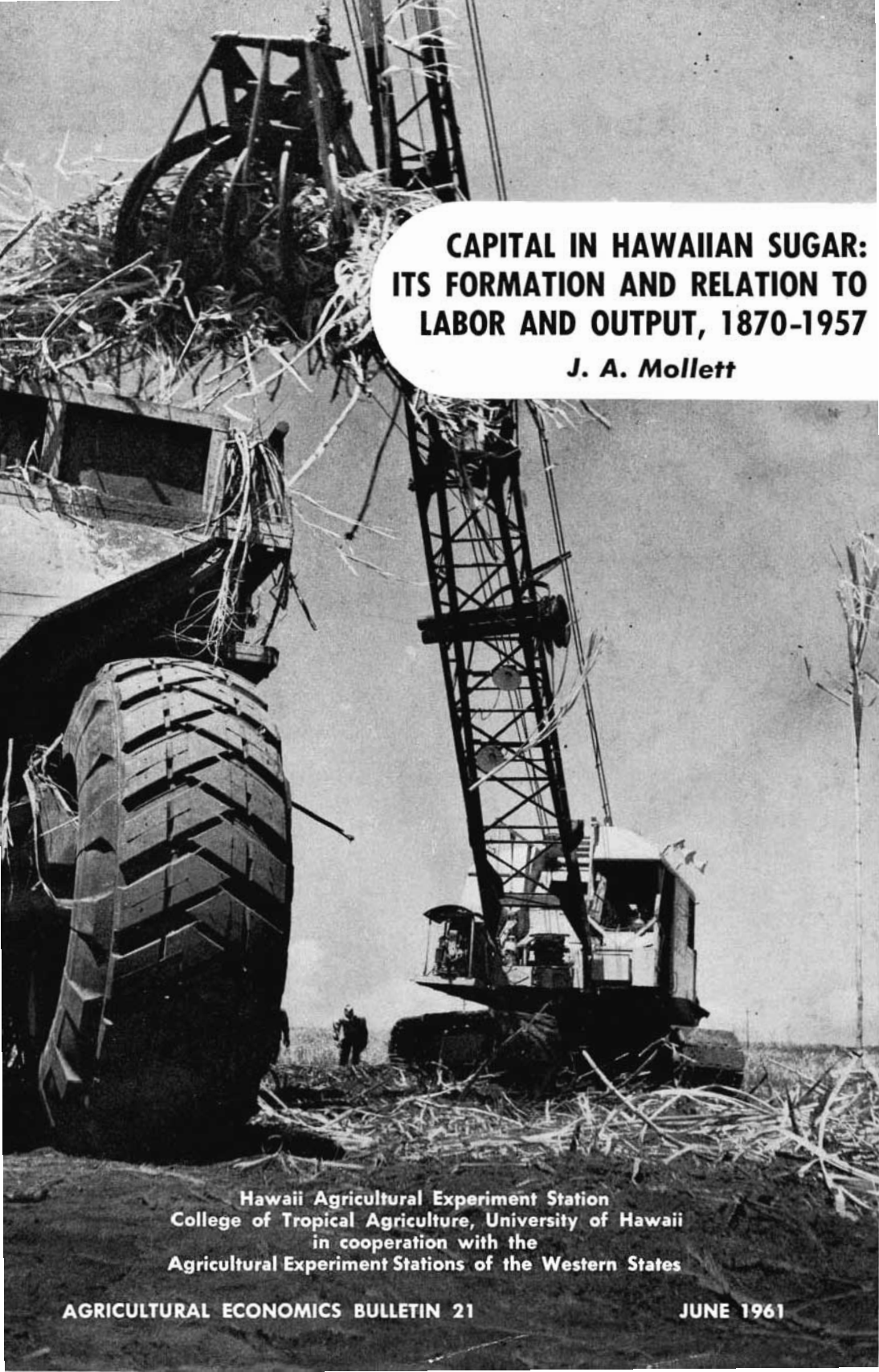

CAPITAL IN HAWAIIAN SUGAR: ITS FORMATION AND RELATION TO LABOR AND OUTPUT, 1870-1957

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College of Tropical Agriculture, University of Hawaii
in cooperation with the
Agricultural Experiment Stations of the Western States

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COVER PHOTOGRAPH: Harvesting cane the modern way.

PREFACE

This publication is the first of a series based on Hawaii's phase of Western Regional Project W-54, "Appraisal of Opportunities for Adjusting Farming to Prospective Markets." The Agricultural Experiment Stations of Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming and the Agricultural Research Service of the U. S. Department of Agriculture are cooperating in conducting various phases of this regional research.

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The author wishes to express appreciation for the valuable assistance of the Hawaiian Sugar Planters' Association and especially of their Treasurer, Mr. T. M. Brown, for providing access to much of the data summarized in this report. The encouragement of Mr. W. M. Bush and Mr. William R. Norwood of Castle & Cooke, Inc., in the early stages of the study should also be mentioned. Mrs. Grace Unemori, Miss Laureen Okamoto, Mr. Jack Rasmussen, and Mr. Dennis Ikehara provided valuable assistance in data collection and analysis. The manuscript was prepared by Mrs. Fukuye Lukela. Professors C. W. Peters (Hawaii), M. R. Benedict (Berkeley), and Boris C. Swerling (Stanford) reviewed the manuscript and made a number of constructive suggestions for its improvement.

The photographs were kindly supplied by the Hawaiian Sugar Planters' Association. The charts were drawn by Mr. Francis H. Hirashiki of the Hawaii Cooperative Extension Service.

SUMMARY

The main object of this study is to trace the growth of capital on sugar plantations in Hawaii from 1870 to 1957. Capital growth is related to numbers of workers employed and to net output in order to obtain ratios of capital to output and capital to labor.

"Real" or physical capital is divided into 10 major types: (1) land, (2) manufacturing, (3) unharvested crops, (4) irrigation, (5) land improvement (other), (6) machines and implements, (7) horses and mules, (8) buildings, (9) social, and (10) miscellaneous.

Physical capital is expressed in constant dollars (1910–14) and in current dollars.

A brief review of the development of Hawaii's sugar industry precedes the main discussion on capital and its relationship to labor and output.

The value of physical capital (including land) in Hawaiian sugar rose abruptly from $2.7 million in 1870 to $28.0 million in 1890, to $87.9 million in 1910, and to a peak of $105.5 million in 1930 (all values expressed in 1910–14 dollars, unless stated otherwise). This upward movement was reversed in the 1930's as capital decreased by $13.5 million ($92.0 million in 1940) and by another $9.6 million in the 1940's ($82.4 million in 1950). The trend was upwards between 1950 and 1957 (1945 was the turning point). In these final 8 years capital rose by $2.5 million to a total of $84.9 million in 1957.

The number of plantations fell from 73 in 1890 (only 20 in 1870) to 27 in 1957. Average size of a plantation increased from 425 acres (in sugar) in 1870 to 8,198 acres in 1957. Average amount of physical capital per plantation rose from $133,000 in 1870 (including land) to $3,142,700 in 1957.

Composition of physical capital altered considerably between 1870 and 1957. Most noticeable changes were the replacement of horses and mules by power-operated equipment, a substantial increase in the social capital (workers' houses, recreational facilities), and a decline in capital invested in irrigation (beginning around 1930) accompanied by a rise in value of other land improvements. Qualitative improvements amongst the different categories of capital were especially significant in manufacturing facilities and implements and machinery. These improvements were labor-saving or capital-saving, or both.

A capital-output ratio expresses the average productivity of capital. It shows how many units of capital are needed to produce 1 unit of output (not 1 extra unit). The capital-output ratio in Hawaiian sugar was 3.80 in 1870 and (almost) half this figure—1.92—in 1957 (including land). This remarkable change in the average productivity of capital was attributable to several factors. Among the more important were the close integration of plantations with their own experiment station, the contribution of research workers at the Hawaii Agricultural Experiment Station, and the recruitment of enterprising managers from mainland agriculture. Early and widespread application of new technologies resulted from these factors. Favorable U. S. tariff policy towards Hawaiian sugar production provided plantation owners with ample funds to invest in improvements.

Only at one period, around 1920, was the declining trend in capital-output ratio halted (3.31 in 1920, compared with 2.70 in 1910).

Trends in the ratio of selected categories of capital to output are examined.

A sixfold increase in the quantity of capital per worker (including land) took place in Hawaiian sugar between 1870 and 1957. Assets per worker increased at varying rates, decade by decade, from 7.1 percent (1890–1900) to 64.1 percent (1940–50). They decreased only in one decade (1920–30, by 7.4 percent). If a standardized work year of 2,000 hours is used, capital per worker (2,000 hours) increased almost tenfold during the 88-year period reviewed.

Striking changes in output per man accompanied these different levels of investment. The relevant figures are $139 (1870), $341 (1900), $612 (1930), $857 (1940), $1,742 (1950), and $2,676 (1957) — assuming a constant work year of 2,000 hours.

Fewer workers, higher yields of sugar, and improved technology (in existence at the pilot stage) imply that capital per worker will continue to rise.

The total quantity of capital (in constant terms) seems likely to remain fairly constant or to show a slow decline. No very marked changes are expected in the composition of physical capital.

The study ends with a short review of the financing of Hawaiian sugar. It concludes that the industry has been able to finance not only itself but to invest relatively large amounts in other domestic and foreign enterprises.

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CAPITAL IN HAWAIIAN SUGAR: ITS FORMATION AND RELATION TO LABOR AND OUTPUT, 1870–1957

J. A. Mollett[1]

INTRODUCTION

Purpose and Scope

The main object of this study is to trace the growth of capital employed on sugar plantations in Hawaii from 1870 to 1957. The relationship of capital to output and to labor employed on plantations is also an important feature of this work. Past, present, and possible future trends in these important and dynamic relationships are examined. Sugar production in this 88-year period rose very rapidly from a relatively minor industry to Hawaii's predominant industry. Growth in the importance of sugar, dramatically increasing in the 1880's and 1890's and sustained in this century, has had its counterpart in growth of capital invested in plantations.

Attention is focused on "real" or physical capital used in sugar production. Capital as used in this study does not include financial holdings of sugar companies or capital invested by them in any nonfarming activity.

This study attempts to measure physical relationships between "real" capital, output, and labor by converting all measurements (except hours of work) to constant dollars. Physical capital used on sugar plantations is divided into 10 major types: (1) land, (2) manufacturing, (3) unharvested crops, (4) irrigation, (5) land improvement, (6) machines and implements, (7) horses and mules, (8) buildings, (9) social, and (10) miscellaneous. These headings are largely self-explanatory.

[1] Assistant Agricultural Economist, Hawaii Agricultural Experiment Station, and Assistant Professor, College of Tropical Agriculture, University of Hawaii.

Land is included as a category of capital although traditionally it has been classified as a separate factor of production. This item is "unimproved land," mostly as man found it. It is obviously different from the other nine categories of capital which are either man-made or reproducible. It is included to complete the total of investment in Hawaiian sugar production.

Manufacturing includes mill buildings, mill machinery, light and power stations, cane-cleaning plant, molasses plant, and research laboratories. Unharvested crops usually cover about one-half of the area of land in Hawaiian sugar production. Their value reflects the amount of labor, fertilizer, water, herbicides, and other inputs expended on them. Irrigation, (other) land improvement, and buildings, although considered separately, could perhaps be placed in one group with the heading "land improvement."

Investment in the "social" category includes such items as plantation workers' houses, hospitals and hospital equipment, playgrounds, recreational buildings, and band equipment. Items not included under the first nine headings are listed under the "miscellaneous" heading. It includes a wide assortment of assets: stocks on hand, wharves, sea walls, dredging equipment, maps, forests, fisheries, and dairies.

The general outline of this study follows closely a similar but much more comprehensive study of United States agriculture by Dr. Alvin S. Tostlebe entitled *Capital in Agriculture: Its Formation and Financing Since 1870* (a study by the National Bureau of Economic Research, New York, published by Princeton University Press, 1957).

Tostlebe's study covers the 81-year period from 1870 to 1950. Wherever possible, methods of analysis used in Tostlebe's work have been employed in this study. This should make possible valid comparisons in capital growth between United States (mainland) agriculture, the 10 "type of farming regions" into which Tostlebe divides the United States, and Hawaii's sugar plantations.

While changes in real capital and related changes in output and numbers of workers on plantations are the main part of this study, attention is also given to the factors which determined these changes. The significance of these factors for the future is also reviewed.

No detailed analysis is made of the source of financing which made investment in Hawaiian sugar possible but some attention is given to this important subject (worthy of a separate inquiry).

It should be stressed at this early stage that attention is focused on *net* capital formation. Cost of replacing existing capital through depreciation reserves is not considered.

Sources of Data

The main source of information about physical capital was the detailed financial records of sugar plantations. These records differ in the amount and type of data supplied but generally they are very comprehensive. They contrast sharply with the rather meager financial data obtainable from other types of farming (until fairly recently). Annual plantation statements supply information not only about income, the balance sheet, "other investments," a statement of lands owned or leased, "property, plant and equipment," an analysis of operating expenses and crop costs, but also about rainfall, electric power generated, and number of millions of gallons of water pumped.

This source provided adequate data for the period from 1900 to 1957. Financial records were less complete for the three decades between 1870 and 1900. Supplementary information was collected from early surveys of Hawaii's developing sugar industry and census returns for that period.

Information relating to the number of workers employed in sugar production in Hawaii and to output of sugar was obtained primarily from the Hawaiian Sugar Planters' Association. Additional data relating to labor were obtained from the series of 5-year reports on labor conditions in Hawaii prepared from 1900 onwards by the United States Commissioner of Labor.

Measurement of output in "net" terms, excluding purchases from other sectors of the economy, was made possible by using data contained in the income statements of plantations.

Sources of data are of course given in detail throughout the text of this study. Only the main sources are listed here.

Methods of Adjusting for Price Changes

Money cannot be used as a measure of physical volume in any perceptible time period if its value changes. For this reason physical capital employed in Hawaiian sugar production from 1870 to 1957 has been expressed in terms of constant dollars. Wherever possible, the quantity of physical units of a particular capital item on plantations every tenth year has simply been multiplied by an average 1910–14 price. If the number of units was not known, then constant price values were obtained by dividing current values (as shown in plantation balance sheets) by an index (1910–14) of prices paid for the relevant items. Price deflators used for the various categories of capital are given in table 4 (page 25).

Limitations of Data

The limitations of data used in this study are not very numerous or too important. The wealth of detail contained in plantations' annual inventories

and the inclusiveness of these data covering almost all plantations back to 1900, at least, provide the basis for this statement. Data relating to capital growth in the dynamic period between 1870 and 1900 were more difficult to collect than for later years but the quality of their sources suggests that they should be reasonably accurate. Careful compilation of sugar production and of the number of workers employed on plantations by the Hawaiian Sugar Planters' Association provides good figures needed for the important capital-output ratios and capital-labor ratios.

A weakness does arise, however, in the attempt to measure growth in physical capital by adjusting for price changes. If all the various capital items could have been neatly placed in categories and counted in units, decade by decade, then this problem would not have arisen. With land, for example, it does not arise. To measure change in land investment (unimproved land), acres in sugar at 10-year intervals were simply multiplied by an average 1910–14 land price. Mules could be counted at each census period and valued in constant terms. But few other capital items could be treated in this way. Information was not always available as to the number of physical units (tractors, for instance) used at each census date. Also, while unimproved land and mules remained constant in terms of quality in the period under review, this cannot be said for such items as machines and implements. Improvement in quality of machines and innovations in kinds of machines make it difficult to state accurately current values in terms of constant price values. This trend towards capital-saving equipment (relatively cheaper) is to some extent counterbalanced by improvement in quality of raw sugar which is not reflected in the output figures.

Another limitation of the attempt to measure growth of physical capital in terms of constant dollars is that the selection of the price base has an influence on this measurement. Values of physical capital are calculated in terms of 1910–14 prices in this (and Tostlebe's) study. Would the rate of capital development have been different if measured in terms of 1960 dollars or 1950 dollars? Tostlebe found that, for United States agriculture, capital growth was very similar measured in 1910–14, 1929, and 1950 prices. His study showed that it was unlikely that any substantially different conclusions would have been reached if an alternative price base were used. These findings have been accepted in the preparation of this report.

A BRIEF REVIEW OF THE DEVELOPMENT OF HAWAII'S SUGAR INDUSTRY

Some understanding of the development of the sugar industry in Hawaii is a necessary prelude to this study on capital growth. The development of Hawaii's chief industry has been closely related to United States tariff policy

and related political activity. Its first important impetus came in the Civil War period when the price of raw sugar went up from 4 cents per pound in 1861 to 25 cents per pound in 1864. Sugar exports from Hawaii to the United States mounted from a mere 572 tons in 1861 to 8,865 tons in 1864 and continued to expand. Decline in the importance of whaling in the Pacific during the late 1860's and 1870's was another stimulant. It had caused Honolulu merchants and bankers to seek new outlets for their activities. Provisioning the whaling trade had provided Honolulu with a major part of its income. Sugar seemed to provide a suitable alternative outlet for local investment.

As the nearest sugar cane-growing area to the developing Pacific Coast region, Hawaii had a distinct advantage over its competitors. Between 1865 and 1875, investment in local sugar production continued at a relatively rapid pace. Considerable progress was made in mill practices (grinding cane to obtain raw sugar). Iron replaced cumbersome wooden mills. Steam replaced animal power. Annual output of raw sugar rose to 9,600 tons in 1870 and to 12,900 by 1875.

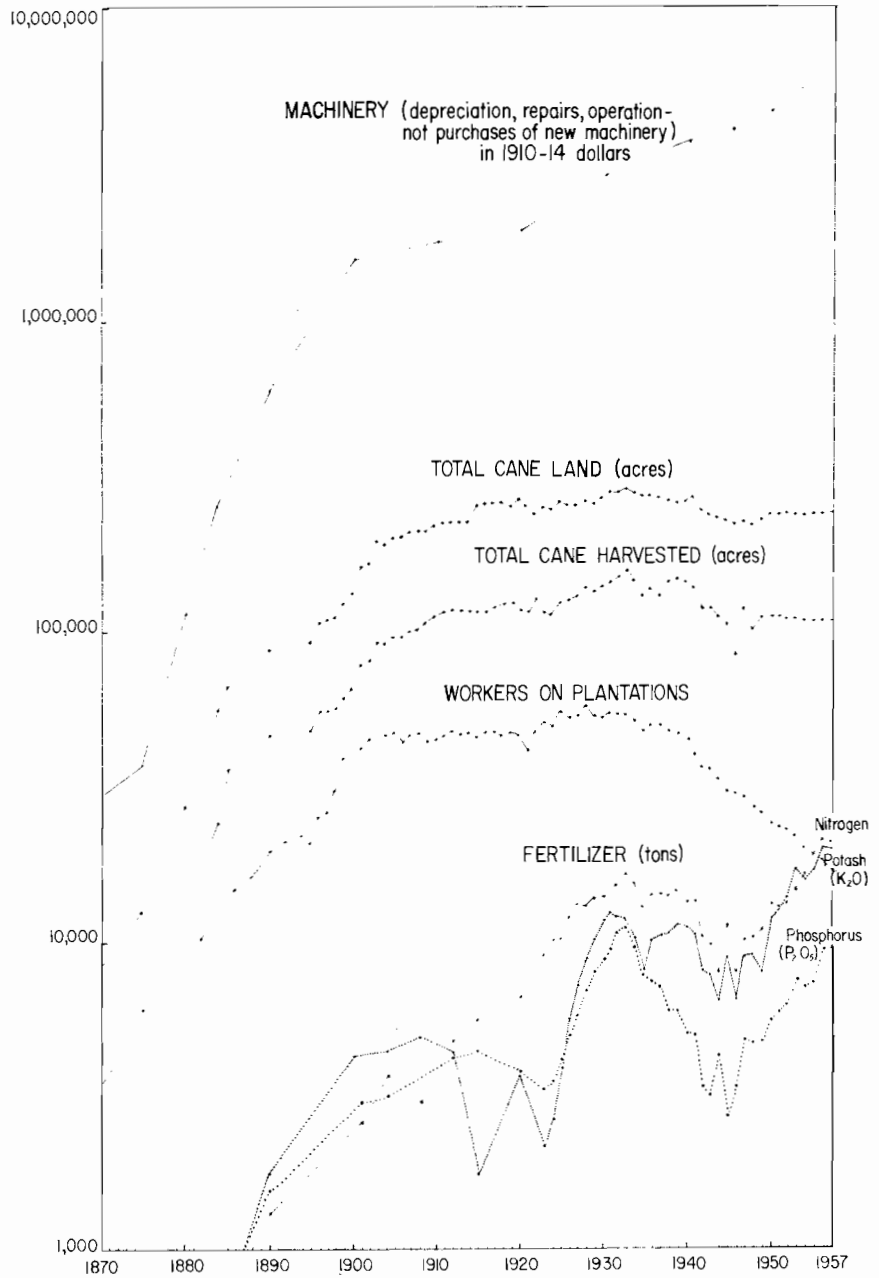
This early stage of development ended in 1875 with the passage in Congress of the Reciprocity Treaty between Hawaii and the United States. Among its several provisions, this Treaty provided for the entry of duty-free Hawaiian sugar to the markets of the United States. Fear that Great Britain would acquire the Islands had provided the chief political motive for this Treaty so favorable to Hawaii's sugar interests. Duty paid on Hawaiian sugar entering the United States ranged from 2¼ to 2¾ cents per pound at the time of the Treaty. The immediate outcome was the cancellation of this duty. In effect, the United States gave Hawaiian sugar producers a bounty of about 2 cents a pound.

The impact of such a drastic change in the fortunes of sugar growers in Hawaii was dramatic and immediate. Capital poured into the industry, land was cleared, irrigation was developed, and workers began to stream in from foreign (mainly Asian) countries. Output rose and profits were lucrative. Figures 1 and 2 indicate some of these dramatic changes. Annual production increased from 12,900 tons in 1875 to 32,600 tons in 1880, to 133,310 tons in 1890, and to 297,000 tons in 1900. The number of workers on plantations rose from 3,260 to 37,760 in this period (1875–1900). Land in sugar increased tenfold from 12,000 acres in 1875 to 128,000 acres in 1900.

One student of the period noted that "so great were the profits that all problems of capital scarcity disappeared. The development of the Hawaiian sugar industry after 1875 was largely through capital of its own creation."[2]

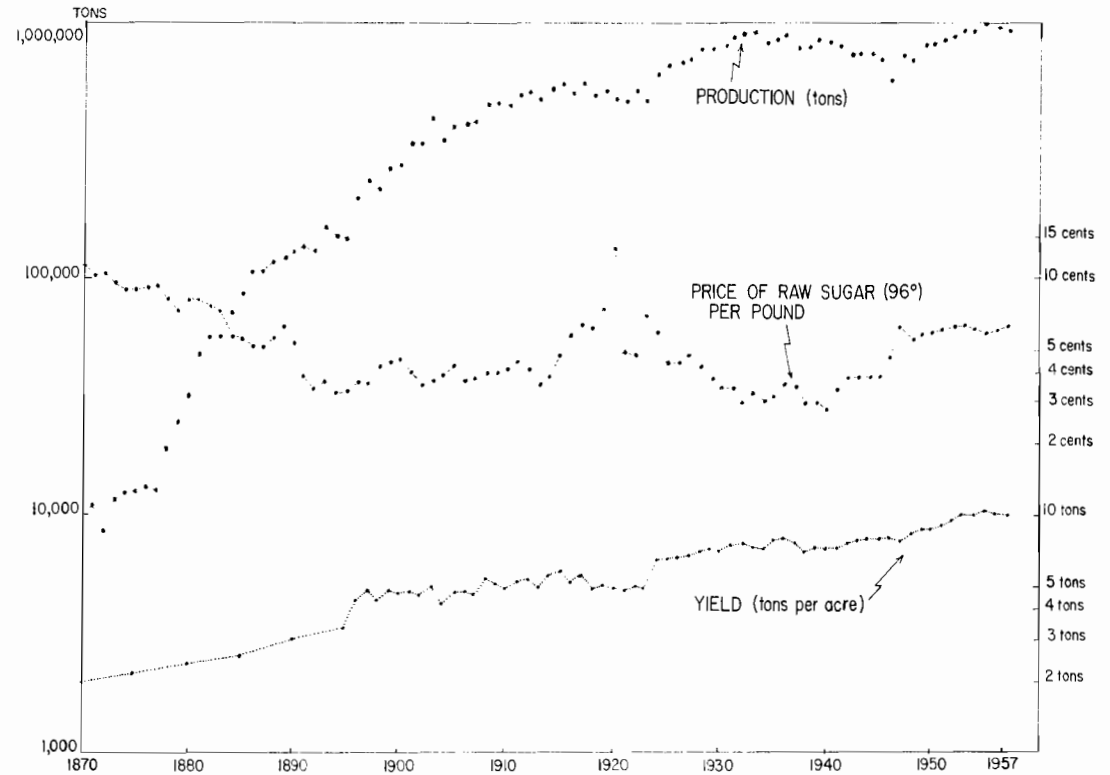
[2] William H. Taylor, *The Hawaiian Sugar Industry,* Dissertation, University of California, 1935, p. 16.

FIGURE 1. Trends in selected inputs used in Hawaiian sugar production, 1870–1957.



Source: Hawaiian Sugar Planters' Association. Financial records of plantations.

FIGURE 2. Trends in production, yields per acre, and price per pound of raw sugar (96°), Hawaiian sugar plantations, 1870–1957.



Source: Hawaiian Sugar Planters' Association.

A temporary setback to Hawaii's boom in sugar came with the passage of the McKinley Tariff Act in 1890. Congress allowed for the free entry of sugar into the United States in that Act forcing Hawaii, once again, into direct competition with Cuba, Java, and Brazil. Drastic falls in the price of sugar occurred. The 1890 Act was succeeded in 1894 by another act which imposed a 40 percent ad valorem duty on foreign sugar and placed Hawaii in a favored position once again through the Reciprocity Treaty.

The McKinley Act had far-reaching significance for Hawaiian sugar interests. First, it spurred their attempts, eventually successful in 1898, to have Hawaii annexed by the United States. (As Hawaii was a foreign country *de jure* [in 1880–84], its sugar producers could not receive the bounty of 2 cents per pound received by domestic sugar growers. A bounty, incidentally, designed to encourage an infant sugar beet industry.) Secondly, the relatively short period when the McKinley Act was in effect was one of intensive competition with other countries for the United States market. It forced an improvement in methods of cultivation and manufacturing in Hawaii, led to the establishment of a privately-operated sugar experiment station[3] and, importantly, increased concentration of economic and financial control in agencies located in Honolulu which handled the marketing of sugar and the purchasing of supplies for the plantations.

The Hawaiian Sugar Planters' Association was founded in 1895; from then onwards the industry became closely integrated in the production, marketing, and, later, refining of its sugar. Hawaii had become overwhelmingly dependent on sugar by the turn of the last century. Sugar exports from Hawaii in 1897, for example, amounted to $15.4 million out of an export total of $16.2 million.

Annexation to the United States in 1898 provided an additional stimulus to local sugar growers. Relatively great developments took place in irrigation; scientific investigation and management became firmly established. The number of plantations, which had risen sharply around 1875 (from 20 in 1870 to 73 in 1890), began to decline as plantations were amalgamated to form larger units under the control of the agencies.

Figures 1 and 2 show the extent of the changes in selected inputs (land, labor, fertilizer, machinery), raw sugar prices, sugar yields, and production

[3] A. R. Grammar, "A History of the Experiment Station of the Hawaiian Sugar Planters' Association 1895–1945," Reprint from *The Hawaiian Planters' Record*, Vol. LI, Nos. 3 and 4, 1947, pp. 177–228. It is interesting to note that one of the first actions of the Louisiana Sugar Planters' Association was also the formation of a privately-operated Sugar Experiment Station in 1885 (now a part of Louisiana State University).

J. Carlyle Sitterson, *Sugar Country—The Cane Sugar Industry in the South, 1753–1950*, University of Kentucky Press, 1953, p. 255.

between 1870 and 1957. Land in sugar reached its peak in 1932 with 254,600 acres in the crop. This area gradually declined to 221,300 acres in 1957. Workers on plantations increased from 8,400 in 1880 to 44,270 in 1910 and to a peak of 56,600 in 1927.

Hawaii's sugar industry employed only 16,800 workers in 1957. This sharp drop in employment amounting to 40,000 workers since the peak year of 1927 and its relationship to output and capital are discussed later. These movements in inputs of land and labor were not accompanied by similar movements in the application of machinery, water, fertilizers, and new technology. Land became more intensively used. The work of the experiment station of the Hawaiian Sugar Planters' Association led to improved methods of cultivation and harvesting, irrigation, and disease control. Better varieties of cane were introduced, resulting in much higher yields. Tons of sugar per harvested acre (sugar is a 2-year crop in Hawaii) rose from 3.27 in 1895 to 5.16 in 1910, to 7.43 in 1930, and to 10.16 in 1957.

Higher yields from around 1910 onwards on a land area covering between 220,000 to 255,000 acres, caused Hawaiian sugar production to be increased from half a million tons to just over 1 million tons in the early 1930's. More output then became increasingly difficult as a result of a scarcity of suitable land, restrictions of known water resources, technological difficulties, and rising costs of extending the intensive margin of cultivation. Sugar prices (except in 1920) in real terms were never again to become as attractive as in the lucrative 30 to 40 years following the Reciprocity Treaty.

Changes in the United States tariff structure which had originally stimulated the growth of Hawaii's sugar industry also played an important role in the great expansion in production from around 600,000 tons in 1920 to 1 million tons in 1930. This expansion largely resulted from increases in the U. S. tariff on Cuban sugar (up from 1 cent to 1.60 cents per pound in 1921, to 1.76 cents in 1922, and to 2 cents in 1930). Hawaii, Puerto Rico, and the Philippines, then classified as U. S. offshore areas, gained at the expense of Cuba. Higher tariffs placed these three areas in a stronger competitive position. Cuba, which had supplied almost half the sugar used in the United States from 1902 to 1929, found its portion down to 30 percent in 1930–33. In contrast, Hawaii, the Philippines, and Puerto Rico increased their share of the U. S. market to 45 percent from a 25 percent share between 1902 and 1929.

The net effect of higher tariffs was described by the U. S. Department of Agriculture as bringing "greater overproduction in the domestic areas and ever increasing depression in the world market. Imports from Cuba were cut in half and the Cuban price fell below 1 cent per pound. Economic ruin and political revolution were the consequences. By 1933 it had become evident

that the tariff was no longer adequate to insure either a healthy domestic industry or a dependable source of foreign supplies."[4]

Some governmental control over supply, other than tariffs, was considered necessary. The Jones-Costigan Act of 1934[5] and a series of Sugar Acts (1937, 1948, 1956) met this need. These Acts, while varying in detail, had three common features: (1) the U. S. market was allocated among continental, offshore, and foreign areas in relation to estimates of U. S. consumption of sugar; (2) sugar producers in domestic areas were offered a compliance payment for keeping within their quotas and meeting certain minimum conditions of pay and employment for sugar workers; (3) sugar producers in domestic areas also generally received a quota premium arising from the difference between U. S. sugar prices and "world" sugar prices.

A processing tax (1934–36) and later an excise tax (since 1937) on domestically consumed sugar paid for compliance payments. There is little evidence that the excise tax raised the price to consumers.[6] Related reciprocal reductions in tariff helped to keep consumer prices down. The part of the tax money collected on domestically grown sugar (including Hawaii) came mostly out of producers' incomes and was returned to them as a *quid pro quo* for compliance with the program.

Hawaii's first quota under the 1934 Jones-Costigan Act was 14.15 percent (916,550 tons) of total U. S. supplies. The territory's quota was 8.3 percent (15,782 tons) below "average quantities imported in the most representative years of the period 1925–33." Since that time, quota restrictions have not too seriously interfered with sugar output in Hawaii. The situation has not been so acutely unfavorable in Hawaii as in other regions since production had already become fairly well stabilized. Labor difficulties, economic pressure on marginal plantations, and alternative opportunities for investment have led in several years since 1934 to production being less than the quota (rising in absolute terms). This situation has made it unnecessary to establish detailed regulations on proportionate shares for sugar producers in Hawaii since quota legislation has been in effect.

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[4] U. S. Production and Marketing Administration, *Sugar Reports,* No. 11, June 27, 1951, p. 2.

[5] This Act provided for adjusting sugar supplies to consumption requirements by establishing quotas; adjusting sugar production in the various areas within the quotas; and, financing this program through a processing tax on sugar of one-half cent a pound. The production adjustment and processing tax phases of this program were terminated as a result of the Supreme Court decision on January 6, 1936, in the Hoosac-Mills case (which liquidated other Agricultural Adjustment measures). However, the quota provisions of the Jones-Costigan Act were unaffected by the decisions and Congress ratified them by Public Resolution No. 109, 74th Congress.

[6] See Murray R. Benedict and Oscar C. Stine, *The Agricultural Commodity Programs—Two Decades of Experience,* The Twentieth Century Fund, New York, 1956. Ch. 7, "Sugar," pp. 280–328.

A detailed description of the operation of plantations and their agencies is not given in this brief review of the industry.[7] At present, five agencies and one trust company handle all financial, shipping, and merchandising matters for the plantations. The current location of sugar plantations on the four islands of Kauai, Oahu (on which Honolulu is situated), Maui, and Hawaii is shown in figure 3. In addition to 27 plantations with 219,000 acres, some 20,000 acres are cultivated by 1,250 independent growers and adherent planters. These growers cultivate small areas of land which are not usually suitable to put under direct management of a plantation. Contractual arrangements between these growers and the plantations vary in accordance with local conditions. Management decisions are made by the individual growers. This independence (from plantations) is mandatory if the highest rates of compliance payment for small sugar growers is desired. Sugar harvested from the small plots is included in the respective plantation's total production. Roughly half the land used by independent planters is leased to them by the plantations, the rest is planter-owned or leased from outside sources. Most planters are located on unirrigated plantations on the island of Hawaii.

The relative importance of Hawaii's sugar industry has inevitably declined from its supreme position in the closing decades of last century. Military expenditure has assumed the prominent role in the Islands' income pattern. Sugar comes second, followed closely by pineapple and tourism. In 1957, the relevant income figures were $308 million from military expenditure, $146 million from sugar, $110 million from pineapple, and $80 million from the tourist industry. The value of marketings from other sectors of Hawaii's agricultural industry amounted to $41 million, or 13.9 percent, of total marketings. Sugar used 221,000 acres in 1957, followed by pineapple with 76,700 acres and nonplantation crops (vegetables, fruits, coffee, macadamia nuts, rice, taro) with 16,400 acres. Some 1,008,000 acres were used for grazing beef cattle and a few sheep.

Hawaii's population has increased more than fourfold since 1900, from 154,000 to 635,000 in 1958. The population has become highly urbanized. In 1900, about three-fourths lived in rural areas or in small plantation towns. Most island residents were dependent on sugar for employment and income. By 1930, Hawaii's population had risen to 368,000 and the urban trend had become established. Sugar employed 52,000 workers and the population of

[7] For a detailed description see: James H. Shoemaker, *Labor in the Territory of Hawaii,* 1939, House Document No. 848, 76th Congress, 3rd Session, Washington, D. C., June 1939, pp. 13–35.

Sugar in Hawaii: The Story of Sugar Plantations, Their History, Their Methods of Operation and Their Place in the Economy of Hawaii, Hawaiian Sugar Planters' Association, Honolulu, 1949, 96 pp.

John W. Vandercook, *King Cane: The Story of Sugar in Hawaii,* Harper & Brothers, New York, 1939, 192 pp.

William H. Taylor, *op. cit.,* pp. 34–61.

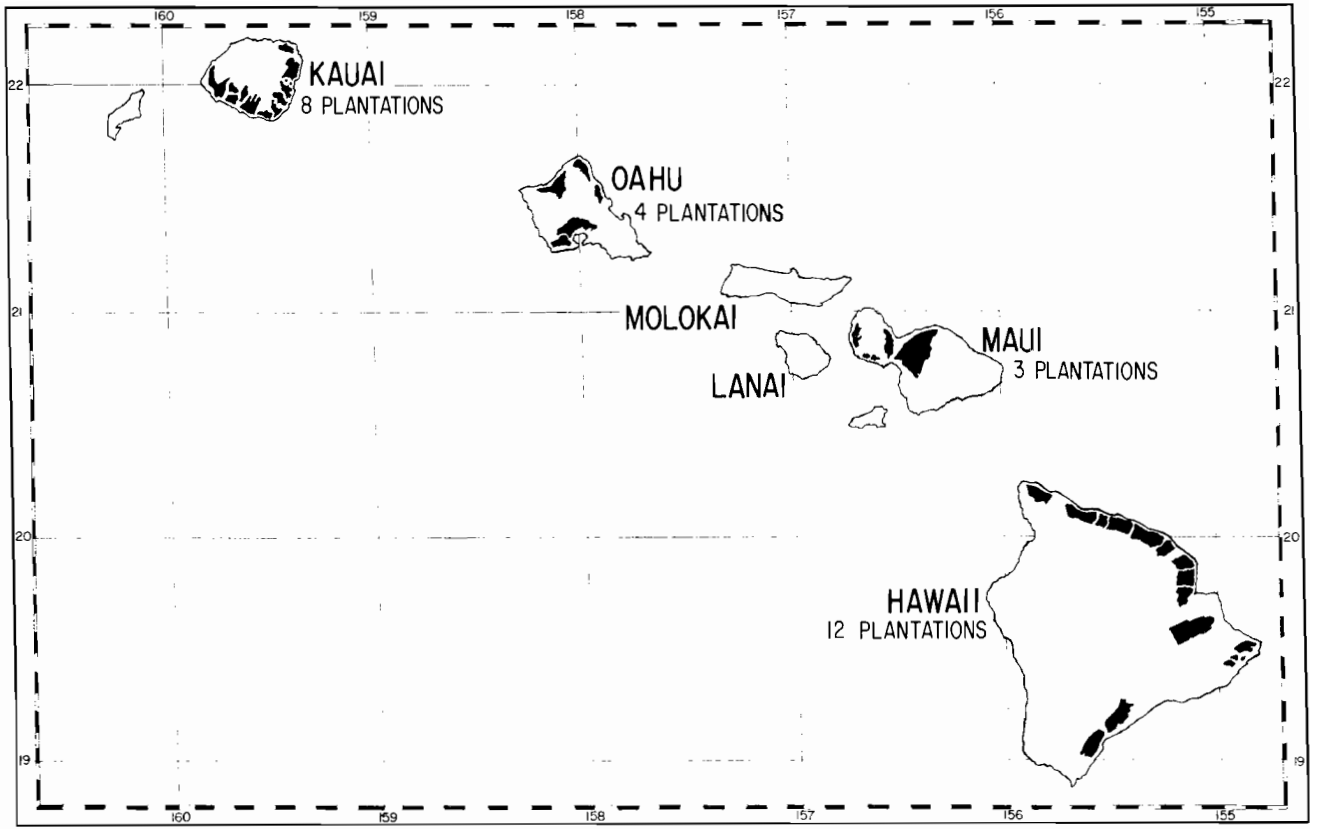


FIGURE 3. Location of 27 Hawaiian sugar plantations, 1957.

sugar plantation towns was estimated at 110,000. Since then, output has been maintained while the number of workers in sugar had dropped to 17,000 [14,150 in 1960] and population in plantation towns had fallen to 34,000 by 1957.

PHYSICAL CAPITAL IN HAWAIIAN SUGAR, 1870–1957

The changes which took place in the amount and composition of physical capital in Hawaiian sugar production between 1870 and 1957 are examined in three periods. The first period, from 1870 to 1900, covers the initial phase of tremendous growth; the second period, from 1900 to 1930, covers a time of continued but uneven and much slower expansion in physical capital; the last period, from 1930 to 1957, deals with a different situation from the other two, for during its greater part the value of physical capital (measured in constant dollars) declined.

1870–1900

The value of physical capital (excluding land)[8] in Hawaiian sugar, expressed in 1910–14 dollars, rose abruptly from $1.4 million in 1870 to $4.5 million in 1880, to $14.7 million in 1890, and again up sharply to $40.2 million in 1900. Table 1 shows these changes together with information about the changing composition of physical capital. Land in constant terms rose from $1.3 million in 1870 to $19.5 million in 1900.

Absolute and percentage changes in physical capital are shown in table 2 for the entire period under review, 1870–1957. This table shows that between 1870 and 1880, physical capital increased by $3.1 million, or 227 percent; by $10.2 million, or 228 percent, in the following decade; and by as much as $25.6 million, or 175 percent, between 1890 and 1900.

Changes in value of physical capital expressed in current dollars are shown in table 3. The value of capital (current prices) amounted to $1.7 million in 1870, $5.0 million in 1880, $14.2 million in 1890, and $35.6 million in 1900.

Land (valued in its unimproved condition) represented 49 percent of total investment in 1870, 47 percent in 1880, 48 percent in 1890, and 33 percent in 1900. The decline in relative significance of land between 1890 and 1900 is an indication of the rise in the importance of reproducible capital (figure 4).

[8] Unless otherwise stated, the term "physical capital" in the remainder of this text excludes land.

TABLE 1. Physical capital (including land) used in Hawaiian sugar production, value in 1910–14 dollars, 1870–1957

PHYSICAL CAPITAL	1870	1880	1890	1900	1910	1920	1930	1940	1945	1950	1957
	Thousand dollars										
Land	1,297	3,966	13,347	19,525	32,691	36,077	38,369	35,864	32,236	33,617	33,763
Manufacturing	520	1,725	5,660	12,617	15,510	13,966	18,848	16,801	10,956	11,724	13,772
Unharvested crops	400	1,311	4,100	9,439	17,127	20,828	19,283	16,651	16,422	18,723	19,333
Irrigation	100	350	2,000	10,473	12,549	10,096	12,818	8,139	5,770	4,721	4,915
Land improvement	70	260	495	1,050	1,243	1,084	2,461	2,479	1,941	3,216	4,668
Machinery, implements	125	402	970	1,784	2,498	3,129	3,201	2,728	3,493	4,421	3,884
Horses, mules	55	105	430	791	1,212	1,477	1,016	504	254	52	35
Buildings	80	272	800	2,576	3,152	4,818	5,939	5,011	2,385	2,073	2,054
Social	*	*	*	192	518	646	1,672	2,124	1,604	2,822	1,638
Miscellaneous	13	36	198	1,301	1,408	1,375	1,940	1,675	1,020	1,068	791
Total	2,660	8,427	28,000	59,748	87,908	93,496	105,547	91,976	76,081	82,437	84,853

* Negligible.
Source: Financial records of sugar plantations. Current values adjusted by price deflators given in table 4, page 25.

TABLE 2. Absolute and percentage changes in physical capital (excluding land) used in Hawaiian sugar production, value in 1910–14 dollars, 1870–1957

YEAR	TOTAL PHYSICAL CAPITAL (EXCLUDING LAND)	CHANGE BY DECADES*	
		Absolute	Percent
	1910–14 dollars (1,000)	*1910–14 dollars (1,000)*	
1870	1,363	–	–
1880	4,461	3,098	227
1890	14,653	10,192	228
1900	40,223	25,570	175
1910	55,217	14,994	37
1920	57,419	2,202	4
1930	67,178	9,759	17
1940	56,112	—11,066	—16
1950	48,820	—7,292	—13
1957	51,090	2,270	5

* Except between 1950–57, an 8-year period.
Source: Derived from data given in table 1.

Investment in manufacturing facilities to convert cane to raw sugar was the largest single item of reproducible or physical capital in 1870. It accounted for 38 percent of capital. Comparable figures for 1880, 1890, and 1900 were 39 percent, 39 percent, and 31 percent, respectively.

The next largest item of investment was unharvested crops—29 percent of total capital in 1870. Machinery and implements (9 percent) were next, followed by irrigation (7 percent), buildings (6 percent), other land improvement (5 percent), and horses and mules (4 percent). Distribution of investment changed considerably by 1900 (figure 4). Investment in manufacturing still retained first place (31 percent) but irrigation now accounted for 26 percent of reproducible capital as compared with only 7 percent in 1870. Increased investment in irrigation amounted to $10.4 million (1910–14) dollars in absolute terms between 1870 and 1900. The most active period of investment in irrigation was from 1890 to 1900, when the value of irrigation works rose from $2.0 million to $10.5 million. The rest of the investment pattern in 1900 was as follows: unharvested crops (24 percent), buildings (6 percent), machines and implements (4 percent), other land improvement (3 percent), horses and mules (2 percent), and social and miscellaneous (4 percent).

Figure 1 has shown how the area of land in sugar, and yield per acre of sugar, changed rapidly between 1870 and 1900. Total area of land in sugar cane increased from 10,260 acres in 1870 to 128,000 in 1900. Average yield of sugar per acre rose in this 30-year period from 2.0 tons to 4.7 tons. Total production climbed from 9,600 tons to 297,100 tons.

TABLE 3. Physical capital (excluding land)* used in Hawaiian sugar production, value in current dollars, 1870–1957

PHYSICAL CAPITAL	1870	1880	1890	1900	1910	1920	1930	1940	1945	1950	1957
	Thousand dollars										
Manufacturing	707	1,984	5,377	11,230	15,510	24,859	31,665	26,377	21,256	28,490	33,741
Unharvested crops	520	1,508	4,305	8,495	16,785	34,310	32,079	18,844	21,400	26,400	32,540
Irrigation	130	403	2,000	9,321	12,298	16,155	19,227	13,022	11,252	13,690	13,763
Land improvement	91	299	470	945	1,243	1,734	3,692	3,966	3,785	9,325	13,069
Machinery, implements	156	462	922	1,588	2,498	5,538	4,738	4,338	6,777	12,998	10,877
Horses, mules	36	68	322	672	1,188	1,316	864	353	178	28	21
Buildings	72	204	616	2,035	3,120	7,419	10,571	8,318	5,534	5,803	6,800
Social	†	†	†	152	513	1,001	2,926	3,504	3,689	7,901	5,407
Miscellaneous	16	40	198	1,106	1,380	2,475	3,007	2,345	2,243	3,097	2,334
Total	1,728	4,968	14,210	35,544	54,535	94,807	108,769	81,067	76,114	107,732	118,552

* Land (unimproved) was excluded only because adequate and reliable data relating to land values were generally not obtainable for the period under review. Difficulties in determining "The Value of Sugar Cane Lands" are reviewed by R. A. Cooke in a paper under this heading presented to the Hawaii Chapter of the National Association of Cost Accountants, Honolulu, February 19, 1929, 12 pp. Two conditions, probably peculiar to Hawaii alone, have a distinct bearing on this matter. "The first of these is that with most plantations" (during most of the 88-year period reviewed) "cane lands cannot be used for any other agricultural purpose. If it is unprofitable to raise cane on any certain area, the only alternative is to use the land for pasturage purposes. Secondly, the topography of the plantations is such that the land cultivated to sugar cane on one plantation cannot be profitably used by neighboring plantations because of prohibitive transportation costs."

† Negligible.

Source: Financial records of sugar plantations.

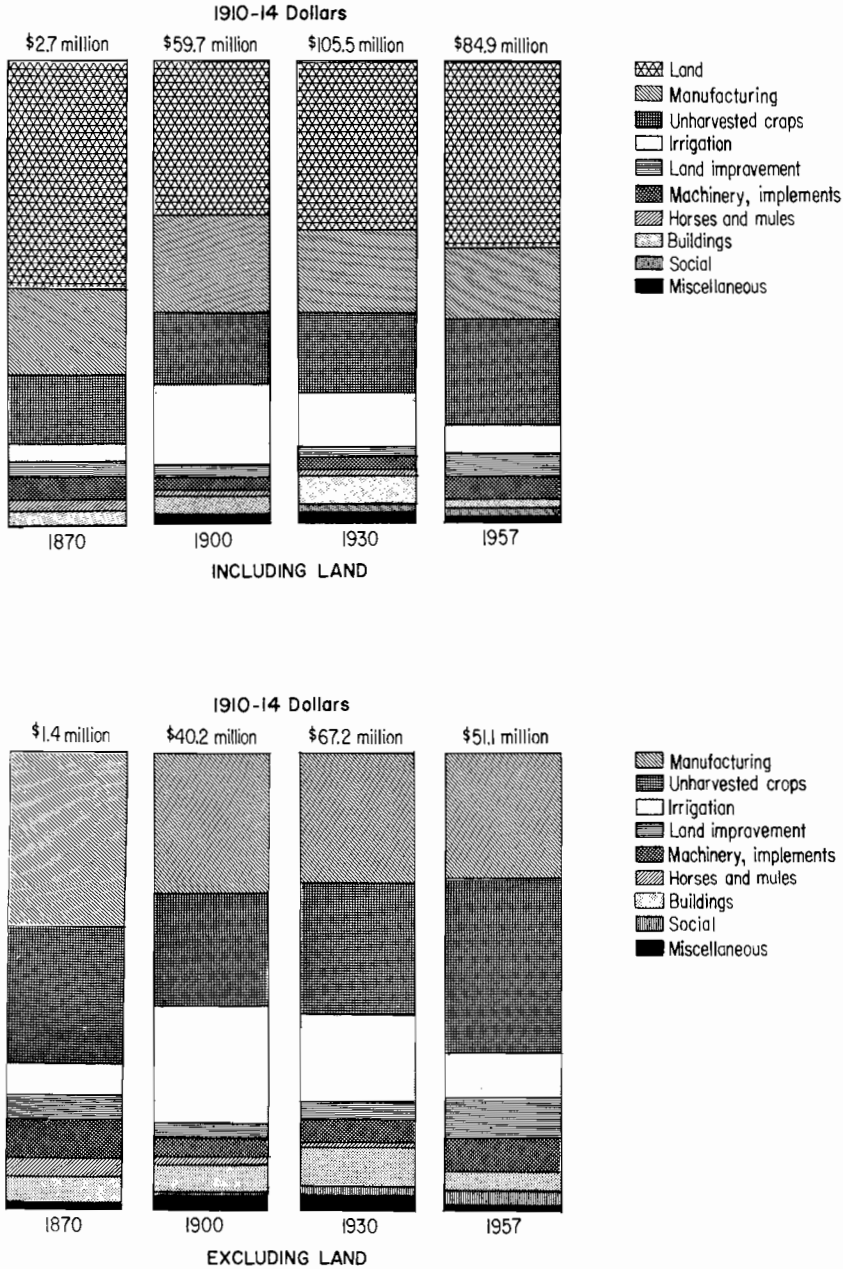
TABLE 4. Implicit price deflators of 9 categories of physical capital, Hawaiian Sugar plantations, 1870–1957

(1910–14 = 100)

PHYSICAL CAPITAL	1870	1880	1890	1900	1910	1920	1930	1940	1945	1950	1957
Manufacturing	136	115	95	89	100	178	168	157	194	243	245
Unharvested crops	130	115	105	90	98	165	166	113	130	141	168
Irrigation	130	115	100	89	98	160	150	160	195	290	280
Land improvement	130	115	95	90	100	160	150	160	195	290	280
Machinery, implements	125	115	95	89	100	177	148	159	194	294	280
Horses, mules	65	65	75	85	98	89	85	70	70	54	60
Buildings	90	75	77	79	99	154	178	166	232	280	331
Social	–	–	–	79	99	155	175	165	230	280	330
Miscellaneous	123	111	100	85	98	180	155	140	220	290	295

Source: Prices of "key" items were obtained from the financial records of plantations and of traders, and from official lists of quantities and prices of material imported into Hawaii. Attention was also given to price series constructed by the U. S. Department of Agriculture. Price deflators for unharvested crops were adjusted to take account of changes in accounting procedure and thus diverge from the general trend.

FIGURE 4. Change in composition of physical capital used in Hawaiian sugar production, 1870–1957.



Source: Table 1.

A more intensive use of land was the chief cause of higher yields experienced between 1870 and 1900. An enormous increase in the application of irrigation water to sugar lands was the main form of this greater intensity, although fertilizer was already beginning to assume an important role in yield increases. Changes in inputs of machinery, implements, and horses and mules tended to stay in proportion to changes in the area of cane. Thus, the ratio between the investment in irrigation and land (unimproved) stood at 1.0 to 13.0 in 1870 but had narrowed to 1.0 to 1.9 by 1900. Corresponding ratios between machinery and implements and land were 1.0 to 10.4 in 1870 and 1.0 to 10.9 in 1900.

Important changes took place in the number of plantations, their average size, and the amount of physical capital invested during this first 30-year period. Table 5 summarizes these changes for the entire period under study. The number of plantations rose from 20 in 1870 to 63 in 1880 to 73 in 1890 and then declined to 52 in 1900. Physical capital per plantation averaged $68,200 in 1870, $70,800 in 1880, $200,700 in 1890, and sharply increased to $773,500 in 1900 as a result of amalgamations. During this 30-year period the average size of plantations (acres in sugar) increased from 425 acres to 2,462 acres.

1900–1930

The hectic pace of investment in Hawaiian sugar production set in the final three decades of the 19th century slackened rather suddenly between 1900 and 1910, almost dropped to a standstill in the next decade, and regained some momentum in the 1920's. Figures given in table 2 illustrate these changes. While the value of physical capital had risen by as much as $25.6 million (175 percent) between 1890 and 1900, the corresponding rise between 1900 and 1910 was about three-fifths of this amount—$15.0 million. It represented a rise of 37 percent over the previous decade. Between 1910 and 1920, the value of physical capital rose by $2.2 million, or only 4 percent, to a total value of $57.4 million. In the third decade of this period, it rose by another $9.8 million, or 17 percent, to a grand total of $67.2 million, the peak level of investment in Hawaii's sugar industry.

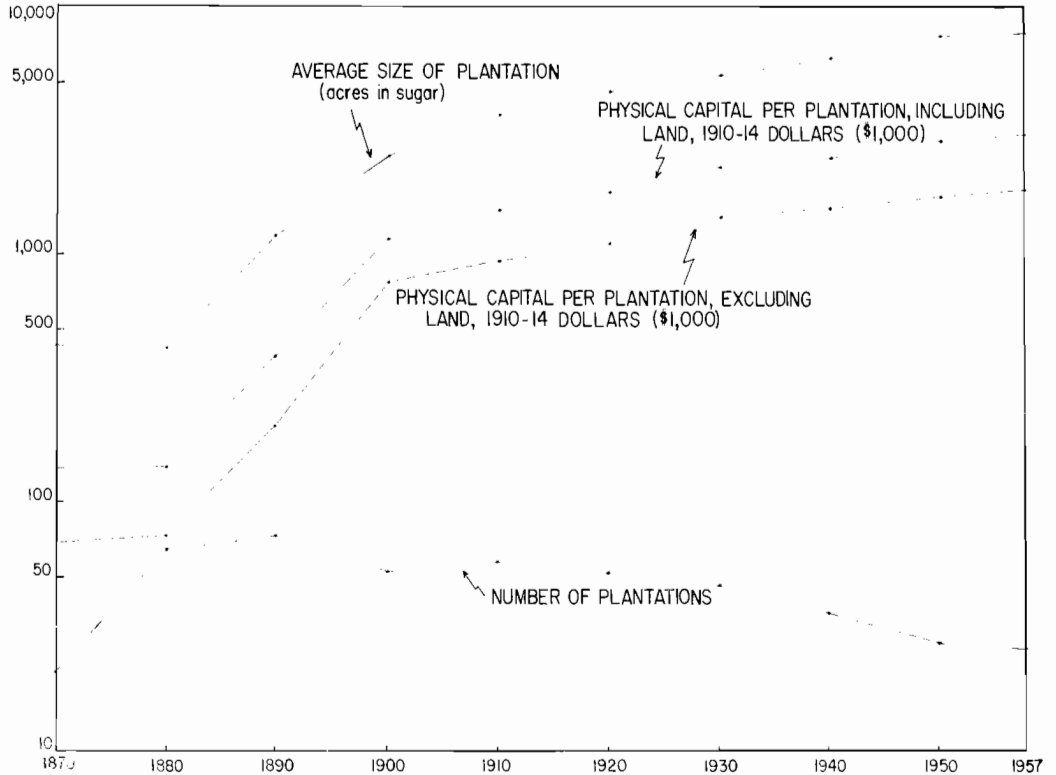
Expansion in the area of land in sugar continued at a rapid pace between 1900 and 1910 (from 128,000 acres to 214,000 acres) but slowed down after this, as land suitable for sugar production became harder to find and more expensive to cultivate. These changes in acreage are reflected in the value of land in sugar which (in constant terms) rose from $19.5 million in 1900 to $32.7 million in 1910, $36.1 million in 1920, and $38.4 million in 1930.

TABLE 5. Number of plantations, average size of plantation (in acres), and average amount of physical capital invested, Hawaii, 1870–1957

YEAR	NUMBER OF PLANTATIONS	AVERAGE SIZE OF PLANTATION	AVERAGE AMOUNT OF PHYSICAL CAPITAL PER PLANTATION		
			Excluding land		Including land
		Acres in sugar	*Current thousand dollars*	*1910–1914 thousand dollars*	*1910–1914 thousand dollars*
1870	20	425	86.4	68.2	133.0
1880	63	413	78.9	70.8	133.8
1890	73	1,192	194.7	200.7	383.6
1900	52	2,462	683.5	773.5	1,149.0
1910	58	3,695	940.3	952.0	1,515.7
1920	52	4,548	1,823.2	1,104.2	1,798.0
1930	47	5,352	2,314.2	1,429.3	2,245.7
1940	37	6,354	2,191.0	1,516.5	2,485.8
1950	28	7,871	3,847.6	1,743.6	2,944.2
1957	27	8,198	4,390.8	1,892.2	3,142.7

Source: Hawaiian Sugar Planters' Association and plantation records.

FIGURE 5. Number of plantations, average size of plantation, and average amount of physical capital invested, value in 1910–14 dollars, Hawaii, 1870–1957.



Source: Table 5.

In current prices, the value of physical capital increased from $35.5 million in 1900 (table 3) to $108.8 million in 1930—a threefold expansion. Much of this increase is explained in terms of the decrease in the value of the dollar, or rising prices. The corresponding increase in constant terms amounted to $27.0 million, or 67 percent.

The composition of physical capital showed striking changes in only two items between 1900 and 1930. Irrigation, which accounted for 26 percent of physical capital in 1900, had a corresponding proportion of 19 percent in 1930. Investment in social facilities (housing, hospitals, recreational facilities, and suchlike) for plantation workers went up from 0.5 percent ($192,000) in 1900 to 2.5 percent ($1,672,000) in 1930. The declining relative position of irrigation seems logical. Major irrigation works were mostly completed at the turn of the century. Better living facilities for workers came to be recognized by plantation authorities as a prime requirement for holding workers on the land and for improving their morale. Living conditions in plantation towns in the first decades of the sugar industry's existence had been fairly primitive.

Other capital items tended to remain unchanged in relative importance, although in absolute terms notable increases took place (table 1).

Between 1900 and 1930, the scale of operation in Hawaiian sugar production continued to rise. The number of plantations declined from 52 in 1900 to 47 in 1930 after climbing to 58 in 1910. The average size of plantations (acres in sugar) increased steadily from 2,462 acres in 1900 to 5,352 in 1930 (table 5). Capital per plantation averaged $773,500 (in 1910–14 dollars) in 1900, $952,000 in 1910, $1,104,200 in 1920, and $1,429,300 in 1930. If land is included in the totals, the average investment was $1,149,000 per plantation in 1900 and $2,245,700 in 1930.

These striking and important changes in scale of operation, continued in later years, suggest that marked economies in the operating costs of plantations resulted from them. One aspect of this relationship—the ratio between capital and output—is examined later.

1930–1957

In contrast to the consistent upward trend in the quantity of capital resources used on Hawaiian sugar plantations between 1870 and 1930, the value of physical capital fell by $11.1 million, or 16 percent, between 1930 and 1940. As a result of this change, physical capital amounted to $56.1 million in 1940, compared with $57.4 million in 1920 and $67.2 million in 1930. This shrinkage in physical volume of capital largely reflected the changing fortunes of the sugar industry. After an exuberant expansion in output in the 1920's (annual production of sugar went from 546,000 tons in 1920 to

FIGURE 6. Land improvement: preparing new land for cane growing has been a major item of capital expenditure.

1,018,000 tons in 1930—almost double), unfavorable cost-price relationships and, to a lesser extent, quota restrictions in the 1930's took the steam out of the industry. The area in cane declined from 251,000 acres in 1930 to 235,000 acres in 1940.

Shrinkage in physical assets continued during World War II. By 1945, their total value had fallen to $43.8 million (in 1910–14 dollars)—a drop of 22 percent from 1940. This wartime decrease largely reflected difficulties encountered by plantation managements in maintaining existing equipment. New construction was closely restricted. Acreage in sugar fell to 211,000 acres in 1945—a 10 percent drop within 5 years.

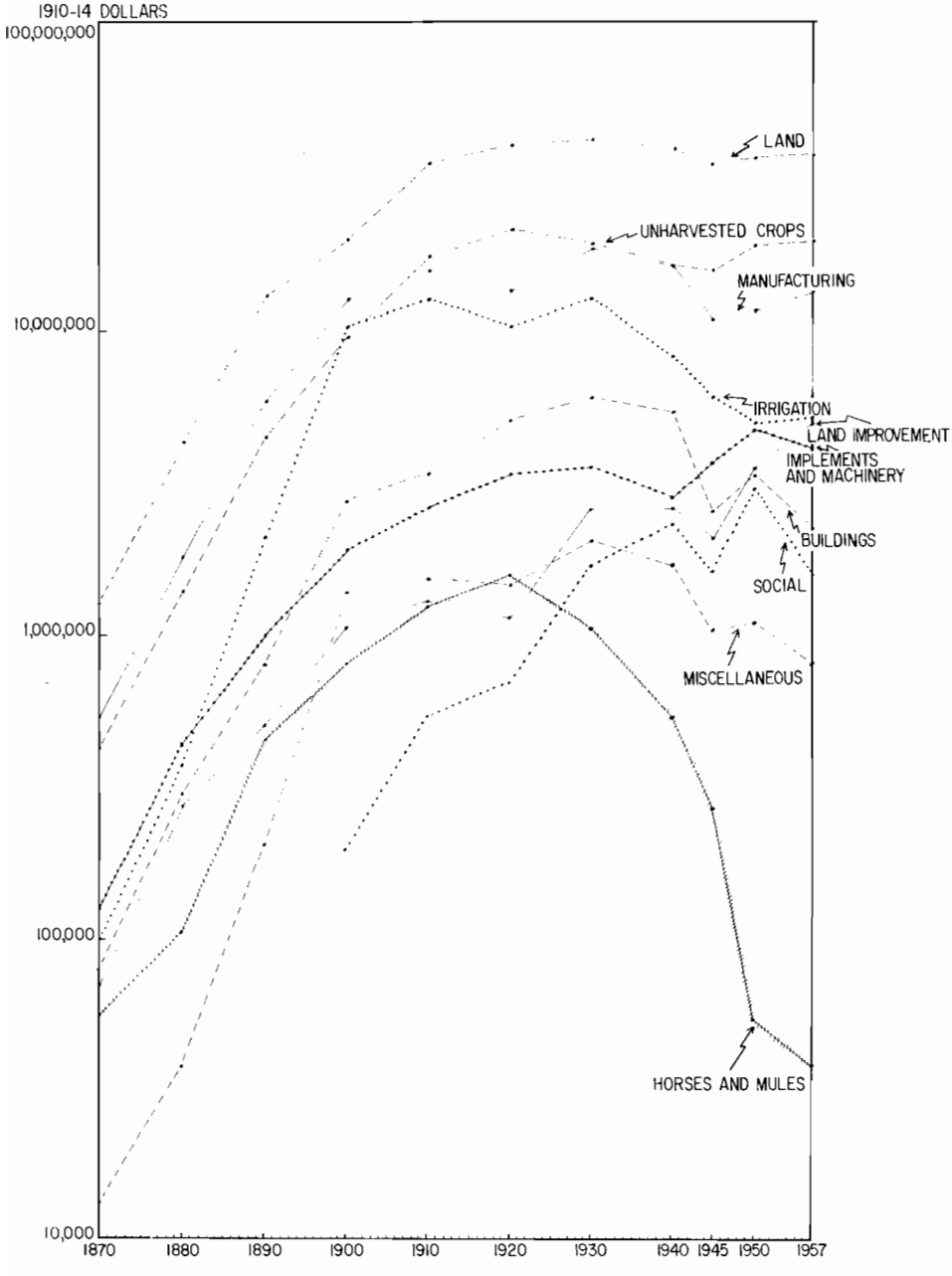
Soon after World War II ended, capital expenditure by plantations increased in a determined effort to overcome the effects of "capital starvation" involuntarily undergone in the war years. A long and costly strike by sugar workers in 1946 provided an additional incentive to plantation managers to invest in labor-saving machines. Between 1945 and 1950, the value of physical capital increased by $5.0 million (in 1910–14 dollars), or 11 percent. The corresponding increase between 1950 and 1957 was $2.3 million, or 5 percent.

Expressed in current prices, the value of physical capital, which amounted to $108.8 million in 1930, fell to $81.1 million in 1940, climbed to $107.7 million in 1950, and continued rising to $118.6 million in 1957.

The changing composition of the physical volume of capital during these and earlier years is indicated in figure 7 (a ratio-scale chart to indicate rate of change). Most notably, horses and mules were replaced by machines. The peak in the use of these animals for draught purposes had been in the early 1920's. Their value declined from $1.5 million (in 1910–14 dollars) in 1920 to $1.0 million in 1930, to $0.5 million in 1940, and down to $35,000 in 1957. Irrigation continued to decline in relative importance—from 19 percent of all physical capital in 1930 to 10 percent in 1957. In absolute terms, value of irrigation works fell in this period from $12.8 million to $4.9 million. This decline appears unduly large. It seems possible that a change in accounting procedure may well have resulted in some investment in irrigation being placed under the heading of "land improvement." In this connection it is significant that the most notable positive change in composition of capital was the increased importance of other land improvement. This item which, in addition to irrigation, reflects the intensity of land use, increased from $2.5 million in 1930 to $4.7 million in 1957. Most of this increase occurred after 1945 (then valued at $1.9 million). Land improvement accounted for 9 percent of physical capital in 1957, compared with 4 percent in 1930.

Better social facilities for plantation workers since 1930 are reflected by the greater proportion of total resources used for this item. Investment in

FIGURE 7. Physical capital (including land) used in Hawaiian sugar production, value in 1910–14 dollars, 1870–1957.



Source: Table 1.

social facilities ($1.7 million in 1930 and $2.8 million in 1950) was 2.5 percent of total physical capital in 1930 and more than double (5.8 percent) this proportion in 1950. Since around 1950, plantations have generally adopted a policy of encouraging workers to buy their own homes rather than to rent plantation-owned homes. As a result of this policy, investment in social facilities had fallen to 3.2 percent of total physical assets in 1957 ($1.6 million).

Figure 7 adequately summarizes other changes which occurred in the relative importance of different types of physical assets.

Table 5 shows that the average size of plantations consistently increased from 5,352 acres in 1930 to 8,198 acres in 1957. The number of plantations during this 27-year period decreased from 47 to 27. Average amount of physical capital per plantation (in 1910–14 dollars) increased steadily from $1,429,300 in 1930 to $1,892,200 in 1957. Corresponding figures, including land, are $2.2 million in 1930 and $3.1 million in the later year.

THE RELATIONSHIP BETWEEN CAPITAL AND OUTPUT

The previous section has analyzed changes in the value and composition of physical capital in the period between 1870 and 1957. It related these changes to trends in the area of sugar cane and production of sugar, and to economic conditions facing the sugar industry in Hawaii. This section examines the relationship between capital and output during this period and also factors which caused this relationship to change.

Output is measured in terms of "value added" in the process of growing and manufacturing raw sugar. It is obtained by deducting from gross output all the intermediate products from other sectors of the economy (fertilizer, fuel, machinery, etc.) used in this process. Table 6 shows gross and net output from Hawaiian sugar plantations between 1870 and 1957 in current prices. The table also shows net output as a proportion of gross output at 10-year intervals. An interesting though not unexpected feature of this table is the widening difference between gross and net output as intermediate products assumed greater prominence. Net output was about 82 percent of gross output in the earliest stage of commercial sugar production around 1870. The ratio between these two output measures remained around 4 to 5 (80 percent) until the 1890's. Then it began to widen. It was 3 to 4 in 1900; i.e., net output was equal to 75 percent of gross output; 3 to 5 in 1920; and 1 to 2 in 1940. Thereafter, the ratio fluctuated around this level. These changing relationships are illustrated in figure 8.

Table 7 shows net output measured in terms of raw sugar and in constant (1910–14) dollars between 1870 and 1957. The table shows that net output

TABLE 6. Gross output and net output from Hawaiian sugar production, 1870–1957, in current dollars

YEAR (1)	NET OUTPUT* (2)	GROSS OUTPUT* (3)	(2) AS PERCENT OF (3)
	Thousand dollars	*Thousand dollars*	*Percent*
1870	820.0	1,000.0	82.0
1880	3,439.6	4,299.5	80.0
1890	9,168.4	11,605.6	79.0
1900	18,799.6	25,166.8	74.7
1910	28,425.5	39,046.0	72.8
1920	58,055.6	95,173.0	61.0
1930	37,419.9	65,764.3	56.9
1940	30,423.1	59,304.3	51.3
1945	33,863.4	63,178.0	53.6
1950	63,554.8	121,056.7	52.5
1957	69,426.5	139,131.2	49.9

* Annual average of 3 years centered at date indicated except: 1870—average of 1870 and 1871; 1900—average of 1899, 1900, and first half of 1901; and 1957—average of 1956 and 1957 (output declined markedly in 1958 owing to a strike lasting 6 months). Output figures (gross and net) exclude compliance payments which tend to be cancelled out by excise taxes on sugar paid by the plantations.

Source: Hawaiian Sugar Planters' Association and financial records of plantations.

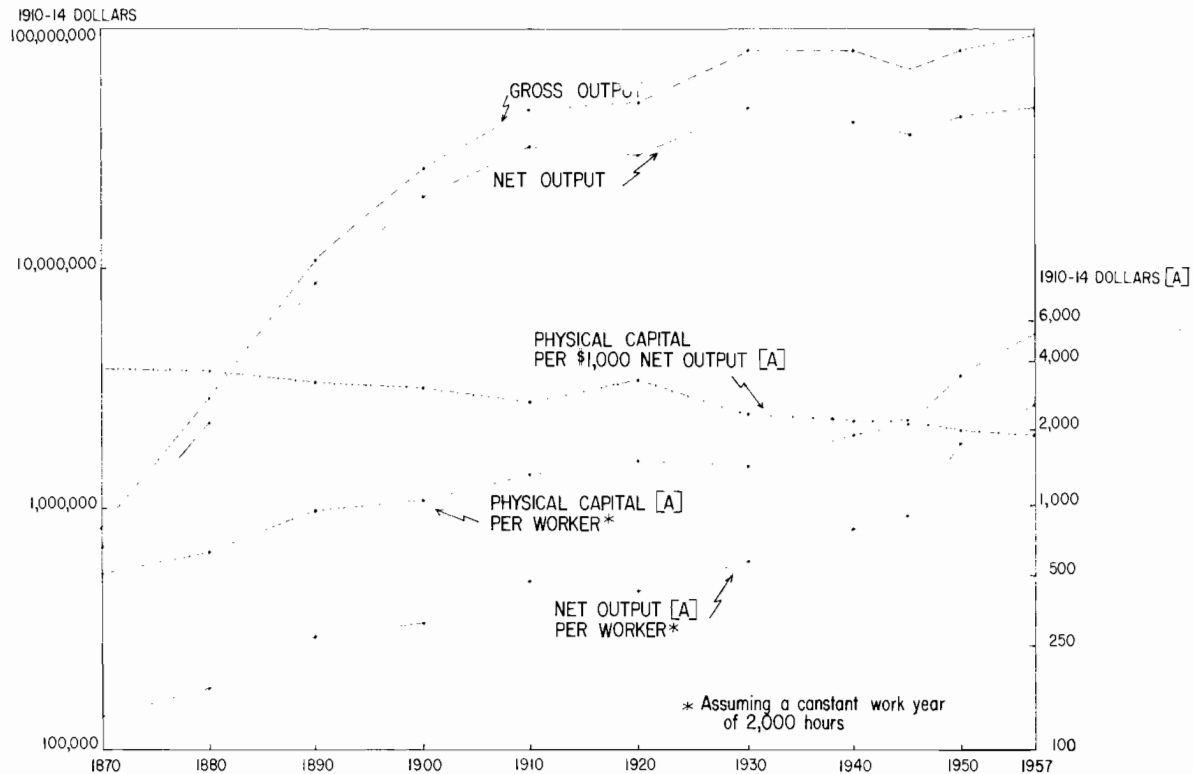
TABLE 7. Net output* from Hawaiian sugar production in tons of sugar (96° raw value) and in 1910–14 dollars

YEAR	NET OUTPUT		CHANGE BY SELECTED PERIODS		
	Sugar	1910–14 dollars	Period	1910–14 dollars	Percent
	1,000 tons	*Thousands*		*Thousands*	
1870	8.5	690.6		–	–
1880	28.2	2,286.4	1870–1880	1,595.8	231.1
1890	105.0	8,499.4	1880–1890	6,213.0	271.7
1900	238.3	19,289.4	1890–1900	10,790.0	126.9
1910	402.3	32,571.0	1900–1910	13,281.6	68.9
1920	348.5	28,212.8	1910–1920	—4,358.2	—13.4
1930	546.7	44,261.6	1920–1930	16,048.8	56.9
1940	499.0	40,397.8	1930–1940	—3,863.8	—8.7
1945	424.6	34,371.9	1940–1945	—6,025.9	—14.9
1950	509.7	41,265.9	1940–1950	868.1	1.0
1957	545.0	44,119.6	1950–1957	2,853.7	6.9

* Annual average of 3 years centered at date indicated; exceptions are noted in footnote to table 6. Net ouput in terms of sugar is obtained by multiplying total annual sugar production by the proportion which net output is of gross output (col. 4, table 6).

Source: Derived from table 6.

FIGURE 8. Output, gross and net, and its relationship to labor and capital, Hawaiian sugar plantations, 1870–1957.



Source: Tables 1 and 7, and figure 1.

rose from $0.7 million in 1870 to $8.5 million in 1890, to $19.3 million in 1900, and to $32.6 million in 1910. This tremendous increase in output resulted primarily from large increases in inputs of land, labor, and water, already described, and favorable cost-price relationships. Sugar prices were generally good and labor was relatively cheap and in plentiful supply. An assured market existed for protected Hawaiian sugar. This upward movement slowed down between 1910 and 1920, net output falling to $28.2 million in 1920 (average of 3 years centered at date indicated). It sharply regained momentum in the 1920's, however; by 1930 net output had reached a peak level of $44.3 million (in constant dollars). Then, less favorable economic conditions and quota limitations checked this upward thrust. Net output dropped to $40.4 million in 1940. It fell by $6.0 million between 1940 and 1945 to a total of $34.4 million. After 1945, as difficulties caused by wartime limitations were overcome, output moved upwards once again—to $41.3 million in 1950 and to $44.1 million in 1957.

Table 8 relates these different levels of output to physical quantity of capital (including land) decade by decade. The relationship between capital and output is expressed by a capital-output ratio. This ratio throughout this study expresses the average productivity of capital. It indicates how many units of capital are needed, on the average, to produce one unit of output. It does not express the marginal productivity of capital, which is the *extra* amount of output produced with an *extra* unit of capital. An increase in average productivity (a falling capital-output ratio) may or may not imply a rise in marginal productivity. Over the greater part of the 88-year period reviewed it clearly does.

Throughout the greater part of the 88-year period under review, the trend in the ratio of physical capital (including, and, excluding land) to output on Hawaiian sugar plantations was markedly downwards. This downward movement was checked in only one short period, around 1920.

Between 1870 and 1957, the capital-output ratio was halved—from 3.80 to 1.92—if land is included with physical capital. Excluding land (unimproved), the ratio dropped from 1.95 in 1870 to 1.16 in 1957. This was a decline of 41 percent. Reduction in the capital-output ratio was relatively slow in the very early years of Hawaii's sugar industry's existence. It became more marked in the 1880's and 1890's as better machinery was used and irrigation developed. The ratio fell by 16 percent between 1880 and 1900 and by another 13 percent between 1900 and 1910. The high rate of change in the capital-output ratio in the first decade of the 20th century was not maintained in the following decade. Between 1900 and 1910, physical capital increased by 37 percent while net output rose by 69 percent. But between 1910 and 1920, net output fell by 13 percent while physical capital continued to in-

TABLE 8. Capital-output ratios in Hawaiian sugar production, 1870–1957

YEAR	NET OUTPUT	LAND	MANU-FACTUR-ING	UNHAR-VESTED CROPS	IRRIGA-TION	LAND IMPROVE-MENT	MACHIN-ERY, IMPLE-MENTS	HORSES, MULES	BUILD-INGS	SOCIAL	MISCELLA-NEOUS	TOTAL
	Million 1910–14 dollars	*(As multiples of net income)*										
1870	0.7	1.85	0.74	0.57	0.14	0.10	0.18	0.08	0.12	*	0.02	3.80
1880	2.3	1.72	.75	.57	.15	.11	.17	.05	.12	*	.03	3.67
1890	8.5	1.57	.67	.48	.24	.06	.11	.05	.09	*	.02	3.29
1900	19.3	1.01	.66	.49	.54	.06	.09	.04	.13	*	.08	3.10
1910	32.6	1.00	.48	.52	.38	.04	.08	.04	.10	0.02	.04	2.70
1920	28.2	1.28	.49	.74	.36	.04	.11	.05	.17	.02	.05	3.31
1930	44.3	.87	.42	.44	.29	.06	.07	.02	.13	.04	.04	2.38
1940	40.4	.89	.42	.41	.20	.06	.07	.01	.13	.05	.04	2.28
1945	34.4	.93	.32	.48	.17	.06	.10	*	.07	.05	.03	2.21
1950	41.3	.82	.28	.45	.11	.08	.11	*	.05	.07	.03	2.00
1957	44.1	.76	.31	.44	.11	.10	.09	*	.05	.04	.02	1.92

* Negligible.
Source: Tables 1 and 7.

crease—by 4 percent. As a result of these changing relationships, the ratio between capital and output, at 3.10 in 1900 and 2.70 in 1910, rose in 1920 to 3.31 (very similar to the 1890 level).

After 1920, the ratio continued downwards. It declined by 28 percent between 1920 and 1930, the largest fall in any decade of the period studied. It fell by another 4 percent between 1930 and 1940 to 2.28, by 12 percent in the following decade (2.00 in 1950), and was at 1.92 in 1957.

This remarkable change in the ratio between capital and output is undoubtedly largely attributable to technological improvements in the cultivation of sugar cane and the milling of cane into raw sugar. Close integration of plantations with their own highly proficient experiment station resulted in early and widespread application of improvements. Research workers at Hawaii Agricultural Experiment Station also contributed important developments (Dr. Harry F. Clements' crop-logging system, for example). Plantation managers, often recruited from mainland agriculture, showed keen enterprise in adapting technology newly introduced in other farming areas to Hawaii. Better cultivation practices, disease-resistant cane varieties, constant improvement in manufacturing facilities, early mechanization of cane harvesting, and a great increase in the use of commercial fertilizers and herbicides, all these were important technological gains. Average yield of sugar per harvested acre (figure 1), about 10 tons in 1957, was double the yield typically experienced between 1900 and 1920 and triple the yield typical of the 1880's and 1890's.[9]

At this point, it is relevant to inquire whether the higher rate of increase in output relative to capital was in some part explained by a substitution of labor for capital. The number of workers on plantations increased at different rates between 1870 and 1927, when the peak of employment (56,600 workers) was reached. After this the plantation labor force decreased more or less continuously until by 1957 it had fallen (16,800 workers) to 30 percent of the peak level in the 1920's.

During the period between 1870 and 1927, rates of increase, decade by decade, in capital were always greater than in number of plantation workers except between 1920 and 1930. Capital per worker (tables 9A, 9B) decreased in the 1920's by 7 percent as the labor force on plantations expanded at a faster rate than capital additions. Between 1927 and 1957, capital per worker continued to increase. The pronounced downward trend in the capital-output ratio cannot be attributed to a greater relative use of labor.

[9] Hawaii leads the world in yields of cane sugar per harvested acre and is very efficient in the recovery of raw sugar from cane.
See: V. P. Timoshenko and Boris C. Swerling, *The World's Sugar Progress and Policy*, Stanford University Press, 1957, pp. 39–61.

FIGURE 9A. Cultivation: Mules and steam provided much of the power in the early days.

FIGURE 9B. Cultivation: Tractor performance has greatly improved in the last two decades—a contrast in power.

TRENDS IN RATIO OF SELECTED CATEGORIES OF CAPITAL TO OUTPUT

The changing relationship between capital and output analyzed in the previous section treats all physical assets as one. In this section, relationships between selected categories of physical capital and output are examined to determine where changes in the industry's capital-output ratio originated. The rate of change in this ratio for the different kinds of capital is also reviewed.

Land

A major cause of the general fall in the capital-output ratio in Hawaii's sugar industry between 1870 and 1957 was the large and generally consistent drop in the ratio between land and output. The latter ratio stood at 1.85 in 1870, and dropped by 7 percent in the next decade, and by another 9 percent between 1880 and 1890. It was 1.57 in 1890. Then as irrigation exerted its first real impact and as fertilizer usage bounded upwards, sugar yields mounted steeply—from around 3 tons per harvested acre in 1890 to around 4.5 tons in 1900. (It will be remembered that this decade included a period of all-out competition with other sugar-producing countries and the establishment of the industry's own experiment station.) The ratio dropped between 1890 and 1900 by 36 percent to 1.01. It remained close to that level in the next decade (1.00 in 1910), but climbed to 1.28 in 1920. This check in the downward trend (it occurred in the ratios of most of the other categories of capital) did not reflect any reduction in yields which, by 1920, were around 5 tons per harvested acre.

The main trend continued between 1920 and 1930. The ratio fell from 1.28 to 0.87, a 32 percent decline. Thereafter, it fluctuated around that level (0.89 in 1940, 0.82 in 1950) and in 1957 was down to 0.76.

The impact of new technology on this ratio between land and output may be expressed in any way—by relating the number of units of land required for 1 unit of output. In 1870, 1 ton of sugar required one-half acre of harvested land (or 1 acre in sugar, harvested every second year). The corresponding figure for 1900 was 0.21 and for 1957—0.10 acre. If account is taken of the large increase in use of intermediate products from other sectors of the economy and land alone is considered, then the corresponding figures for 1870, 1900, and 1957 are 1.0 acre, 0.27 acre, and 0.20 acre, respectively.

Manufacturing

The trend in the ratio between assets grouped under the heading of manufacturing and output followed a different pattern from the land and output ratio. Between 1870 and 1900, the ratio fell by 11 percent (0.74 in 1870, 0.66 in 1900). During the next two decades, the ratio dropped by another 26 percent to 0.49 in 1920. Then it moved downwards 14 percent between 1920

and 1930, and remained at the 1930 level (0.42) until around 1940. The ratio fell by one-third in the 1940's (0.28 in 1950) and was 0.31 in 1957.

This fairly persistent downward trend undoubtedly resulted from basic improvements in the quality and performance of machines and equipment used in the manufacturing process. Amalgamation of plantations and the dismantling of smaller mills which accompanied this action would also generally lead to economy of operation of existing sugar mills.

Unharvested Crops

A relatively small change in the ratio between unharvested crops and output occurred between 1870 and 1957. The decline was from 0.57 in 1870 to 0.44 in 1957—a fall of 23 percent. This fairly steady relationship is not unexpected. It implies that the value of output and of unharvested crops changed at fairly similar rates decade by decade.

Irrigation and Land Improvement

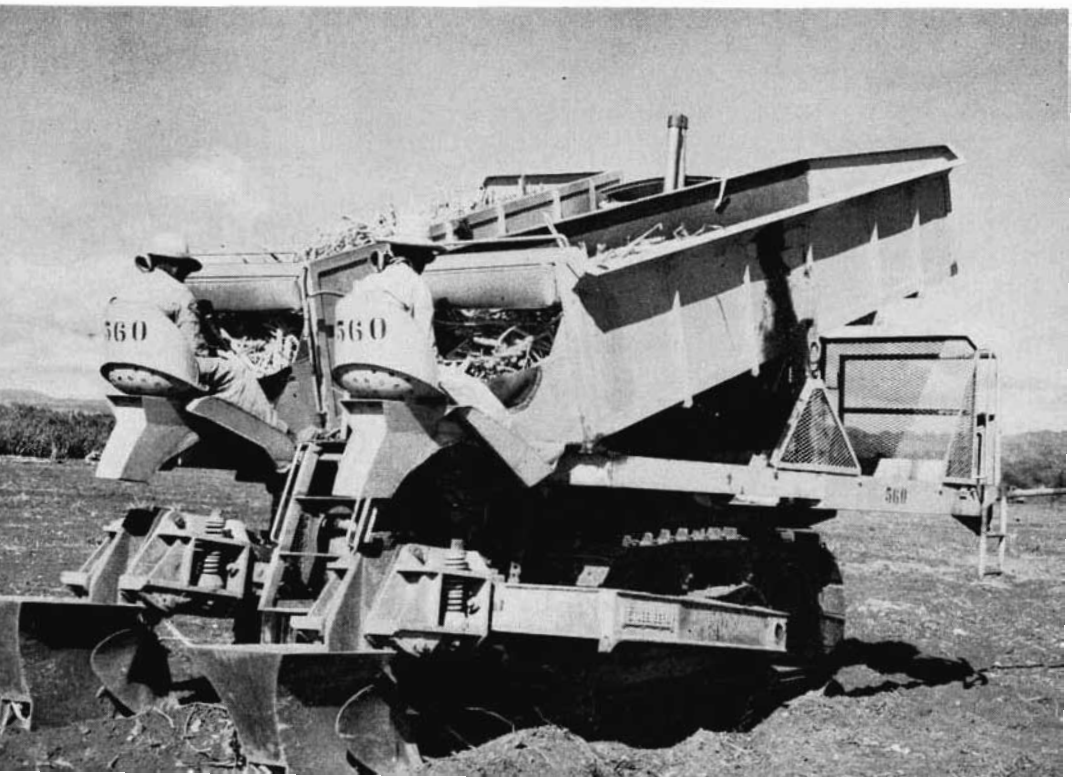
Heavy investment in irrigation and other kinds of land improvement was frequently essential in the early days of Hawaii's sugar industry before cane land became available for planting. This fact is reflected in the ratio between these two items of capital and output. It amounted to 0.24 in 1870 and 0.30 in 1890, but was double this figure, 0.60, in 1900. From then onwards, the ratio steadily declined to 0.40 in 1920, to 0.26 in 1940, and to 0.21 in 1957. In this century few additional major irrigation works or land improvement projects have been developed. Upkeep has become a primary concern. Improving yields and the last-mentioned factor explain the rate of downward movement in the ratio.

Machinery, Implements, Horses, and Mules

Field and harvesting machinery and implements, and the power to operate this equipment, are combined together in one category. Output increased faster than capital in the form of equipment, including horses and mules, during most of the 88-year period under review. The sharpest decline in the relevant ratio occurred in the first 30 years of the period—from 0.26 in 1870 to 0.13 in 1900. Thereafter, through 1957, the ratio varied between 0.08 to 0.12, except for a relatively sharp upward movement in 1920 to 0.16.

Hawaii's sugar industry has deservedly earned the reputation of being a prime innovator in the application of heavy capital equipment to field operations, and more recently to harvesting. Plantation management had strong incentives to improve field equipment and power even if it involved heavy capital outlay. A seasonal supply of labor was not readily available as in other competing sugar cane-growing areas. Local conditions permitted full-time use

FIGURE 10. Planting seed cane: note the high capital expenditure involved with the newer method.



of labor by allowing the cycle of planting, cultivating, and harvesting to continue throughout almost a 12-month period. Thus, relatively heavy overheads involved in the use of expensive equipment could more readily be borne than in other regions where activity in sugar fields was more seasonal. The steam plow was introduced to Hawaii in 1881; in 1910, the gasoline tractor.

Improvement in the quality of equipment probably explains most of the downward movement in the equipment and power to capital ratio between 1870 and 1900. The relatively fast rate of growth in output also influenced this change.

Horses and mules reached their zenith in the early 1920's. Their replacement by tractors appears to have involved no substantial reduction in the equipment-power to capital ratio. It is noteworthy that the ratio between buildings and output dropped fairly steeply as numbers of horses and mules declined. Some connection is clearly involved.

The remarkable capital-saving quality of modern implements and machinery is reflected in the relatively low proportion of investment in this item required to produce $1.00 worth of output—only 9 cents in 1957.

Buildings

The decline in ratio between buildings and output during 1870 and 1957, from 0.12 to 0.05, is in keeping with the general trend in the capital-output ratios for this period. Although investment in buildings increased substantially between 1870 and 1930 (from $80,000 to $5.9 million—in 1910–14 prices), when the peak in building outlay was reached, output rose even faster. The rate of increase in productivity per unit of buildings was obviously accelerating. Capital-saving developments have undoubtedly taken place in buildings in recent decades in Hawaiian sugar production as they have in mainland farming. New types of construction have been developed. The reduction in numbers of horses and mules, already mentioned, sharply cut the amount of building volume needed to house the power units needed to operate field and harvesting equipment.

CAPITAL AND LABOR—THEIR CHANGING RELATIONSHIPS

A sixfold increase in the quantity of physical capital per worker (including land) took place on Hawaii's sugar plantations between 1870 and 1957 (table 9A). The rate of increase varied considerably at different stages of this 88-year period. Between 1870 and 1900, capital per worker (including land) increased by 94 percent. Then the rate of increase slowed down. It ranged from 26 percent between 1900 and 1910 to 9 percent in the decade which followed. This upward trend was reversed, for the only time, in the 1920's when assets per worker fell by 7 percent (table 9B).

TABLE 9A. Physical capital (including land) per worker in 1910–14 dollars and percentage change per decade, Hawaiian sugar plantations, 1870–1957

A. Physical capital per worker

TYPE OF CAPITAL	1870	1880	1890	1900	1910	1920	1930	1940	1945	1950	1957
						Dollars					
Land	398	472	704	517	738	837	730	867	1,114	1,488	2,011
Manufacturing	160	205	299	334	350	324	358	406	379	519	820
Unharvested crops	123	156	216	250	387	483	367	403	567	829	1,151
Irrigation	31	42	105	277	283	234	244	197	199	209	293
Land improvement	21	31	26	28	28	25	47	60	67	142	278
Machinery, implements	38	48	51	47	56	73	61	66	121	196	231
Horses and mules	17	13	23	21	27	34	19	12	9	2	2
Buildings	24	32	42	68	71	112	113	121	82	92	122
Social	*	*	*	5	12	15	32	51	55	125	98
Miscellaneous	4	4	10	34	32	32	37	40	35	47	47
Total	816	1,003	1,476	1,581	1,984	2,169	2,008	2,223	2,628	3,649	5,053

* Negligible.

TABLE 9B. Physical capital (including land) per worker in 1910–14 dollars and percentage change per decade, Hawaiian sugar plantations, 1870–1957

B. Percent change per decade

TYPE OF CAPITAL	1870–1880	1880–1890	1890–1900	1900–1910	1910–1920	1920–1930	1930–1940	1940–1950	1950–1957
Land	18.6	49.2	—26.6	42.7	13.4	—12.8	18.8	71.6	35.1
Manufacturing	28.1	45.9	11.7	4.8	—7.4	10.5	13.4	27.8	58.0
Unharvested crops	26.8	38.5	15.7	54.8	24.8	—24.0	9.8	105.7	38.8
Irrigation	35.5	150.0	163.8	2.2	—17.3	4.3	—19.3	6.1	40.2
Land improvement	47.6	—16.1	7.7	0	—10.7	88.0	27.7	136.7	95.8
Machinery, implements	26.3	6.2	—7.8	19.1	30.4	—16.4	8.2	197.0	17.9
Horses and mules	—23.5	76.9	—8.7	28.6	25.9	—44.1	—36.8	—83.3	0
Buildings	33.3	31.2	61.9	4.4	57.7	0.9	7.1	—24.0	32.6
Social				140.0	25.0	113.3	59.4	145.1	—21.6
Miscellaneous	0	150.0	240.0	—5.9	0	15.6	8.1	17.5	0
Total	22.9	47.2	7.1	25.5	9.3	—7.4	10.7	64.1	38.5

Source: Table 1 and figure 1.

The general trend resumed upwards in the 1930's with an 11 percent change. Then followed a tremendous acceleration in the rate of growth in assets per worker—up 64 percent between 1940 and 1950 and up 39 percent between 1950 and 1957.

Figure 11 shows that physical capital (including land) increased faster than the corresponding rate of increase in number of workers until the 1920's. Total assets in that decade rose by 13 percent while the number of workers increased by 22 percent. As the plantation labor force declined in the 1940's and 1950's, assets either decreased at a slower rate or actually increased.

A fairly similar relationship existed in this 88-year period between physical or reproducible capital (excluding land) and labor. The rise in physical capital per worker between 1870 and 1900 (155 percent) was notably higher than the corresponding rate of 94 percent if land is included with physical capital. It was 17 percent (excluding land) between 1900 and 1910 and 7 percent in the decade which followed. The rate fell by only 4 percent in the 1920's and then rose by 6 percent in the 1930's. Between 1940 and 1957, physical capital per worker rose by 124 percent.

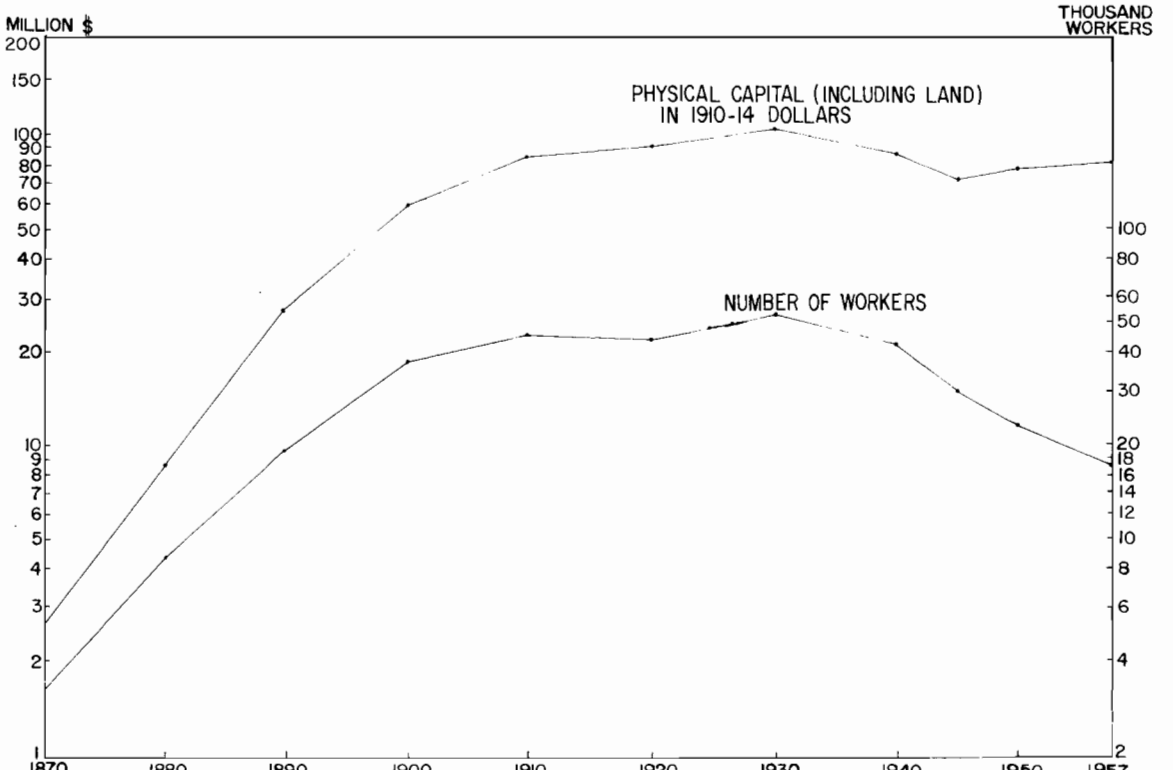
Table 9 gives a detailed picture of absolute and relative changes in physical capital per worker (including land) between 1870 and 1957. Relative importance of the different categories of capital per worker during this period follows the pattern outlined earlier in the discussion on the changing composition of these assets. The table requires careful study if its full implications are to be understood. A mere repetition of its contents appears needless.

Another measure of the change in the ratio between physical capital (including land) and labor is given in table 10. This shows the ratio of capital per 2,000 man-hours (a work year) and takes account of the shorter working week of today as compared with earlier decades. Using this standardized unit, the table shows that capital per worker (2,000 hours of work per year) rose from $535 to $5,146—or tenfold between 1870 and 1957. This is a much higher rate than the corresponding ratio between capital and labor (a sixfold increase) when no account is taken of the difference in hours worked in the two periods.

Capital per worker (2,000 hours) almost doubled between 1870 and 1900 while net output per worker increased by 145 percent. During the next three decades capital increased from $1,055 to $1,460 per worker (2,000 hours), a 39 percent rise; net output per worker showed a corresponding rise of $272 (from $340 up to $612), an 80 percent gain. Another upward movement in both capital (34 percent) and output (40 percent) per man took place in the 1930's.

Capital per man (2,000 hours) rose by $1,530 (78 percent) in the 1940's; output went up by a corresponding $886, or slightly more than double the 1940 figure.

FIGURE 11. Physical capital (including land), value in 1910–14 dollars, and number of workers, Hawaiian sugar plantations, 1870–1957.



Source: Financial records of plantations and Hawaiian Sugar Planters' Association.

TABLE 10. Secular trends in the relationship between total physical capital per worker,* including land and net output per worker, in 1910–14 dollars, Hawaiian sugar plantations, 1870–1957

YEAR	TOTAL PHYSICAL CAPITAL PER WORKER (including land)	NET OUTPUT PER WORKER	PERCENT CHANGE BY SELECTED PERIODS		
			Period	Capital per worker	Net output per worker
	1910–14 dollars				
1870	535.0	138.9		–	–
1880	657.8	178.5	1870–1880	23.0	28.5
1890	968.5	294.0	1880–1890	47.2	64.7
1900	1,054.9	340.6	1890–1900	8.9	15.9
1910	1,357.8	503.1	1900–1910	28.7	47.7
1920	1,522.6	459.4	1910–1920	12.1	—8.7
1930	1,460.3	612.4	1920–1930	—4.1	33.3
1940	1,950.7	856.8	1930–1940	33.6	40.0
1945	2,154.8	973.6	1940–1945	10.5	13.6
1950	3,480.7	1,742.4	1940–1950	78.4	103.4
1957	5,146.0	2,675.8	1950–1957	47.8	53.6

* Assuming a constant work year of 2,000 hours.
Source: Derived from tables 9 and 7.

This sharp upward trend was sustained in the 1950's. Output and capital per man between 1950 and 1957 rose by 54 percent and 48 percent, respectively.

These striking changes in the amount of capital and output per 2,000 hours of work reflect not only tremendous gains in levels of technology but also a change in the quality of management and workers. Better training for both types of work—of a general and a specialized nature—has undoubtedly contributed to improvement in labor productivity.

What happened to the relationship between all plantation workers and physical assets between 1870 and 1957 is shown in table 10. The data contained in that table are usefully supplemented by table 11 which deals with only one kind of physical asset and one group of workers.

They show the relationship between equipment and power available to each field worker and the tons of sugar handled. A constant work-year of 2,000 hours is assumed throughout the period under review in order to obtain a more precise measurement.

Table 11 has several striking features. It shows that equipment and power per field worker remained remarkably steady between 1880 and 1900. A sharp increase in the ratio occurred between 1900 and 1920—from $55 to $90 per

FIGURE 12. Irrigation: a major feature of Hawaii's sugar industry.

TABLE 11. Equipment and power per field worker* in 1910–14 dollars related to tons of sugar handled, Hawaiian sugar plantations, 1870–1957

YEAR	EQUIPMENT AND POWER PER FIELD WORKER* 1910–14 DOLLARS	TONS OF SUGAR HANDLED PER WORKER*	PERCENT CHANGE BY DECADES†	
			Equipment and power	Sugar handled
1870	41.2	2.2	–	–
1880	51.5	2.9	25.0	31.8
1890	55.7	5.3	8.2	82.8
1900	54.5	6.3	—2.2	18.9
1910	77.3	10.4	41.8	65.1
1920	89.8	10.6	16.2	1.9
1930	77.8	18.8	—13.4	77.4
1940	96.8	29.3	24.4	55.8
1950	314.8	67.6	225.2	130.7
1957	466.0	129.0	48.0	90.8

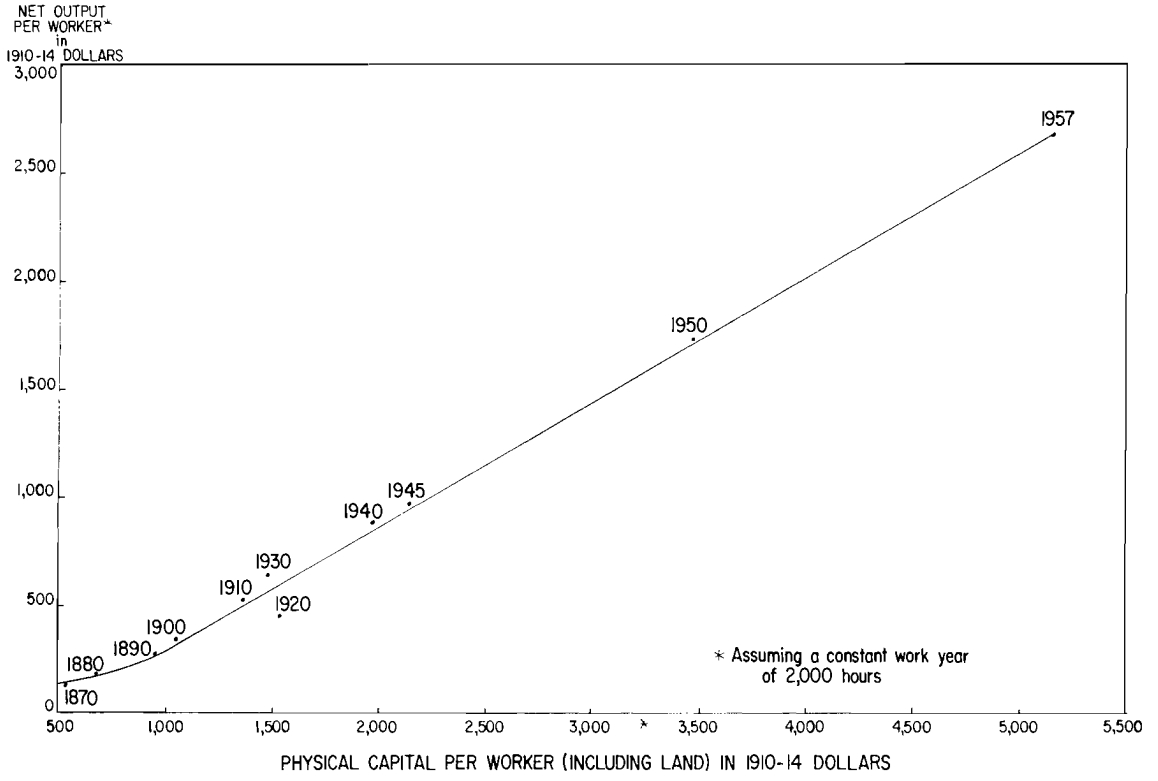
* Assuming a constant work year of 2,000 hours.
† Except between 1950–57, an 8-year period.
Source: Tables 9A and 7 and Hawaiian Sugar Planters' Association.

worker (in 1910–14 dollars), followed by a 13 percent drop to $78 per worker by 1930. The upward trend in this ratio resumed in the 1930's and stood at $97 per worker in 1940. Then the explosion happened! Wartime labor shortages, followed in the early postwar years by the militant sugar workers union's demand for better wages, led to a growing pressure to mechanize cane harvesting. Equipment and power per field worker rose more than threefold in the 1940's and increased another 48 percent to $466 per worker between 1950 and 1957.

More power and equipment per worker, better-quality equipment resulting in capital-saving, together with higher yielding crops of sugar, resulted in a phenomenal rise in tons of sugar handled per worker. In the earliest years of the industry's existence only 2 to 3 tons were handled per 2,000 hours. This tonnage had risen to 6.3 in 1900, to 10.4 in 1910, and slowly up to 10.6 in 1920. Then the upward pace quickened in the 1930's, and around 1940 field workers were handling about 29 tons per 2,000 hours. This quantity had increased by as much as 38 tons, or 131 percent, by 1950 and by another 61 tons, or 91 percent, between 1950 and 1957. The gain in tonnage of sugar handled per worker between 1940 and 1950 was as much as the comparable gain for the 70 years before!

Changes in the relationship between output and physical capital per worker are clearly indicated in figure 8 for 1870–1957. The pattern is similar to the relationship between field workers and tonnage of sugar handled exam-

FIGURE 13. Secular trends in the relationship between total physical capital per worker (including land) and net output per worker, in 1910–14 dollars, Hawaiian sugar plantations, 1870–1957.



Source: Table 10.

ined above. This relationship is presented as a regression between capital and output per workers in figure 13 in order to emphasize the close influence of one factor upon the other.

What were the factors which caused these striking changes in the relationship between capital, output, and labor? It should be clear from the preceding discussion that the relatively heavy capital outlay in Hawaii's sugar industry, from its earliest days, is associated with large plantations. It is also associated with a closely integrated system of growing cane and manufacturing raw sugar to provide a steady flow of cane to the mill. Large irrigation systems were developed, which at the time of construction (mainly in the 1890's and between 1900 and 1910) could only have been financed by large-scale enterprises.

A succession of immigrant workers from China, Portugal, Japan, Korea, Spain, Puerto Rico, and lastly the Philippines poured into this system. As the available supply of workers from Asian countries gradually diminished, generally as the result of government action, efforts to substitute machines for men were increased. In the 1930's the industry was gradually becoming dependent on native-born workers for recruitment. In 1937, the "grab harvesting" method was introduced in an attempt to replace hand-cutting of cane. Trucks for cane hauling had been introduced a year earlier. Both of these developments were to revolutionize the system of cane harvesting and lead to drastic reductions in labor requirements. Railroads (on portable and permanent tracks), hand-cutting and hand-loading had been the chief features of harvesting until the late 1930's.

A general shortage of workers in the war years (1940–45), a 6-month strike in 1946 for improved wages and working conditions, and wider opportunities of employment for island workers—all exerted a stimulating influence on the plantations' drive to mechanize cane harvesting. Plantations generally had sufficient reserves accumulated to finance the relatively high capital outlay experienced after World War II.

In summary, labor was relatively cheap in the early decades of Hawaii's sugar industry. Profit-making did not require large-scale substitution of power and equipment for human labor. As labor became relatively scarce and more expensive, notably after 1946, greater substitution of capital for labor became imperative if productivity of labor was to increase. Success in achieving this objective is apparent from data given in figure 8. It should be stressed, however, that greater productivity per worker was not solely the result of a large rise in physical capital per worker. A complex of factors led to this change, including notably better varieties of cane (yields of sugar were around 8 tons per harvested acre in 1946–48, above 10 tons in 1955–57).

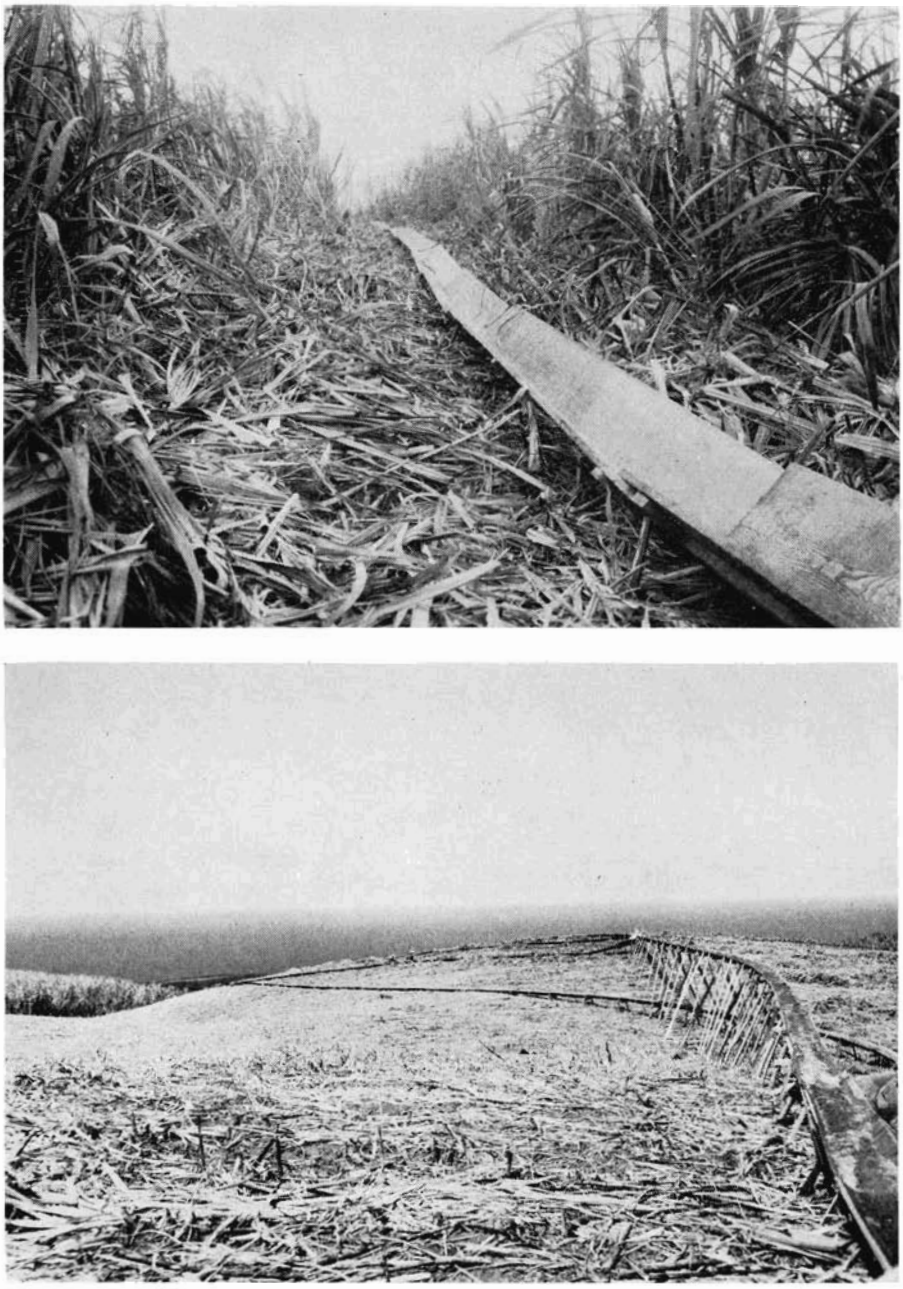


FIGURE 14. Flumes: water was used not only to irrigate the land but to carry harvested cane to the mill.

PROSPECTIVE TRENDS IN CAPITAL GROWTH

Is it possible to draw any conclusions from the mass of data relating to capital growth in Hawaii's sugar industry as to prospective trends? The evidence presented does indicate some very pronounced movements in total quantity of physical capital and land in sugar production, and in the capital-worker, capital-output, and output-per-worker ratios.

Dynamic changes which have occurred since 1940 point the warning that forecasts of future happenings based on past trends (in this instance, during the 1920's and 1930's) may be sharply out of focus. Technological changes and different economic conditions may halt, reverse, or accelerate existing trends. With reservations of this kind in mind, however, some of the more probable prospects may be examined.

It appears quite certain that the shrinkage of the plantation labor force (down to 14,150 in 1960)—so pronounced in the 1950's—will continue. The rate of decline will depend on several factors: the ability of engineers to develop labor-saving equipment, changes in wage rates of sugar workers, and general economic conditions.

Better methods of conveying cane from fields to the mill are likely to reduce labor requirements in the next few years. A current pilot scheme involves movement of the cane in pipes by suction. Improved harvesting machinery and milling practices are other prospective long-term developments.

Better equipment and harvesting methods should not only save labor but also lead to a greater yield of sugar. A recent estimate indicated that on one group of plantations, "we probably are not realizing more than 70 percent of the sugar we are producing in the field. Considering that our production is nearly 280,000 tons then, if we have only 70 percent recovery our true production is 400,000 tons of raw sugar. Considering then that we are thus wasting 120,000 tons of sugar a year, it should not surprise those of you with inventive minds to know that the industry looks forward with considerable eagerness to cane piping, to the diffusion process and to the ionic membranes. . . ."[10]

New strains of cane already available at the Hawaiian Sugar Planters' Experiment Station will gradually be planted on plantations. Improved yielding capacities of these strains indicate that sugar harvested per acre in the next decade should rise by about 10 percent—to 11 tons.

Fewer workers, higher yields, and improved technology (already in existence at the pilot stage) imply that capital per worker will continue to rise.

[10] Harry F. Clements, "Quality in Sugar Production—Field Aspects," *Proceedings of Hawaiian Sugar Technologists,* 18th Annual Meeting, Honolulu, November 16–19, 1959, p. 24.

FIGURE 15A. Cane harvesting: horse- or mule-drawn carts were first used in harvesting (upper photo); later, trains of carts pulled by mules or horses (lower photo) were employed.

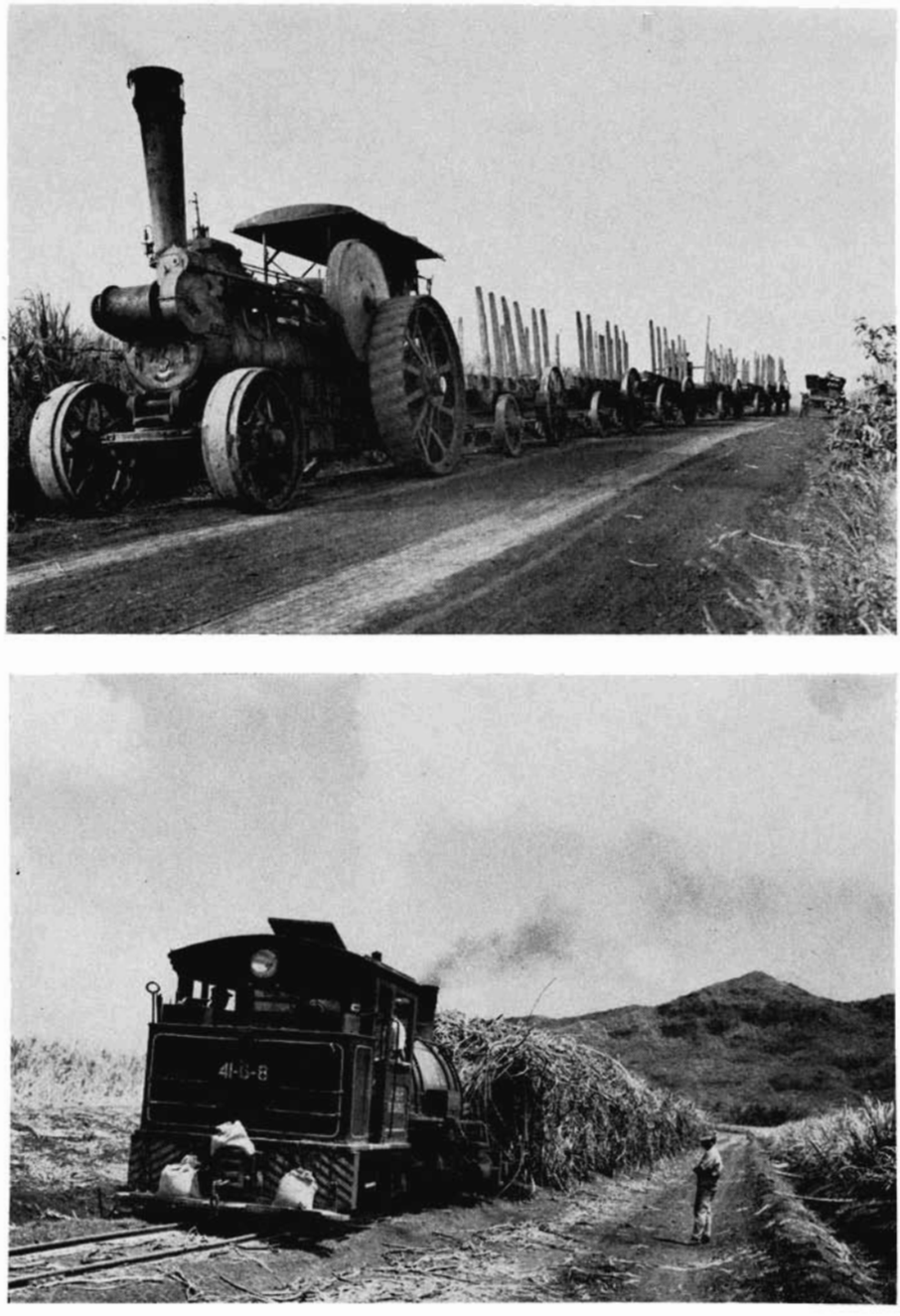


FIGURE 15B. Cane harvesting: the steam engine (upper photo) was replaced by the diesel locomotive (lower photo).

FIGURE 15C. Cane harvesting: trucks were first used in 1936 (upper photo); now specially designed machines (lower photo) do the job.

Shrinkage in the denominator of this ratio alone would ensure this. Productivity per worker should also move upwards although it seems unlikely that the rate of increase will be as great in the coming decade as in the 1950's.

The total amount of physical capital (in constant dollars) seems likely to remain fairly constant or to show a slow decline. More capital-saving equipment is one reason for this possibility. Another related factor is that the area of land in sugar is likely to decline as urban pressure on plantation land on Oahu continues and as several marginal plantations on Neighbor Islands move into other kinds of agricultural production.

No very marked changes are expected in the composition of physical capital. Land improvement will probably assume greater importance on the remaining area of land in cane; power and equipment are also likely to become relatively more significant.

Whether these changes come about depends, of course, on no single factor. Nuclear war, unsettled conditions in Cuba's sugar industry and their repercussions on mainland sugar beet-growing areas and foreign countries, a local setback in development of other industries — all would decidedly interfere with the prospective trends outlined.

THE FINANCING OF HAWAIIAN SUGAR PRODUCTION

This study would be incomplete if no attention was given to the means of financing the relatively large capital expenditures of Hawaiian sugar plantations. The unusually large scale of operation of these plantations gives a special interest to this aspect of production.

Hawaiian plantations were organized as corporations in the very early days of commercial sugar production in the Kingdom. Several factors favored large-scale enterprise. Under the Monarchy the land was originally in large domains which in many places have remained intact. Semiarid sections, well adapted to cane culture if adequate water supplies were available, could only be developed by high initial expenditure for irrigation facilities and heavy maintenance expenses. Reliance upon imported labor also favored large-scale operations. Relatively large amounts of capital needed to market the sugar crop in the United States placed control of the growing industry in the hands of Honolulu agents who found it easier to deal with larger than with smaller producers. Lastly, and of prime importance, the many technical and scientific problems associated with intensive cane cultivation could be handled most effectively by companies with large capital resources.

Early expansion of the Islands' sugar industry was largely financed by the mercantile houses of Honolulu. Pioneer planters generally had few resources of their own. So rapid was the boom (after the passage of the Reciprocity

Act, 1875) that local private capital resources became inadequate and the Hawaiian government had to come to the rescue. It extended loans to the industry.[11] After these temporary difficulties, the industry largely financed itself from the high profits which plantations realized for a time after free access of Hawaiian sugar to the markets of the United States. G. B. McClellan noted in 1899 that "the entire development of the Hawaiian sugar industry has been largely by capital of its own creation."[12]

Capital invested in the industry in 1894—estimated at $36.8 million[13]—was drawn from several groups of nationalities. Already, American domination of the industry was apparent.[14] Capital from American nationals amounted to $21.7 million, from Hawaiian-born Americans $4.4 million; Britons contributed $6.8 million, and Germans $2.0 million. Other contributors included: "half-caste Hawaiians," $0.6 million; "Hawaiian-born British," $0.4 million; Chinese, $0.3 million; and Portuguese, $0.1 million.

Accumulation of surplus funds from profitable sugar production not only enabled the industry to finance itself but also to invest large amounts in other domestic—and later—foreign enterprises. By 1910 Hawaii's sugar interests, through their powerful agencies, were supplying money to develop plantations in the Philippines, Formosa, the Straits, and the West Indies.[15] Such exporting of capital continues to the present day. Current interest is in the development of plantations in Puerto Rico, Australia, Iran, and India.

Thus, Hawaiian sugar plantations had a surplus capital position and a net outflow of capital to other industries some 20 years before United States agriculture was able to attain a similar position.[16] The flow of capital from other sectors of the economy into United States agriculture going on actively in the 19th century, closed about 1925. From 1930 onwards there has been a marked outflow of capital (as repayment of debt and building-up of balances) from agriculture.

Although some 14,000 stockholders have an interest in Hawaii's corporate agriculture, financial control of the sugar industry remains in the hands of five large corporate agencies in Honolulu. Interlocked to an unusual degree

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[11] J. Sullivan, *A History of C. Brewer and Co., Ltd., One Hundred Years in the Hawaiian Islands 1826–1926*, 1926, p. 144.

[12] G. B. McClellan, *A Handbook on the Sugar Industry of the Hawaiian Islands*, 1899, p. 8.

[13] *Hawaiian Almanac and Annual* 1894, p. 44.

[14] The impact of one American, in particular, was especially important—Claus Spreckels. See Shelley M. Mark and J. Adler, "Claus Spreckels in Hawaii: Impact of a Mainland Interloper on Development of Hawaiian Sugar Industry," *Explorations in Entrepreneurial History*, Vol. 10, No. 1, October 1957, pp. 22–32.

[15] *United States Bureau of Labor Bulletin*, No. 94, May 1911, Fourth Report on Hawaii, p. 695.

[16] Tostlebe, *op. cit.*, pp. 148–149.

through a network of directorates, these "Big Five" agencies tend to operate as one unit. They act as bankers for the plantations directing the flow of finance into and from the industry into their many diverse interests.[17]

Less favorable conditions for profit-making in recent years, far different from the halcyon days of the first half century of Hawaii's sugar industry, have lowered the margin of surplus available for capital expansion. The downward trend in the sugar industry's capital-output ratio, indicated earlier, counteracts this change to some extent. Capital-saving equipment, scientific research, and improved methods and management have greatly increased the effectiveness of new capital expenditure. Less is needed to achieve the same result. Or, better results can be obtained with the same amount of capital.

[17] See Robert S. Craig, "The Agency System in Hawaii . . . An Effective Method of Providing Advanced Scientific Management," talk given at the annual meeting, Hawaii Association of Credit Men, May 22, 1954.

William H. Taylor, *The Hawaiian-Sugar Industry,* Thesis, University of California, 1935, pp. 62–89.

William S. Creighton, *The Hawaiian Sugar Industry and Its Financing 1945–1955,* Thesis, Rutgers University, New Brunswick, June 1957, pp. 83–146.

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