawl by sponsoring labor-intensive tourism, federal highway construction and laissez-faire finance and realty practices . . .", McElroy (1979) called this an "anti-agricultural policy" that was responsible for the ". . . annual declines recorded in the number of farms in operation and in the amount of acreage under cultivation." While the Department of Agriculture (1980) stated that "the basic mission of agriculture is self-sufficiency in food production," the Economic Policy Council (1979) believed that "there is no chance of the Virgin Islands ever becoming self-sufficient in food." This latter is given credence by the Planning Office's belief that agriculture is lowest among government's priorities.

Varying views of agriculture have been expressed as a "vogue-like preoccupation with self-sufficiency" (McElroy, 1979) and as a sector ". . . of our economy which manages to receive loving remarks, supportive statements and other types of accolades, but little of the money, and less and less active interest on the part of the general populace. Everyone wants the output of the farms, but little of the work involved" (Economic Policy Council, 1979). The Department of Agriculture (1980) records that efforts to revitalize agriculture have intensified because of an increasing dependence on imported food, concerns over energy conservation and competing land use, the emergence of several back-to-the-land subcultures, and a realization that agriculture is an integral component of the territory's economic development. Yet there is an apparent contradiction in the kind of public evidence which

suggests that 91% of Virgin Islanders surveyed feel that it is "important" or "very important" for government to exert efforts to expand agriculture (Mills, 1979), and the conclusion by the Department of Agriculture that very few young people are currently involved in, or entering, farm production (1979). It identified the obstacles in the path of new farmers to be the unavailability of land, inadequate capital, and lack of technological assistance. Padda (1979) also singled out the lack of trained personnel, a shortage of labor, inadequate supplies of water and insufficient marketing facilities as factors that inhibit the development of agriculture and which contribute to its decline. Still, the moribund state of agriculture in the territory cannot be attributed to a lack of effort on the government's behalf as the following evidence indicates.

Existing policy includes the following initiatives taken by government:

1. A sorghum production subsidy in the form of a direct payment of $40.00 per acre to farmers who cultivate land in sorghum;
2. A 95% exemption from real property taxes for land officially certified in use for agriculture;
3. A 90% reduction of tax on income derived from agriculture to any applicant who is certified;
4. The provision of a number of direct services to small farms (like land preparation, fertilizer, seeds, and slips);
5. The enforcement of zoning and building regulations to minimize the relentless pressure from residential and commercial encroachment (Mills, 1983); and
6. The acquisition of land primarily for farming purposes, such as the purchase of the Harvland property for $6.4 million.

In the final analysis, it is patently obvious that, given the overwhelming priority accorded to tourism in the local economy, agriculture in general will never be able to compete as a viable enterprise in the market place in the foreseeable future. Yet this is not to be considered an endorsement of a dirge over agriculture. On the contrary, it is to emphasize that it would be misleading to treat agriculture solely as a business in the market economy. The severely limited land resource dictates that even at the cost of heavy subsidization by both the local government and federal farm programs, agrarian land should be protected from further encroachment by nonfarm uses. The simple view is that land devoted to agriculture is a far more desirable use than the several other competing uses with their potential for closing off the "commons," introducing visual blight, or despoiling the environment.

The frustration of agricultural officials is clear evidence that the existing package of tax incentives, subsidized in-kind services, and input prices are quite inadequate to stave off the continual infringement on agrarian land. It appears that nothing short of a full and conscious policy commitment by the highest levels of government, expressed in deeds and not political rhetoric, regarding the role that agriculture is to perform in the future economy of the Virgin Islands, will arrest the persistent slide that will make agriculture, by the year 2000, a thing of the past. For it is worth repeating that once agricultural land is committed to an alternative use, it is extremely unlikely that it will ever be returned to the productive agricultural domain.

References

1. Bartholomew, D.J. 1982. Stochastic models for social processes. (3rd ed.). New York: John Wiley & Sons.
2. Blalock, Jr., H.M. 1979. Social statistics. New York: McGraw-Hill Book Co.
3. Blaut, J.M., F.X. Mark, and A.E. Dammann. 1965. Report to the Governor of the United States Virgin Islands on the reconstruction of the agriculture economy of St. Croix. Virgin Islands: College of the Virgin Islands, Caribbean Research Institute.
4. Collins, L. 1975. An introduction to the Markov chain analysis. Norwich: University of East Anglia, Geo Abstracts, Ltd.
5. Collins, L., R. Drewett, and R. Fergfuson. 1974. Markov models in geography. The Statistician 23(3/4):179-209.
6. Dovring, F. 1962. Farm size data: Frequency distribution, interpolation, and projection. (Res. Rep. No. AERR-50): Illinois: Agricultural Experimental Station, University of Illinois College of Agriculture.
7. Economic Policy Council. 1979. Economic policy guidelines: Vol. 2, Background narrative. Virgin Islands: Department of Commerce.
8. Judge, G.G., and E.R. Swanson. 1961. Markov chains: Basic concepts and suggested uses in agricultural economics. (Res. Rep. No. AERR-49): Illinois: Agricultural Experimental Station, University of Illinois College of Agriculture.
9. Kemeny, J.G., A. Schleifer, Jr., J.L. Snell, and G.L. Thompson. 1962. Finite mathematics with business applications. New Jersey: Prentice-Hall, Inc.
10. Kemeny, J.C., and J.L. Snell. 1976. Finite Markov chains. New York: Springer-Verlag.
11. Krenz, R.D. 1964. Projection of farm numbers for North Dakota with Markov chains. Journal of Agricultural Economics Research 16(3):77-83.
12. Miller, R.W. 1979. The Virgin Islands Economy. Washington, DC: Office of Territorial Affairs, Department of the Interior.
13. McElroy, J.L. Agricultural policy in a scarce and fragile environment. *In:* D.S. Padda (Ed.), 9th Annual Agriculture and Food Fair of the Virgin Islands, 1979, pp. 17-20. Virgin Islands: V.I. Department of Agriculture and College of the Virgin Islands Cooperative Extension Service.
14. Mills, F.L. 1979. Public evidence for a vigorous agricultural program. *In:* D.S. Padda (Ed.), 9th Annual Agriculture and Food Fair of the Virgin Islands, 1979, pp. 9-11. Virgin Islands: V.I. Department of Agriculture and College of the Virgin Islands Cooperative Extension Service.
15. Mills, F.L. 1983 (May). Land-use change in a microstate: The case of the U.S. Virgin Islands. Paper presented at the meeting of the Caribbean Studies Association, Santo Dominigo, Dominican Republic.
16. Padda, D.S. 1979. Developing a viable agriculture industry in the U.S. Virgin Islands. *In:* D.S. Padda (Ed.) 9th Annual Agriculture and Food Fair of the Virgin Islands, 1979, pp. 24-16. Virgin Islands: Department of Agriculture and College of the Virgin Islands Cooperative Extension Service.
17. U.S. Bureau of the Census. 1961. U.S. Census of Agriculture: 1959. 1(54), Virgin Islands. Washington, DC: U.S. Govt. Printing Office.
18. U.S. Bureau of the Census. 1966. Census of Agriculture: 1966. 1(53), Virgin Islands. Washington, DC: U.S. Govt. Printing Office.
19. U.S. Bureau of the Census. 1972. 1969 Census of Agriculture: 1(53), Virgin Islands. Washington, DC: U.S. Govt. Printing Office.
20. U.S. Bureau of the Census. 1977. 1974 Census of Agriculture: 1(54), Virgin Islands of the United States. Washington, DC: U.S. Govt. Printing Office.
21. U.S. Bureau of the Census. 1980. 1978 Census of Agriculture: 1(54), Virgin Islands of the United States. Washington, DC: U.S. Govt. Printing Office.
22. U.S. Bureau of the Census. 1983. 1982 Census of Agriculture: 1(54), Geographic Area Series, Virgin Islands. Washington, DC: U.S. Govt. Printing Office.
23. Virgin Islands Planning Office. 1977. Land use and housing elements: U.S. Virgin Islands. V.I.: Office of the Governor.