URBAN ENCROACHMENT ON AGRICULTURAL LAND IN EAST ASIA: THE JAPAN MODEL

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY
MICHAEL ARTHUR GRAFF

1971

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ABSTRACT

URBAN ENCROACHMENT ON AGRICULTURAL LAND
IN EAST ASIA: THE JAPAN MODEL

By

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The processes and elements involved in urban expansion have received considerable attention in recent decades. Urban population growth attributable to natural increase and migration, and associated increases in the amount of land devoted to residential and industrial uses have led to increases in the areal extent of urban centers. A large portion of these increases involved the conversion of agricultural land to urban uses. A study of the eastern part of the United States, for example, indicates that between 1910 and 1959 approximately 16,000,000 acres of farm land were taken out of production due to the expansion of cities.* Studies of urban expansion in other developed nations substantiate the pervasive nature of the phenomenon of urban encroachment on agricultural land.

The situation in developing nations is uncertain due to the limited amount of information that is available. While data related to agricultural characteristics and farm

population can be easily obtained, data related to urban growth is either of limited usefulness or not available. There are indications, however, that urban expansion at the expense of agricultural land has occurred. Consideration is given to the implications of urban encroachment on agricultural land for economic development in the developing nations. It is concluded that responsible government officials and agencies are either unconcerned about, or unaware of the problems that may arise as a result of the removal of agricultural land from production.

In the absence of data related to urban growth in the developing nations a set of variables that can be used to identify and distinguish between urban and agricultural areas and indicate areas of transition was derived. Using 1965 data for the prefectures of Japan forty-six variables measuring urban and agricultural characteristics were submitted to both factor analysis and discriminant analysis. The factor analysis yielded seven factors representing distinct urban and agricultural qualities. The prefectures were grouped on the basis of the factor scores and discriminant analysis was then used to test the appropriateness of the groupings. Five groups were identified representing a distinct urban-agricultural dichotomy within the country. In addition, two prefectures were identified that show strong signs of being in a transitional stage between agricultural and urban status.

On the basis of the results of the analysis it was concluded that the variables selected are well suited to the task of identifying and distinguishing between urban and agricultural areas. Further study of the problem of urban encroachment on agricultural land and testing of the variable set are recommended.

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*John Fraser Hart, "Loss and Abandonment of Cleared Farm Land in the Eastern United States," Annals of the Association of American Geographers, 58:417-440, September, 1968.

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Geography

1971

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CHAPTER I

INTRODUCTION

The decade of the 1960's was a period of great progress in the field of economic development. The activities undertaken in the pursuit of development ranged from modest national plans to extensive international cooperation ventures and associations. Some of the international associations, to be sure, were outgrowths or continuations of organizations formed at earlier times and some of them passed out of existence during the 1960's. Most of them, however, were heavily involved in the development efforts carried out in various parts of the world. In western Europe the European Economic Community and European Free Trade Association became functional and made considerable progress in reducing trade barriers and advancing regional cooperation among their respective members. In the Americas the Alliance for Progress was formed in 1961 and attempted to improve economic conditions in the Latin American nations. Africa and the Middle East witnessed the formation of the East African Federation and the United Arab Republic. Asia too, saw the establishment of several regional organizations.

The Asian Development Bank was capitalized with support from industrialized and developing nations alike in order to provide funds for national economic development projects. In 1966, the Asian and Pacific Council was formed as a regional consultative body. One of the oldest organizations that is still active is the Economic Commission for Asia and the Far East which was created under the auspices of the United Nations in 1946. Its mission was, and still is, to advise member nations and assist them in the formulation of national and international development plans. The largest and most widely discussed project it has initiated is the multi-national Mekong River Development Plan which has involved the technical and financial cooperation of more than twenty nations.[1]

The organizations mentioned, as well as many others, have as their primary reason for existence the promotion of economic development. They have been complemented in their efforts by the work done in formulating and implementing individual development plans in their respective member nations. The development activity has not been without its problems, however. Almost every nation and organization has encountered political, economic or social difficulties.

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[1]C. Hart Schaaf, and Russel H. Fifield, The Lower Mekong (Princeton, New Jersey: D. Van Nostrand Co., Inc., 1963); Willard A. Hanna, "The Mekong Project," (seven parts), American Universities Field Staff Reports, Southeast Asia Series, Vol. 16, Nos. 10-14, 16, and 17; Gilbert F. White, "The Mekong River Plan," Scientific American, April, 1963, pp. 49-59.

Most of the difficulties encountered have been unique to a particular nation or organization. But one, population growth and associated urban expansion, has been common to virtually all of them.

Population growth by itself, and many of its ramifications in both developed and developing nations, has received widespread and increasing attention in the past decade.[2] Urban expansion has also received considerable attention from geographers, particularly in the developed nations.[3] In these discussions, however, little attention is given to the accompanying removal of agricultural land from production by urban encroachment.[4] Even less attention has been given to the implications for economic development contained within this concomitant phenomenon. Studies of urban expansion, while numerous, tend to concentrate on

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[2]Georg Borgstrom, Too Many (New York: Macmillan Co., 1969); Ronald Freedman (ed.), Population: The Vital Revolution (Garden City, New York : Doubleday and Co., 1964); Paul R. Ehrlich, "Too Many People," The Environmental Handbook, Garrett de Bell, editor (New York: Ballantine Books, Inc., 1970), pp. 219-232.

[3]Jean Gottmann and Robert A. Harper (eds.), Metropolis on the Move: Geographers Look at Urban Sprawl (New York: John Wiley and Sons, Inc., 1967); Lawrence G. Wolf, "The Metropolitan Tidal Wave in Ohio; 1900-2000," Economic Geography, 45:133-154, April, 1969; George S. Wehrwein, "The Rural Urban Fringe," Economic Geography, 18 :217-228, July, 1942.

[4]For example, Borgstrom, op. cit., p. 312, devotes two paragraphs out of over 300 pages of text to the topic. The discussion in Gottmann, op. cit., pp. 57-66, is centered on how best to plan for the urban absorption of agricultural land rather than on the effects of its removal from production.

describing the process involved in the expansion of urban areas and the decline of agricultural activity on the urban fringe.[5] The removal of agricultural land from production is more often than not passed over as being little more than an interesting side effect of expansion. This shortcoming may be due, in part, to the fact that most studies center on the developed nations where the role of agriculture in the economy is decidedly second to that of industry. It may also be due to the fact that many of the investigations involve nations that still have unused lands far from urban centers to which agriculture can be shifted as the cities expand. Consequently, concern for the fate of agricultural land near expanding urban centers has been minimal. Concern for the preservation of agricultural land near the urban centers in the more densely populated developing nations has been even less evident.

The purpose of this study is to investigate the implications for economic development of the removal of

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[5]Paul F. Griffin and Ronald L. Chatham, "Urban Impact on Agriculture in Santa Clara County, California," Annals of the Association of American Geographers, 48: 195-208, September, 1958; R. G. Colledge, "Sydney's Metropolitan Fringe: A Study in Urban-Rural Relations," The Australian Geographer, 7:243-255, February, 1960; Rodney Steiner, "Reserved Lands and the Supply of Space for the Southern California Metropolis," The Geographical Review, 56: 344-362, July, 1966; Lorne H. Russwurm, "Expanding Urbanization and Selected Agricultural Elements: Case Study, Southwestern Ontario," Land Economics, 43:101-107, February, 1967; Wehrwein, op. cit., footnote 2.

agricultural land from production by urban encroachment. I will focus on one developed and two developing nations, Japan, Taiwan and Korea, examining each of these nations in turn.[6] The emphasis of my investigation will be on their growing populations, expanding urban areas and the effects of this growth on agricultural land. I will show that while data related to the farming population and cultivated area of each country are available in considerable detail, similar data concerning urban population and urban areas are comparatively lacking. The implications of this shortage will be explored. Finally, I will attempt to identify a set of variables that can be used to distinguish agricultural, urban and transitional areas within a country using multivariate analysis.

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[6]More precisely, the forty-six Prefectures of Japan included in the 1965 census, Taiwan Province, Republic of China, and the eleven southernmost provinces of Korea which constitute the Republic of Korea. Throughout the discussion each of these areas will be referred to simply as Japan, Taiwan, or Korea. The uncertain futures of Taiwan and Korea are recognized, but the possible effects of reunification with their respective counterpart nations will not be considered here. Therefore, each will be treated as a separate and distinct economic unit. Similarly, the effects on the Japanese economy that might flow from the reunification of Okinawa and the Kurile Islands with Japan will not be included in this study.

CHAPTER II

POPULATION GROWTH

Since World War II the developing nations have experienced rapid increases in population. The primary factor contributing to the accelerated population growth has been a decline in death rates induced by the spread of modern medical, sanitation and pest control practices. While death rates have declined birth rates have remained at levels similar to those that prevailed before World War II. The net result has been an increase in population size.[7] The operation of this process is exemplified by the experience of one Asian island country, Ceylon.

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[7]Paul R. and Anne H. Ehrlich, Population, Resources, Environment: Issues in Human Ecology (San Francisco, California: W. H. Freeman and Co., 1970), pp. 20-23; George J. Stolnitz, "The Demographic Transition: From High to Low Birth Rates and Death Rates," Population: The Vital Revolution, Ronald Freedman, editor (Garden City, New York: Doubleday and Co., Inc., 1964), pp. 30-46. It should be kept in mind that though the emphasis here is placed on modern developing nations, the developed nations also experienced changes in their birth and death rates during their development. The difference, however, is that the changes took place over a much longer period of time than has been the case in the modern developing nations. In addition, the bases from which the populations of many developing nations have grown were larger than those from which the developed nations grew. Consequently, population growth in modern developing nations has been more rapid and involved larger numbers of people.

Ceylon's birth and death rates[8] in 1945 were both relatively high, being 35.9 and 21.5 respectively. Between 1921 and 1946 the island's population grew at the average annual rate of about 1.75 percent. In 1947 a malaria control program was initiated that involved the intensive spraying of DDT to eradicate disease-spreading mosquitos. The success of the program was reflected in the rapidly declining death rate which by 1950 had fallen to 12.4. The birth rate during the same period increased slightly to 39.7. The rate of natural increase, however, almost doubled, rising from 14.7 to 27.8. By 1965 the death rate had declined further to 8.2 and the birth rate showed signs of a downward trend, having declined to 33.1. The rate of natural increase remained considerably above the 1945 level at 24.9. The effect of these changes is reflected in the rapid growth of the population. In the intercensal period from 1953 to 1963 a total of 2.46 million people were added to the population at an average rate of 3.0 percent per annum.[9] When the 1953 base population of 8.10 million is considered the burden created by the rapid addition of almost two and a half million people becomes apparent. Such a sudden and rapid increase in population is what is meant by the popular term "population explosion."

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[8]Birth and death rates and rates of natural increase are stated in units per thousand population.

[9]Ceylon Year Book 1968 (Colombo, Ceylon: Department of Census and Statistics, 1968), pp. 38-39.

Ceylon has not been unique in its experience with population growth. Other developing nations have followed the Ceylonese pattern of declining death rates, essentially static high birth rates and increasing rates of growth. The experience of the British Crown Colony of Mauritius has been almost identical to that of Ceylon.[10] Malaya[11] and Thailand[12] have witnessed similar rapid population growth, with annual rates of increase of three percent or more. Hong Kong,[13] and Taiwan[14] and Korea[15] were faced with expanding populations once conditions became more settled following the disruptions of the late 1940's and early

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[10]Harley J. Walker, "Overpopulation in Mauritius: A Survey," The Geographic Review, 54: 243-244, April, 1964.

[11]Marion W. Ward, "A Review of Problems and Achievements in the Economic Development of Malaya," Economic Geography, 44:326, 328, 333, October, 1968.

[12]United States Department of State, Background Notes: Thailand (Washington, D.C. : United States Government Printing Office, April, 1968), p. 3.

[13]T. D. Vaughn and D. J. Dwyer, "Some Aspects of Postwar Population Growth in Hong Kong," Economic Geography, 42:37-38, January, 1966.

[14]Council for International Economic Cooperation and Development, Taiwan Statistical Data Book 1970 (Taipei, Taiwan: Executive Yuan, 1970), p. 4.

[15]Economic Statistics Yearbook, 1970 (Seoul, Korea: Bank of Korea, 1970), p. 8. In fact the rate of population increase in Korea was such that the editors of the Korea Annual were moved in 1965 to state that, "The 'population explosion' has become one of the most feared phenomena in the Republic of Korea today." Korea Annual, 1965 (Seoul, Korea: Hapdong News Agency, 1965), p. 139.

1950's. The pattern in the developing nations of Latin America[16] and Africa[17] has been similar to that found in the Asian nations. They, too, have followed the general trend outlined in the case of Ceylon.

While the picture presented of population growth in the developing nations is generally bleak there are some bright spots that give reason to believe that the trend described may be reversed. Indications have appeared in Hong Kong and Taiwan during the last decade that point to a decline in their rates of natural increase.[18] It should be noted, however, that population growth in these two densely inhabited places continued at rates of over two percent per annum. Unless their growth rates can be brought below the two percent level soon their populations will double before

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[16]Alfonso Gonzalez, "Population Growth and Socio-Economic Development: The Latin American Experience," Journal of Geography, 70: 36-40, January, 1971.

[17]John I. Clarke, "Population Distribution and Dynamics in Cameroon," Geography and a Crowding World, Wilbur Zelinsky, Leszek A. Kosinsky, and R. Mansell Prothero, editors (New York: Oxford University Press, 1970), pp. 351-352; Marcin Rosciszewski, "Population Growth and Economic Development in Egypt," Geography and a Crowding World, Wilbur Zelinsky, Leszek A. Kosinsky, and R. Mansell Prothero, editors (New York: Oxford University Press, 1970), p. 332.

[18]Ronald Freedman and others, "Hong Kong: Fertility Decline: 1961-1968," Population Index, 36:3-18, January-March, 1970; Ronald Freedman, "The Accelerating Fertility Decline in Taiwan," Population Index, 31: 430-435, October, 1965; "The Continuing Fertility Decline in Taiwan," Population Index, 33: 3-17, January-March, 1967.

the end of the century. Such a prospect for already crowded places like Hong Kong and Taiwan is, to say the least, disturbing.

The phenomenon of rapid population growth continues to be one of the distinguishing characteristics of developing nations. Combined with population growth in general has been an extraordinary increase in the proportions of populations living in urban centers. These disproportionate increases have been brought about largely through the migration of considerable numbers of people from rural to urban areas. The impetus for this migratory activity has been the combined effect of population pressure in rural areas and the attractiveness of urban centers.[19] People unable to make a satisfactory living in rural areas due to the increased numbers are placing high demands on the agricultural resources. Thus, many migrate to the cities in search of employment.[20] Others are drawn to the cities by the

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[19]Glenn T. Trewartha, A Geography of Population: World Patterns (New York: John Wiley and Sons, Inc., 1969), pp. 147-154; John Fraser Hart, "The Adjustment of Rural Population to Diminishing Land Resources," Geography and a Crowding World, Wilbur Zelinsky, Leszek A. Kosinsky, and R R. Mansell Prothero, editors (New York: Oxford University Press, 1970), pp. 97-99. Paul R. and Anne H. Ehrlich, op. cit., pp. 37-41.

[20]An exception has been noted in the Philippines where migrants have moved to new agricultural lands rather than to the cities. It is recognized, however, that the new agricultural lands will eventually be filled and that should the current high rate of population increase continue the cities can expect to receive an increasing number of

opportunities for employment and large incomes that the rural communities do not offer. But whether people are motivated to migrate by rural population pressure or the attractions of the urban areas, they sometimes discover that they are little better off in cities than they were in rural areas. In fact, some migrants find their position worsened as a result of their move due to their inability to find employment, the poor housing facilities available to them and a number of other discouraging conditions. Still, many find city conditions better than those they left behind, and in any event most are either unwilling or unable to return to their rural places of origin.[21]

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migrants. Paul D. Simkins, "Migration as a Response to Population Pressure: The Case of the Philippines," Geography and a Crowding World, Wilbur Zelinsky, Leszek A. Kosinsky, and R. Mansell Prothero, editors (New York: Oxford University Press, 1970), pp. 259-268.

[21]Jacqueline Beaujeu-Garnier, "Large Overpopulated Cities in the Underdeveloped World," Geography and a Crowding World, Wilbur Zelinsky, Leszek A. Kosinsky, and R. Mansell Prothero, editors (New York: Oxford University Press, 1970), pp. 269-278.

CHAPTER III

URBAN EXPANSION

The expansion of urban centers and accompanying removal of agricultural land from production has been going on for some time. The processes which bring about urban expansion, though, have as yet only been alluded to. Since an understanding of these processes is needed in order to fully appreciate the implications of urban expansion a brief review of geographical literature related to the topic is in order.

The concentration of population in urban areas has occurred in both the developing and developed nations. The growth of urban population in the developed nations has differed, though, from that experienced by the developing nations. It took place over a longer period of time and was stimulated more by the employment opportunities created through industrialization than by population pressure in rural areas.[22] In both developed and developing nations, however, increases in urban population have led to the enlargement of the urbanized areas. Expansion of the urban

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[22]Paul R. and Anne H. Erhlich, loc. cit.; Trewartha, loc. cit.

areas has been brought about primarily through the growth of residential districts, although the role of industries locating on the outer edges of cities cannot be overlooked. In order to examine the phenomenon of urban expansion in detail a consideration of the literature dealing with developed nations will be necessary, for most of the studies that have been done relate to the conditions found in and near the urban centers of these nations.

Sinclair's Model

Von Thunen's analytical model of the "isolated state" in which the intensity of agricultural land use declines with distance from the urban center,[23] while still applicable in developing nations, has been found inadequate when attempting to describe agricultural land use patterns in modern urban-industrial societies. A model of agricultural land use which better fits the realities of urban expansion in such developed nations has been formulated by Robert Sinclair.[24] In analyzing Von Thunen's model he notes that conditions affecting the relationships between urban

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[23]Michael Chisholm, Rural Settlement and Land Use (London: Hutchinson University Library, 1962), pp. 21-35.

[24]Robert Sinclair, "Von Thuenen and Urban Sprawl," Annals of the Association of American Geographers, 57:72-87, March, 1967.

centers and neighboring agricultural lands have changed considerably since the early nineteenth century when Von Thunen did his work. Modern transportation, refrigeration and food processing techniques have reduced the need for farmers producing perishable goods to locate immediately adjacent to urban markets. The development of national and international markets has further reduced the farmer's dependence upon a single regional market for the disposal of his produce. Furthermore, entry of expanding urban centers into the competition for the use of land has added a complicating element to the competition. Finally, Sinclair notes one significant fact differentiating ". . . most modern urban areas from the cities of Von Thunen's experience. Whereas Von Thunen envisaged a static city, with set boundaries, in most modern industrialized nations the theme is urban expansion, with population growth and constantly expanding areas of urban land use."[25] Urban expansion is the phenomenon that Sinclair has incorporated into his model of land use patterns.

The determinant in the location of agricultural and urban land uses in Sinclair's model is the value of land rather than distance from the urban market and associated transportation costs. The value of land is set by the competitors seeking to use it. Since a given piece of land

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[25] Ibid., p. 77.

will generally yield a higher return when used for urban purposes than it will for agricultural purposes, urban users can and do outbid their agricultural competitors for the use of land on the urban fringe. A gradient of land values, extending from the core of the urban area where values are highest to the rural countryside where they are low can be constructed.[26] Along the gradient are found specific land uses ranging from business and industrial through residential to agricultural. The area in which urban and agricultural land uses intermingle is the urban-rural fringe.

Associated with the land value gradient in the urban-rural fringe is an "air of anticipation"[27] among the agricultural land users. As the population increases within an urban area, pressures causing urban expansion into the urban-rural fringe grow, land values rise, and the farmers anticipate selling their lands and leaving the fringe. The final decision to sell is brought about by a combination of factors. These include the opportunity to make

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[26]Two studies by Norio Hasegawa involving the Japanese cities of Sendai and Hirosaki illustrate the existence of a land value gradient in large cities and also point to the movement of the gradient outward from the city over time. Norio Hasegawa, "Spatial Variation of Land Value and Land Use-Case Study of Sendai and Hirosaki," Science Reports of the Tohoku University (7th series), 12:145-158, March, 1963; "Changes in the Spatial Variation of Land Value and Land Use," Science Reports of the Tohoku University, 13:157-164, March, 1964.

[27]Sinclair, op. cit., p. 78.

money by selling to an urban developer, rising taxes that come with annexation of agricultural lands to the city, zoning restrictions, and the problems associated with farming in or near residential areas.[28]

Like land values, the "air of anticipation" takes the form of a gradient that declines with distance from the city. It is measured in terms of agricultural investment, the amount of money spent for materials, labor, and equipment by farmers. As might be expected, such investment decreases the closer the farms are to the city and the greater the degree of anticipation felt by farmers. A farmer looking ahead to the sale of his property is unwilling to expend financial resources on land that may soon be going out of production.

A third gradient, increasing with distance from the urban-rural fringe, is recognized by Sinclair. This gradient, which he labels "Value for Agriculture," is also measured in terms of agricultural investment. It reflects decreasing land values with distance from the city and an

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[28]Listed among the disturbing elements associated with urban encroachment in a study of Santa Clara County, California were rising land prices and taxes, pilferage of crops, and complaints from nearby residents about dust raised during plowing and problems associated with pesticide spraying. Paul F. Griffin and Ronald L. Chatham, "Urban Impact on Agriculture in Santa Clara County, California," Annals of the Association of American Geographers, 48: 201-203, 205-206, September, 1958.

accompanying decrease in the likelihood of urban encroachment. More importantly, it reflects a feeling of security held by the farmers. They feel that they can carry on their work with little or no interference from the urban centers and probably will be able to continue to do so for some time. As a result, agricultural activity, as measured by investment, becomes increasingly intense with distance from the urban-rural fringe.

The interaction of the three forces represented by the gradients (changing land values, anticipation of urban encroachment and the feeling of security reflected by the rural farmers' willingness to invest) is summarized by Sinclair.

> The effect of distance from the city thus is expressed in the following simple relationship: As the urbanized area is approached from a distance, the degree of anticipation of urbanization increases. As this happens, the ratio of urban to rural land values increases. Hence, although the absolute value of land increases, the relative value of agricultural utilization decreases. The result of this process is a basic agricultural land use pattern which is the reverse of that found in Von Thunen's time.[29]

The general picture thus presented is one of an expanding urban area bordered by a transition zone of both urban and rural land uses, with an outlying area of agricultural land use which better conforms to the conditions described by the Von Thunen model.

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[29]Sinclair, op. cit., p. 78.

Metropolitan Tidal Wave

A more general model descriptive of the expansion of urban population and its movement away from the urban center has been put forward by Hans Blumenfeld.[30] His concept of an expanding "tidal wave" of population growth has been succinctly summarized by Laurence Wolf.

> As he conceived it, population growth rates rise outward from the center of the metropolis in concentric circular rings until the crest of the wave is reached and then subside. The tidal wave moves outward over the decades, decennial growth rates declining in each ring behind the crest as the latter advances and increasing in the rings toward which the crest is advancing.[31]

The relevance of this model to the problem of urban expansion is made clear when it is applied to a particular place. Wolf's study of Ohio provides an example of its application.

Wolf modified Blumenfeld's model slightly, defining four major zones of metropolitan growth activity along with four minor zones, only one of which will be dealt with here. The innermost area is characterized by the loss of population during at least two of the three most recent

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[30]Hans Blumenfeld, "The Tidal Wave of Metropolitan Expansion," Journal of the American Institute of Planners, 20:3-14, 1954. For a description and discussion of a mathematical model supporting Blumenfeld's expansion model see: Piotr Korcelli, "A Wave-Like Model of Metropolitan Spatial Growth," Papers: Regional Science Association, Ninth European Congress, 1970, 24:127-138, 1970.

[31]Laurence G. Wolf, "The Metropolitan Tidal Wave in Ohio; 1900-2000," Economic Geography, 45: 133, April, 1969.

decades. It is labeled the paleo-urban zone. The meso-urban zone is contiguous with the paleo-urban and is characterized by moderate growth rates having a tendency to decline decennially. The area having the greatest population growth rate (sixty percent or higher in the period from 1950 to 1960 in Wolf's study) is designated the neo-urban zone. This zone constitutes the crest of the wave and is notable for the amount of construction under way within it. Beyond the crest of the wave lay the peri-urban and agro zones. The peri-urban zone is an area experiencing increasing growth rates as the wave approaches. The rural area toward which the wave is advancing is the agro zone, composed mainly of land devoted to agricultural uses.

Using United States Census data for the period from 1900 through 1960 Wolf plotted the position of the "tidal wave" in Ohio in 1960. Based on trends in the data he then projected the position of the wave and its component zones for the year 2000. The projection shows a considerable change in the position of the wave crest. Almost all of the 1960 peri-urban zone was converted to neo-urban zone status. The meso-urban and peri-urban areas became enlarged, with the peri-urban zone covering much of the area previously labeled agro-zone.[32]

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[32] Ibid., pp. 137, 147.

Wolf cites several reasons for the continuing movement of the wave. Among them is population pressure within the urban center, brought about both through natural increase and through immigration. A second reason is the movement of people from the older parts of the cities to the more desirable suburban developments. This movement is often accompanied, and sometimes preceded, by a shifting of industrial and service operations to the edges of the cities. Credit is also given to the automobile for making it possible for people to live far from their places of employment in or near the city and commute to work.[33]

The net effect of the projected movement of the tidal wave is to submerge much of the agro zone under the advancing weight of urban expansion along a front stretching from Cincinnati to Cleveland. The speed at which the wave crest is calculated to be moving is three miles per decade. At this rate it can easily be appreciated that a considerable area will become urbanized as the wave moves outward from the urban center.[34]

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[33] Ibid., pp. 142-145.

[34] For example, over the forty year period covered by the projection the advance of the wave at the rate of three miles per decade along a front only ten miles along would involve a total area of 76,800 acres, or 120 square miles.

Supporting Studies

Most studies dealing with the growth of urban population and the expansion of urban centers tend to be descriptive of the processes involved in these phenomena. Such studies, while providing little data related to the actual amount of land involved in urban expansion, lend credence to the concepts embodied in the models of Sinclair and Wolf and merit some attention here.

In an investigation of the urban-rural fringe George Wehrwein, in 1942, elaborated upon several of the elements contributing to the conversion of agricultural land to urban uses.[35] Among the elements discussed were increasingly available public and private transportation facilities, rising land values and taxes, and the attractions of suburban living. Citing Indianapolis, Indiana as an example, he illustrates the operation of these elements in the growth of an urban center. From a town originally occupying only a portion of a township, Indianapolis grew and expanded to become a city covering an entire township and parts of four

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[35] George S. Wehrwein, "The Rural-Urban Fringe," Economic Geography, 18:217-228, February, 1945. A study of the growth of Los Angeles between the mid-1800's and 1958, involving several of the elements discussed by Wehrwein, may be found in: Howard J. Nelson, "The Spread of an Artificial Landscape Over Southern California," Annals of the Association of American Geographers, 49:80-100, September, 1959.

others. By 1960 the urbanized area had expanded further, covering major portions of the townships it had only started to infiltrate in 1941. The metropolitan district of Indianapolis had also grown and included all of the county in which the city is situated.[36] Unfortunately, the direction and rate of expansion is not made clear and the lack of a follow-up study leaves the course of subsequent growth uncertain.

The results of a study similar to Wehrwein's were published in 1945. Using Sydney, Australia as the study area, N. R. Wills described essentially the same processes and effects that Wehrwein had discussed, although placing more emphasis on the rural aspects of the urban-rural fringe.[37] Wills, too, noted rising land values and the encroachment of residential and industrial uses upon agricultural land as characterizing the fringe. In addition, he noted the small size of the farms and the intensive use of the land for the raising of fruits and vegetables, more extensive uses being unfeasible due to the high cost of land and water and high taxes.

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[36]Based upon a comparison of Wehrwein's map and those included in the 1960 census report. Wehrwein, op. cit., p. 225; U.S. Bureau of the Census, U.S. Census of Population: 1960, Vol. I, Characteristics of the Population, Part 16, Indiana (Washington, D.C.: U.S. Government Printing Office, 1963), pp. 16-30, 16-158.

[37]N. R. Wills, "The Rural-Urban Fringe-Some Agricultural Characteristics," The Australian Geographer, 5:29-35, February, 1945.

Like Wehrwein, Wills did not give any indication of the direction in which urban expansion was moving. Fortunately, a second study involving Sydney has been conducted by R. G. Golledge,[38] that allows for comparison of the city's features in 1945 and 1954. A map of the city and the surrounding area showing the position of the urban-rural fringe in 1933, 1947, and 1954 clearly reveals its outward movement, although it is difficult to distinguish the 1947 from the 1954 position. Golledge provides a second map, however, showing only the position of the urban-rural fringe in 1954. Comparing this map with Wills' map of the fringe it is readily apparent that urban expansion occurred in two directions, south and west from the center of the city. In discussing a number of characteristics of the urban-rural fringe Golledge rather obliquely attributes the expansion to forces such as population growth, the citizen's preference for suburban areas over urban areas as places of residence, and industry's need for additional land. As did Wehrwein and Wills, Golledge fails to include any data concerning the amount of agricultural land taken out of production by urban expansion.

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[38]R. G. Golledge, "Sydney's Metropolitan Fringe: A Study in Urban Rural Relations," The Australian Geographer, 7:243-255, February, 1960.

Further evidence supporting the models of Sinclair and Wolf can be found in work done by Kalevi Rikkinen[39] and Derek Smith.[40] Rikkinen's study of population movements in the area of Duluth, Minnesota tends to support Wolf's "tidal wave" model. Although the time period considered is shorter than that examined by Wolf, a definite movement of population outward from Duluth in the 1950-1960 period can be seen on Rikkinen's maps. The study of the decline of market gardening areas on the urban-rural fringe of Adelaide, Australia conducted by Smith fits into the framework of Sinclair's model quite well. There the rising land values and taxes associated with urban expansion are causing farmers to sell their land and move to areas farther from the city. Smith indicates that the farms remaining in the part of the fringe closest to the city will eventually be replaced by residential subdivisions.

As mentioned above, few studies pertaining to urban expansion provide information related to the amount of agricultural land that is removed from production. Most of them simply indicate that it is being converted to urban uses. As will become evident, however, the amount of land lost from production is not insignificant.

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[39]Kalevi Rikkinen, "Change in Village and Rural Population with Distance from Duluth," Economic Geography, 44: 312-325, October, 1968.

[40]Derek L. Smith, "Market Gardening At Adelaide's Urban Fringe," Economic Geography, 42: 19-36, January, 1966.

Before trying to determine the cost of urban expansion in terms of agricultural land converted to non-agricultural uses, I should note that not all expansion is accomplished at the expense of agriculture. Significant additions to the areal size of cities are made by means of reclamation projects. The draining of swamps and filling in of bays and estuaries have increased the amount of land available to many riverine and coastal cities.[41] Urban areas also frequently encroach upon lands that are unsuited to farming due to poor soil conditions or unfavorable terrain. On the other hand, not all agricultural land that is removed from production is lost to urban encroachment. In a study of thirty-one eastern states in the United States, Hart showed that while urban expansion is a major cause for the loss of agricultural land it is not the only cause.[42] Other causes he cited include abandonment of low quality land, placing land in reserve through conservation plans such as the Soil Bank Program, conversion to forest uses, and the decline of a major crop such as cotton in the southern states. Even

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[41]For a brief discussion and photographs of land fill activities in San Francisco Bay, California where 265 square miles of "land," much of it for urban uses, have been created see: William Bronson, How to Kill a Golden State (Garden City, New York: Doubleday and Co., Inc., 1968), pp. 166-187.

[42]John Fraser Hart, "Loss and Abandonment of Cleared Farm Land in the Eastern United States," Annals of the Association of American Geographers, 58:417-440, September, 1968.

with these causes taken into consideration, the impact of urban expansion on agricultural land is still considerable.

Although Hart plainly illustrated that urban expansion is not the only cause for a decline in the amount of agricultural land in production, the results of his study point to its importance in urban areas. In the study, he used data on cleared farm land in 2,041 counties for the period from 1910 through 1959. A total loss of over sixty-five million acres is shown to have occurred during the fifty year period under consideration, thirty percent of it in 281 metropolitan counties. A careful examination of the figures on net loss (gains minus losses) reveals a slightly different picture. When net loss is considered, almost forty percent is accounted for by the 281 losing metropolitan counties. This amounted to more than 16,000,000 acres of farm land being taken out of production in metropolitan areas.[43] Though other causes may be cited, it seems safe to assume that a large portion of that land was converted to urban uses.

As with Wolf's three miles per decade rate of advance for the metropolitan "tidal wave" though, figures such as these are useful only as gross indicators of the amount of agricultural land being removed from production by urban expansion. Two more useful indicators have been

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[43]Computed from data contained in Hart's study. Hart, op. cit., pp. 421, 428.

provided by Lorne Russwurm[44] and by Griffin and Chatham.[45] In the conclusions of this study of agricultural indicators of urban expansion, Russwurm noted that an average of 192 acres of "improved farm land"[46] was removed from production for each 1,000 persons added to the study area's population. The rate of removal in two townships bordering the city with the greatest percentage population increase was slightly higher, 221 acres per thousand persons added.[47] Net loss during the 1941 to 1961 period covered by the study was over 50,000 acres. The usefulness of Russwurm's ratio of 192 acres lost per thousand population added is enhanced by his statement that "Since the abandonment of marginal land is negligible in the study area the loss of improved farm land is almost solely attributable to conversion into urban land uses."[48] A measure has thus been arrived at that can be used for comparative purposes.

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[44]Lorne H. Russwurm, "Expanding Urbanization and Selected Agricultural Elements: Case Study, Southwestern Ontario," Land Economics, 43:101-107, February, 1967.

[45]Griffin and Chatham, op. cit., footnote 5.

[46]"Improved farm land as classified by the Census of Canada includes cropland, improved pasture and fallow land." Russwurm, op. cit., p. 103.

[47]Ibid., p. 107.

[48]Ibid., p. 106.

Griffin and Chatham's study of urban expansion in central California's Santa Clara County focuses on the forces causing expansion and its effects on agriculture. The primary effect of urban expansion there has been the replacement of farms with residential districts, factories, and shopping centers. The amount of "cultivable soils"[49] taken over by urban uses between 1942 and 1957 totaled 76,000 acres, thirty-three percent of the total available in 1942. The rate of conversion was 257 acres per thousand persons added to the population.[50] Unlike Russwurm, the authors of this study do not clearly indicate whether or not other causes contributed to the loss of "cultivable soils." The tenor of their study, however, indicates that the share attributable to other causes, such as those investigated by Hart, is small. A second value, although considerably different and somewhat less precise in its meaning, may therefore be added to the indicators used to gauge the costs of urban expansion.

The reported rates of agricultural land conversion provide an indication of the effect of urban expansion on

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[49]The soils referred to represent grades I through IV, excellent through poor, as classified by the National Resources Planning Board in 1934. Figure 2 in the study classifies the great bulk of the cultivable soils as "Excellent" and the remainder as "Fair." Griffin and Chatham, op. cit., p. 199.

[50]Ibid., pp. 199-203.

agriculture in the urban-rural fringe. In brief, the effect is one of displacement of agriculture by urban land uses. Its magnitude is reflected by the figures in the studies done by Russwurm, Griffin and Chatham, and Hart. In addition, the likelihood that urban expansion will stop in the near future does not appear great when Wolf's metropolitan "tidal wave" and the forces involved in Sinclair's model are considered. The prospect for the foreseeable future is for continued urban expansion, much of it at the expense of agricultural land.

Urban Expansion In Developing Nations

While the discussion has dealt with urban expansion in developed countries there is reason to believe that similar events are occurring in the developing nations, especially in and near the major urban centers. Urban populations in the developing nations have been increasing and thus creating pressures that lead to urban expansion. In Mexico the urban population increased from 17.7 million in 1960 to 28.7 million in 1969. A similar increase occurred in Iran with urban population growing from 6.8 to 11.3 million in the same period.[51] Large increases were also

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[51]Figures for 1960 obtained from: Department of Economic and Social Affairs, Growth of the World's Urban and Rural Population, 1920-2000, Population Studies No. 44 (ST/SOA/Series A/44), (New York: United Nations, 1970), Table 4, p. 60. Figures for 1969 obtained from: Department

recorded in Taiwan where the population of cities of 50,000 or more people increased from 2.8 million to 6.6 million between 1955 and 1968.[52]

Along with increases in urban population have gone increases in urban area. In Hong Kong and the New Territories the urban area has increased considerably since the turn of the century. The change is illustrated in maps accompanying a study by C. P. Lo in which he discusses the changes, particularly marked since the end of World War Two, that have occurred there.[53] The rate of conversion of agricultural land to non-agricultural uses in Taiwan has been estimated to be approximately 9,900 acres per year.[54]

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of Economic and Social Affairs, Demographic Yearbook 1969 (New York: United Nations, 1970), pp. 144-150. In these and many other developing nations the increases in urban population were much larger in both percentage and absolute terms than were the increases in rural population.

[52]T. K. Tsui, Director, Overall Planning Division, Council for International Economic Cooperation and Development, Taipei, Republic of China. Personal correspondence, February, 15, 1971.

[53]C. P. Lo, "Changing Population Distribution in the Hong Kong New Territories," Annals of the Association of American Geographers, 58:278, 281-283, June, 1968. Other reports on urban expansion in Hong Kong and the New Territories may be found in: S. G. Davis, "The Rural-Urban Migration in Hong Kong and its New Territories," Geographical Journal, 128:329, September, 1962; T. D. Vaughan and D. J. Dwyer, "Some Aspects of Postwar Population Growth in Hong Kong," Economic Geography, 42:47-50, January, 1966; C. T. Wong, "Some Notes on Agricultural Geography in Hong Kong," The Geography Teacher, 1970, p. 28.

[54]Te Tsui Chang. Long-Term Projections of Supply, Demand and Trade for Selected Agricultural Products in

Between September, 1967 and June, 1968 I observed the construction of a number of apartment buildings on agricultural land near Mu Shan, a suburb of Taipei.[55] The area shown in Figure 1 is a suburban area to the south of Taipei as it was in September, 1967. Figure 2 shows the same area in January, 1968. The clump of what appears to be brush on the left side of both photographs is actually a living fence of intertwined bamboo surrounding a farm house. The presence of that type of fence indicates that the farm house within it has been there for many years since it is the fence type favored by the older indigenous farmers. The buildings in the background have almost all been built since the end of World War Two, most of them on land that was previously used for farming. The building under construction that can be seen on the right side of Figure 2 is an apartment building that will house ten families when completed. It was built on land, visible in Figure 1, that had been used for the raising of both rice and vegetables before construction was started. This, and other similar instances I have observed in Taiwan, Korea, the Philippines and South

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Taiwan (Taipei, Republic of China: National Taiwan University, October, 1970), footnote 1, p. 48.

[55]My presence in Taiwan during this period was under the auspices of the California State Colleges International Program, 1600 Holloway Ave., San Francisco, California.

Figure 1. Suburban Area South of Taipei City, Taiwan, September, 1967.

Figure 2. Suburban Area South of Taipei City, Taiwan, January, 1968.

Vietnam,[56] indicate that as in the developed nations, the urban centers in developing countries are expanding, often at the expense of agricultural land. The implications of such expansion for economic development in the developing nations merit consideration.

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[56]The opportunity to observe cities and their environs in these countries was afforded through employment as a crew member on merchant vessels in the years from 1964 through 1969. Although the cities visited were all seaports they were also the largest and most rapidly growing cities in these countries. All had newly built suburban areas on their peripheries and signs of construction underway were evident. Visits to port cities in Japan and a month-long overland journey, from Kagoshima in the south to Sapporo in the north, in 1968 revealed residential and industrial development there similar to that found in developed nations of the western world.

CHAPTER IV

IMPLICATIONS

The Problem

The implications of population growth and urban expansion for economic development in the developing nations manifest themselves in several ways. As more people and larger urban areas must be provided for the problems of organization and administration multiply. More of virtually everything, from schools and jobs to roads and houses, is needed to accommodate the growing numbers of people. A basic need that grows at about the same rate as the population is the need for food. As the number of people to be fed in a country increases the demands placed upon agriculture also increase. The amount of food that must be produced grows ever larger. At the same time the amount of land available for producing food is being diminished as urban centers expand in response to pressures created by population growth. The situation created is one in which given a continuation of population and urban growth, the country's agricultural producers will eventually be unable to meet the needs of the population for food. The country will then be forced to expend valuable foreign

exchange earnings for the purchase of food on the world market. If it has not reached the economic "take off" point in its development before it must start purchasing food, progress in development is likely to be impeded. This impediment will result from the need to divert foreign exchange from investment in capital goods contributing to development to investment in food, an item which is largely unproductive in terms of economic development. As long as the need to purchase food from abroad exists, the rate of economic development will be retarded due to the diversion of investment capital away from development projects and into the stomachs of the populace.[57]

Solutions

A number of solutions are available for coping with and solving the problem of guaranteeing a country an adequate supply of food. Those holding promise of being successful include controlling population growth, increasing the productivity of agriculture, increasing the amount of land farmed, and minimizing losses of cultivated land to urban expansion. The first of these, controlling the growth of population, is the solution that ultimately will have to be adopted by all countries, both developed and developing.

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[57]Ester Boserup, "Present and Potential Food Production in Developing Countries," Geography in a Crowding World, Wilbur Zelinsky, Leszek A. Kosinsky, and R. Mansell Prothero, editors (New York: Oxford University Press, 1970), p. 112.

Its adoption will be forced on them by the earth's limited capacity to provide sustenance for human beings. The amount of success enjoyed in implementing the other solutions mentioned will determine how soon population control becomes an absolute necessity for the survival of mankind.

Controlling population growth is a long term solution to the food supply problem. This is primarily because the implementation of control programs designed to halt population growth requires a considerable amount of time. People must first be convinced that limiting population size is a good idea and necessary if they are to realize material improvements in their lives. Once people are convinced of this necessity they must be provided with the means to limit the number of children produced. Programs aimed at limiting population growth must consider the currently fertile population as well as the increasing numbers of people who will be entering the reproductive ages over the next fifteen to twenty years. The large numbers of participants in future birth control programs are seen today in the number of children under fifteen years of age in the total population. In the developing nations they constitute about forty percent of the total and represent ". . . the gunpower of the population explosion."[58] Halting population growth will require a tremendous blunting of their reproductive potential.

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[58]Paul R. and Anne H. Ehrlich, op. cit., p. 31.

Given these and other considerations, including important religious, political and cultural barriers that must be overcome, it has been estimated that it will be thirty years before birth control programs can significantly slow population growth.[59] In the meantime other ways of meeting the food supply problem will have to be found. Although population control programs are necessary if the appearance of unsupportable numbers over a long period of time is to be prevented, they do not provide a ready means of limiting the need for food and the load on agriculture in the immediate future.

The prospects for increasing the productivity of agriculture in the developing nations through the use of hybrid seeds, fertilizer, pesticides, and increased irrigation seem quite good. In the Philippines, for example, rice production was increased experimentally to 10,000 pounds per acre between 1962 and 1968 at the International Rice Research Institute at Los Banos.[60] The remarkable

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[59] Ibid.; For a brief discussion of some of the problems involved and techniques developed in a birth control program operating in Taiwan see: Loren Fessler, "Taiwan as a Model for Family Planning," American Universities Field Staff Reports, East Asia Series, Vol. 17, No. 7, May, 1970.

[60] Melvin A. Benarde, Race Against Famine (Philadelphia: Macrae Smith Co., 1968), p. 56. Although the figure reported by Benarde represents production under experimental conditions it does indicate the potentialities of new rice strains when properly raised. Actual production levels are far below those achieved under carefully controlled experimental conditions. The Japanese, for example, are considered

increase in productivity came about through the use of the IR-8 "miracle rice" seed, plus proper irrigation and fertilization. Though average yields have not equalled those produced experimentally, the use of the new strains of rice seed has resulted in the Philippines changing from a rice deficient to a rice surplus country.[61]

While it is possible to raise agricultural productivity significantly there are two sets of problems that have arisen or may appear in the future associated with increasing production. The first of these is related to the spread and adoption of new seeds and techniques. Areas in which adoption has already occurred are those that were best prepared to handle these innovations. Further extension of the area planted to the "miracle" grains will require considerable investment in irrigation works, better marketing systems, and efforts to educate farmers in the use of the seeds, fertilizers and pesticides. Mechanisms will also have to be set up to provide small farmers with

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to have rice yields among the highest in the world, yet in 1968 their average yield was 4,490 kg. per hectare or about 4,000 lbs. per acre. Average yields in Taiwan and Korea have been about 3,000 kg. per hectare (2,700 lbs. per acre) in recent years.

[61] Bernarde, op. cit., pp. 56-67.

a means of securing credit at reasonable rates if they are to be able to take full advantage of the latest innovations in agriculture.[62]

The second set of problems involves difficulties that may arise as the adoption of the new seeds and techniques becomes more widespread. For instance, the disease resistance capabilities of the new strains of wheat and rice are largely unknown. Should a plant pathogen appear for which agronomists are unprepared, entire crops could be lost and the countries depending upon them faced with a food shortage crisis on rather short notice. Fluctuations in market prices paid to farmers must be guarded against lest prices decline as production rises and leave farmers in financial difficulty even though they produce more food. Finally, the international effects of formerly food deficient countries becoming self-sufficient must be considered. What will happen to the economies of the countries that currently depend on food exports to provide them with foreign exchange if the markets for their produce disappear? These and other

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[62] Clifton R. Wharton, Jr., "The Green Revolution: Cornucopia or Pandora's Box?" Foreign Affairs, 48: 758-768, April, 1969; "The Third World: Seeds of Revolution," Time, July 13, 1970, pp. 24, 27. A discussion of some of these problems which have appeared in India may be found in: Wolf Ladejinsky, "Ironies of India's Green Revolution," Foreign Affairs, 48: 758-768, July, 1970.

potential problems must be allowed for and the limitations of the "green revolution" recognized when evaluating the prospects for increasing food production.[63]

Another solution for the food supply problem is the addition of more land to the area which is already in agricultural production. Estimates of how much land on a world scale that could be converted to use for food production vary widely, from a few million to several billion acres. Most of the potentially arable land, however, is in the Amazon Basin and sub-Saharan Africa, and its use must await the development of techniques suited to the tropical climate and the "fragile" soils found in these areas.[64] In Asia almost ninety percent of the potentially arable land is already in use. Utilization of the remainder will require the clearing of land and construction of irrigation facilities. Overall, most of the land that can be easily and inexpensively developed for agricultural use is already in production.[65] Further additions to the area now in production will require considerable amounts of time, money and planning. The first two requirements are those which developing nations tend to have in short supply.

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[63]Wharton, op. cit., pp. 468-75.

[64]Joseph A. Tosi, Jr. and Robert F. Voertman, "Some Environmental Factors in the Economic Development of the Tropics," Economic Geography, 40:189-205, July, 1964.

[65]Paul R. and Anne H. Erhlich, op. cit., pp. 91-96; Lester R. Brown, "The World Outlook for Conventional Agriculture," Science, 148:607, November, 1969.

The last of the solutions mentioned earlier, minimizing losses of cultivated land to urban expansion, is at best only a partial solution. It is, however, one that would help to maintain food supplies and avoid having to purchase food from abroad. It is also a solution that can be implemented relatively quickly and at costs lower than those associated with population control projects or plans aimed at increasing agricultural production. In its simplest form it involves little more than governments ordering a halt to the conversion of land from agricultural to urban uses. Although such an order would do nothing to increase food supplies, it would help keep them from being diminished. It would also serve to retain the opportunity to increase the productivity of the preserved farm land in the future, an opportunity lost once land is converted to urban uses. The costs of enforcing the order and planning for urban growth that would not encroach upon agricultural land would appear to be the only direct costs involved. Finally, the inherent rationality of preserving existing farm land, and thereby at least safeguarding the current levels of food production, should appeal to virtually everyone. Consequently, opposition to this solution would be limited primarily to those having vested interests in urban expansion, i.e., land speculators, construction firms and perhaps local politicians.

The Implication

The major implication of urban encroachment upon agricultural land for economic development is that it is compounding existing problems of food supply, or hastening the day when the securing of food becomes a problem in many developing nations. Each piece of farm land converted to urban uses represents an increase in the food supply problem. If the stocks of food are to be maintained the production from each piece of converted farm land must be replaced. This can be done by increasing the productivity of the remaining farms, putting new land into use, or a combination of both. These procedures require time, planning and the investment of capital in order to be effective. If it becomes necessary for a country to expend capital simply to replace farm production lost due to urban expansion, any efforts aimed at increasing the total amount of food available will be diluted. A larger investment will be required to produce an increase than would have been otherwise necessary. In addition, capital invested in the simple maintenance of the food supply, either for increasing domestic production or financing food imports, can not be made available for investment in economic development projects. Urban expansion is, therefore, a double-edged sword striking at both food production and the investment capital available for development. It is a process that developing nations can ill-afford to have going on within their boundaries.

An indication of the effects of urban encroachment on agricultural land can be gained by considering a hypothetical situation in a developing nation. Assume that between 1955 and 1968 the cost of urban expansion in terms of agricultural land in Taiwan was one-twentieth of that found in Griffin and Chatham's study of Santa Clara County, California. This amounts to 12.9 acres or 5.4 hectares per thousand persons added to the population. Assume also that all agricultural land converted to urban uses was rice producing land, that yield per hectare was three metric tons, and that annual per capita consumption of rice was 130 kilograms.[66]

Between 1955 and 1968 4,572,000 people were added to Taiwan's population. If the assumed values had been operating 24,679 hectares of land capable of producing 74,087 metric tons of rice would have been removed from production. These figures represent production from 2.7 percent of the 900,000 hectares of cultivated land in use in 1968 that would have been unavailable due to urban expansion. Rice needed to meet the average per capita consumption would not have been available for 570,000 people, about five

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[66]Three metric tons per hectare is close to the average yield reported for Taiwan in the years 1965 through 1969. The consumption rate of 130 kilograms per capita is an estimate based on data from Japan and Thailand. Units of measure: 1 hectare equals 2.45 acres, 1 metric ton equals 1,000 kilograms, 1 kilogram equals 2.2 pounds.

percent of Taiwan's 1968 population. The cost of providing a basic supply of rice for this many people would place a sizable dent in foreign exchange reserves that might otherwise have been used for economic development projects. Fortunately, Taiwan in 1968 produced sufficient quantities of rice with which to meet its needs, and capital was not diverted from development projects to feed the people.

The Record in Other Countries

In light of the points that have been discussed it would appear desirable for a developing country to undertake a multifaceted program aimed at retarding population growth, increasing agricultural production, and stopping the conversion of land from agricultural to urban uses. Most countries have started projects designed to increase food production and have adopted programs either explicitly or implicitly aimed at curbing population growth. While efforts in these areas have at least begun, projects and plans for preserving agricultural land are lacking, even in developed countries.

In the Netherlands, for example, the conversion of agricultural land to urban uses is seen as

inevitable.[67] Plans for controlling urban expansion are designed to make the conversion process orderly and in accord with urban development designs. In Poland, plans for dealing with urban growth in Warsaw call for the spreading of the city's functions to satellite cities.[68] Apparently the possibilities for the expansion and merging of the satellite cities to form one large metropolitan area have not received much attention. In addition to these examples, some of the literature discussing urban expansion implies that the major problem is not encroachment on farm land as such, but the failure to plan the encroachment properly. Careful planning for the conversion of land from farm to urban uses is seen as the best way to assure a regular and adequate supply of land for urban growth.[69]

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[67] Ronald H. Buchanan, "Toward Netherlands 2000: The Dutch National Plan," Economic Geography, 45:261-266, July, 1969.

[68] Michal Kaczorowski, "The Warsaw Metropolitan Region," Papers: Regional Science Association, Crawcow Congress, 1965, 16:100-103, 1966.

[69] Edward Higbee, "Agricultural Land on the Urban Fringe," Metropolis on the Move: Geographers Look at Urban Sprawl, Jean Gottmann and Robert A. Harper, editors (New York: John Wiley and Sons, Inc., 1967), pp. 57-66; Steiner, op. cit., p. 361, passim.

In the developing nations efforts aimed at halting urban expansion have been at best only partially effective. In Egypt the construction of public buildings on arable land has been prohibited.[70] In Taiwan one of the criteria used in selecting a site for the new provincial capital was that it be located so as to minimize the amount of agricultural land taken out of production.[71] These two examples indicate that there is at least an awareness of the need to preserve agricultural land in some of the developing countries.

On the otherhand, in Hong Kong and the New Territories where population pressure on the land is heavy, ". . . rapid expansion of urban industrial areas has converted much fertile land into . . ." new towns, roads, reservoirs, and shack settlements.[72] In Korea the government has passed a number of laws aimed at increasing agricultural production. At the same time government housing projects have been designed to

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[70]Rosciszewski, op. cit., p. 340.

[71]Yukon Feng, "Urbanization Policy and Metropolitan Planning in Taiwan," Industry of Free China, 25:25, June, 1966.

[72]C. T. Wong, "Some Notes on Agricultural Geography in Hong Kong," The Geography Teacher, 1970, p. 28.

" . . . decentralize metropolitan population into rural areas . . . ."[73] The impression gained, whether developing or developed nations are considered, is that most efforts that have been made to halt urban expansion are at best piecemeal, of limited scope or designed to place the preservation of agricultural land second in importance behind urban development plans.

A Hypothetical Projection

A simulation model can be used to demonstrate the effects of successfully implementing programs designed to curb population growth and increase food production while nothing is done to halt urban expansion. Given a specific population, the amount of food produced, and a rate of food consumption, the size of the food surplus or deficit in a country may be determined. If rates of change in food production and population are added to the model the surplus or deficit condition of the food supply over a period of time may be estimated. Other variables can be added to determine their effect and aid in predicting if and when a country will encounter a food deficit situation.

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[73] Korea Annual 1969 (Seoul, Korea: Hapdong News Agency, 1969), pp. 203, 246.

A deterministic mathematical model[74] incorporating those elements just described was designed and programmed for use with a computer (Appendix A). The model was set up to include changing amounts of cultivated land, crop yields, and food consumption and changing rates of population increase. An indicator of the demands placed on agricultural land due to the forces of population growth and urban expansion was also included in the program.

The functioning of the model depends upon a number of assumptions that specify the conditions and limits within which it operates. The basic assumption is that effective population control and food production increasing programs have been implemented in a hypothetical place called Country X. Equally basic is the assumption that nothing is being done in Country X to halt urban encroachment on agricultural land. Along with these assumptions go provisos that all cultivated land will be planted to one crop, the consumption rate and agricultural technology will remain constant, and no catastrophes such as war or drought will occur. With these basic conditions established, a more detailed

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[74] J. P. Cole and C. A. M. King, Quantitative Geography (New York: John Wiley and Sons, Ltd., 1968), pp. 479-481.

discussion of the rates of change will help explain the operation of the model.

Country X is a small state encompassing 50,000 square kilometers, about half the size of Korea. Its population numbers 45,000,000 and has been increasing at the rate of three percent per annum. A birth control program was successfully initiated and it is expected that the rate of population increase will decline at the rate of one tenth of one percent per annum. The rate of increase is assumed to continue declining until it reaches one percent per year and then stabilize at that level.

This set of conditions fits within the time span of thirty years which is estimated to be required for birth control programs to significantly slow population growth.[75] The rate of decline in the rate of population increase is similar to that reflected in population figures for Korea where a birth control program was started in 1963.[76] Also, the stabilization

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[75]Paul R. and Anne H. Ehrlich, op. cit., p. 31.

[76]Chi Soo Youk, "The Economic Program and Population," Korean Affairs, 1:35-36, February-March, 1962. A discussion of some of the problems with the Korean birth control program.

level of one percent per annum is similar to the growth rate that Japan has maintained since the mid 1950's.

The programs designed to increase food production involve both increasing yields through the adoption of modern farming methods and bringing all of the available arable land into use. Rice is assumed to be the crop that will be raised on all of the cultivated land. Yields are expected to increase from a beginning level of 3,000 kilograms per hectare to about 4,500 kilograms per hectare, approximating Japanese yields in 1967 and 1968. The rate of increase is assumed to be three percent per year.

Country X has an arable area equal to one quarter of its total area. It is assumed that at the beginning of the projects aimed at increasing the amount of land being cultivated only eighty percent of the arable land is in use. Each year 1.25 percent of the total amount of the arable land will be added to the amount being cultivated. The area being cultivated will increase until all of the arable land has been put into production. At the same time, one quarter of one percent of the arable land will be assumed to have been removed from production each year by urban expansion. The result is that the net annual increase

in the amount of land in agricultural production will be only one percent of the total amount of arable land. When all of the land that can be cultivated has been put into production the cultivated area will start declining as urban expansion continues.

A consumption rate 120 kilograms per capita per year was selected based upon data for Japan and Thailand. In Japan, the rate of consumption for rice was about 100 kilograms per capita in 1970.[77] The consumption rate in Thailand has been estimated to be between 146 kilograms and 167 kilograms per capita.[78] The rate of 120 kilograms per capita is therefore probably conservative. It may even represent austere consumption levels forced on Country X by low agricultural productivity and a concentration of investment capital in industrial economic development projects.

In order to allow for double cropping within the model a measure of the rate of land utilization was included. A value greater than one for this measure indicates that double cropping is being practiced. The rate is held constant on the assumption that it is the

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[77]Bureau of Statistics, Statistical Handbook of Japan, 1970, (Tokyo, Japan: Office of the Prime Mininster, 1970), p. 31.

[78]Edward VanRoy, "The Malthusian Squeeze," Asian Survey, 7:473, 1967.

maximum possible under the conditions prevalent in Country X. The value chosen for the rate of utilization was 1.55, denoting the production of two crops of rice on a little more than half of the cultivated land. It was selected on the basis of data for Japan and Taiwan and falls midway between a low of 1.18 in Japan and a high of 1.88 in Taiwan in 1968.[79]

The computations involved in the model are simple and straightforward. Consumption (C) is the product of population (P) and the consumption rate (CR). Total yield (TY) is calculated by multiplying the amount of land cultivated (CL) by the rate of utilization (R), and that product by the yield value (Y). The food surplus or deficit is determined by subtracting consumption from total yield, a negative value indicating a food deficit. The general formula is:

$$SD = TY - C$$
$$\text{Where} \quad TY = CL \times R \times Y$$
$$\text{and} \quad C = P \times CR$$

To estimate the food supply over a period of time the population, cultivated land, and yield values are incremented at the selected rates and the computations repeated.

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[79]Council for International Economic Cooperation and Development, Taiwan Statistical Data Book 1970 (Taipei, Taiwan: Executive Yuan, 1970), p. 28; Bureau of Statistics, Japan Statistical Yearbook 1969 (Tokyo, Japan: Office of the Prime Minister, 1970), p. 113.

Results of the Simulation

The results of using the values for Country X in the simulation model are shown in Table 1. The units of measure are hectares for cultivated land and kilograms for yield, total yield, consumption and surplus-deficit status. The figures for year one represent the situation in Country X at the start of the birth control and food production increasing programs. There was a rice shortage that amounted to 750,000,000 kilograms, meaning that food for 6.25 million people had to be purchased or otherwise procurred from abroad. By the eleventh year the combined effects of slowing population growth, increasing yields, and additional land being put into agricultural production were felt and a food surplus was produced. In the fifteenth year yields reached the maximum level possible and the largest surplus of the thirty-five year period resulted. This happened even though not all of the arable land was in production. All of the arable land was brought into production in the twenty-first year and total yield reached its highest level. Although a surplus was produced it was smaller than those produced in the preceding years due to the continuing growth of the population and increasing consumption needs. The rate of population increase reached its stabilization level of one percent per annum in the twenty-first year and remained at that level for the rest of the simulated period.

TABLE I

SIMULATION

AGRICULTURAL PRODUCTION AND POPULATION IN COUNTRY X

YEAR	POPULATION	CULTIVATED AREA	PCT. ARABLE AREA CULTIVATED	CULTIVATED AREA PER CAPITA	YIELD	TOTAL YIELD	CONSUMPTION	SURPLUS - DEFICIT STATUS
1	45000000	1000000	80.00	.0222	3000	4649999999	5400000001	-750000000
2	46350000	1012499	81.00	.0218	3090	4849368749	5562000000	-712631250
3	47694150	1024399	82.00	.0215	3182	5056514624	5723299000	-666784375
4	49039596	1037499	83.00	.0212	3278	5271724820	5883550343	-611825523
5	50383785	1049999	84.00	.0209	3376	5495298764	6042406207	-547109438
6	51662577	1062499	85.00	.0206	3477	5727538473	6199504764	-471970291
7	52954177	1074999	86.00	.0203	3582	5968768917	6354496487	-385727566
8	54225036	1087499	87.00	.0201	3689	6219318403	6507004399	-287685996
9	55472212	1099999	88.00	.0198	3800	6479528966	6656665500	-177136534
10	56692601	1112499	89.00	.0196	3914	6749754776	6803112141	-53357364
11	57883145	1124999	90.00	.0194	4031	7030362559	6945977496	84385062
12	59040808	1137499	91.00	.0193	4152	7321732029	7084897046	236834983
13	60162584	1149999	92.00	.0191	4277	7624256342	7219510090	404746252
14	61245510	1162499	93.00	.0190	4405	7938342554	7349461271	588881282
15	62286684	1174999	94.00	.0189	4537	8264412109	7474402113	790009995
16	63283271	1187499	95.00	.0188	4537	8352331386	7593992547	758338839
17	64232520	1199999	96.00	.0187	4537	8440250664	7707902435	732348229
18	65131775	1212499	97.00	.0186	4537	8528169942	7815813069	712356872
19	65978488	1224999	98.00	.0186	4537	8616089220	7917418639	698670580
20	66770230	1237499	99.00	.0185	4537	8704008497	8012427663	691580834
21	67504703	1249999	100.00	.0185	4537	8791927775	8100564367	691363408
22	68179750	1250000	100.00	.0183	4537	8791927775	8181570011	610357764
23	68861547	1246874	99.75	.0181	4537	8769947956	8263385711	506562244
24	69550163	1243749	99.50	.0179	4537	8747968136	8346019568	401948568
25	70245664	1240624	99.25	.0177	4537	8725988317	8429479764	296508553
26	70948121	1237499	99.00	.0174	4537	8704008497	8513774561	190233936
27	71657602	1234374	98.75	.0172	4537	8682028678	8598912307	83116371
28	72374178	1231249	98.50	.0170	4537	8660048859	8684901430	-24852571
29	73097920	1228124	98.25	.0168	4537	8638069039	8771750444	-133681405
30	73828899	1224999	98.00	.0166	4537	8616089220	8859467949	-243378728
31	74567188	1221874	97.75	.0164	4537	8594109400	8948062629	-353953227
32	75312860	1218749	97.50	.0162	4537	8572129581	9037543254	-465413673
33	76065989	1215624	97.25	.0160	4537	8550149761	9127918697	-577768925
34	76826648	1212499	97.00	.0158	4537	8528169942	9219197874	-691027931
35	77594915	1209374	96.75	.0156	4537	8506190123	9311389853	-805199730

During the last fourteen years the population continued increasing, drawing upon the surplus agricultural production to meet its needs. At the same time, however, the effects of urban encroachment on an agricultural land began to appear as the amount of cultivated land actually decreased. Total yields declined while consumption needs continued to increase. Finally, after a seventeen year period of surpluses, agricultural production reached the point, in the twenty-eighth year, where it could not supply enough food to meet the country's needs. Production continued to decline until, in the last year of the simulated period, the food deficit was larger than it had been at the start of the birth control and food production increasing programs.

What would have happened if urban expansion onto agricultural land had not occurred? First, the amount of time required to put all of the arable land into use would have been shorter, sixteen instead of twenty years. As a result the first rice surplus would have appeared in the tenth rather than in the eleventh year. Second, there would not have been a decrease in the amount of cultivated land in the latter part of the simulated period. Third, total yields would have remained at the peak levels reached in the twenty-first and twenty-second years. The surpluses would, therefore, have been sufficient to provide for increases in the population for an additional two years, delaying the

reappearance of a food deficit from the twenty-eighth to the thirtieth year. Finally, since only population growth would have been involved in the reappearance of food shortages they would have been smaller and increased in size less rapidly. The magnifying effect of decreasing total yields brought about by the removal of cultivated land from use would not have joined with population growth to increase the size of the deficits.

The indicator of the demands placed on agricultural land due to population growth and urban expansion mentioned earlier is presented in the column titled Cultivated Land Per Capita in Table 1. The figures represent the amount of cultivated land available to support each person in the population. As can be seen, the amount available declined continuously, even when the total amount of cultivated land was increasing. Looking at these figures in another way the number of people to be supported by each hectare of cultivated land increased thirty percent, from forty-five to sixty-four, during the period simulated. It should be noted, however, that the rate of decline varied. It was highest in the early years when rates of population increase were high. The lowest rates appeared in the middle years as the rate of population increase approached its stabilization level and cultivated land approached the maximum possible area. The rate increased as the effects of the removal of cultivated land from production were added to those of population growth. The

effects of urban expansion can thus be seen not only in changes in the amount of food produced, but also in the amount of land available to provide food for each person.

If the years when there was a food surplus are looked upon as the years in which economic development could best take place the effect of urban expansion becomes clear. In the case of the hypothetical Country X, the effect of urban encroachment on agricultural land was to shorten the period available for economic development by a total of three years. A second effect was to reduce the size of surpluses and thus also reduce the amount of income that might have been gained through their sale. If all arable land had been put into production by the sixteenth year the surplus in that year would also have been fifty-two percent larger and presented greater opportunities to earn foreign exchange with which to finance economic development. Finally, when deficits reappeared they were larger than they would have been if no land had been converted from agricultural to urban uses.

In short, the effect of urban encroachment on agricultural land and was to force Country X to attempt to establish a firm base for its economic development in a shorter period than would otherwise have been the case. It was also placed in the position of having to pay for development projects with less than the full potential amount of financial assistance from the agricultural sector of the economy. In

addition, it had to contend with larger food deficits in the years of shortage than would have appeared if no farm land had been removed from production.

The obvious solution to the food supply problem is to halt the growth of population. As noted earlier, though, this is a long term solution that is fraught with problems of its own. Increasing agricultural production is another solution that could reduce or eliminate the problem of food supply. Although it too has its problems and limitations, increasing food production is a solution that can be effectively implemented in less time than is required for birth control programs to take effect. The remedy advocated here, to be implemented in conjunction with the other two, is to halt the conversion of agricultural land to urban uses. It is a solution that may be put into effect rapidly and at relatively low costs in comparison to other remedies. It is also a solution that has received little apparent attention in developing nations such as Taiwan and Korea or in developed nations such as Japan.

CHAPTER V

TAIWAN, KOREA AND JAPAN

Taiwan and Korea are two of the most rapidly developing nations in Asia today. They rank second and third respectively behind Japan in terms of per capita income, employment in manufacturing, and industrial production.[80] They are also countries that have, while managing to curb population growth and increase food production, experienced rapid urbanization of their populations. The growth of urban population in Taiwan, Korea and Japan,[81] has led to an increase in the areal size of urban centers. An examination of population growth patterns, changes in the amounts of land in agricultural and urban uses, and increases in production of the basic food staple, rice, provides some insight into the problem of urban encroachment on agricultural land.

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[80]Based on data from: 1969 World Population Data Sheet (Washington, D.C.: Population Reference Bureau, 1969); Taiwan Statistical Data Book 1970 (Taipei Taiwan: Executive Yuan, 1970); Economic Statistics Yearbook (Seoul, Korea: Bank of Korea, 1970); Japan Statistical Yearbook 1969 (Tokyo, Japan: Office of the Prime Minister, 1970).

[81]More precisely, the forty-six prefectures of Japan included in the 1965 census, Taiwan Province, Republic of China, and the eleven southernmost provinces of Korea which constitute the Republic of Korea.

The period between 1955 and 1968 was chosen for examination because of the availability and comparability of data for those years. Another consideration in selecting this time period was the level of stability in each country. The instability and dislocation brought about by World War Two and the upheavals that followed in the post-war years had largely subsided by 1955. Japan was started on the path to economic recovery, helped along by both American aid programs and the demands for goods and services generated by the Korean War. The situation on Taiwan had changed from one of impending war with the forces on the Chinese mainland to one emphasizing the development of the island as an economic unit. Conditions in Korea were less stable, but the ravages of war had been replaced by the demands of peace and the need to rebuild and develop the country. Given the availability of data and the prevailing conditions, 1955 was felt to be a reasonable starting point for an examination of these countries.

The selection of 1968 as a cutoff was based solely on the availability of data. While some information related to Taiwan and Korea for 1969 was available, much of it was based upon estimates or preliminary returns for the year. Data for Japan comparable with that for other years was not available. In order to avoid the use of potentially misleading information, therefore, data for 1969 are not included in the tables accompanying this study.

Population Increase

The populations of Taiwan, Korea, and Japan increased considerably between 1955 and 1968 (Table 2).[82] In Taiwan the increase amounted to slightly more than fifty percent. Japan's population grew by almost fourteen percent. In Korea the increase was thirty-eight percent during the shorter thirteen year period from 1956 through 1968.[83] These percentage figures, while considerably different, mask the size of the increases in terms of the number of people actually added to the populations. Taiwan's fifty percent increase, for example, represents the addition of 4.57 million people to the population while Japan's fourteen percent increase represents the addition of 12.13 million people to its population.

The differences between Taiwan, Korea and Japan in terms of growth rates are considerable. The growth rate

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[82]Population figures for Taiwan do not include military personnel. Those for Korea are estimates based upon the 1955 and 1960 census reports. Allowances were apparently made for the effects of birth control programs started in 1963 in the figures for the years from 1964 onward. The estimate for 1966 is 182,000 higher than the figure arrived at through the census taken in that year. Figures for Japan are estimates based upon census reports for 1955, 1960, and 1965.

[83]Figures published in Korea Annual (Seoul, Korea: Hapdong News Agency, 1970), p. 398, for 1967 and 1968 are somewhat larger than those shown in Table 2. Using those figures, the increase in population between 1956 and 1968 was thirty-nine percent instead of thirty-eight percent.

Table 2

Population, Growth Rate, and Density Per Hectare of Cultivated Land

Year	Taiwan			Korea			Japan		
	Population (1000's)	Growth Rate	Density	Population (1000's)	Growth Rate	Density	Population (1000's)	Growth Rate	Density
1955	9,078	3.8%	10.40	N.A.	N.A.	N.A.	89,276	N.A.	N.A.
1956	9,390	3.4%	10.72	22,307	N.A.	N.A.	90,170	1.0%	15.00
1957	9,690	3.2%	11.10	22,949	2.8%	11.48	90,924	0.8%	15.04
1958	10,039	3.6%	11.36	23,611	2.8%	11.73	91,763	0.9%	15.13
1959	10,431	3.9%	11.88	24,291	2.8%	12.05	92,638	0.9%	15.25
1960	10,792	3.5%	12.42	24,989	2.8%	12.34	93,419	0.8%	15.39
1961	11,149	3.3%	12.79	25,700	2.8%	12.64	94,285	0.9%	15.49
1962	11,512	3.3%	13.20	26,432	2.8%	12.81	95,178	0.9%	15.65
1963	11,884	3.2%	13.63	27,184	2.8%	13.07	96,156	1.0%	15.87
1964	12,257	3.1%	13.89	27,939	2.7%	12.87	97,186	1.1%	16.09
1965	12,628	3.0%	14.20	28,670	2.6%	12.71	98,248	1.1%	16.36
1966	12,993	2.9%	14.50	29,375	2.4%	12.81	99,056	0.8%	16.52
1967	13,297	2.3%	14.74	30,067	2.3%	13.00	100,243	1.2%	16.88
1968	13,650	2.7%	15.17	30,747	2.2%	13.26	101,408	1.2%	17.20

Sources: Taiwan Statistical Data Book 1970, Taipei, Taiwan, 1970.
Economic Statistics Yearbook 1970, Seoul, Korea, 1970.
Japan Statistical Yearbook 1964, Tokyo, Japan, 1970.
Growth Rates and Densities calculated from these sources.
N.A.--Not Available.

data shown in Table 2, however, mask a significant similarity of the countries under consideration. While growth rates in Taiwan and Korea declined, reflecting the implementation of birth control programs, the actual number of people added to their populations each year increased. The same thing happened in Japan even though the growth rate there remained relatively constant.

In 1956, 312,000 people were added to Taiwan's population, an increase of 3.4 percent over the 1955 population. By 1968 the growth rate had decreased to 2.7 percent, but 353,000 people were added to the population. Korea's experience was similar. The growth rate declined from 2.8 to 2.2 percent while the actual number of people added increased from 642,000 in 1957 to 680,000 in 1968.[84] Even with its relatively constant growth rate, Japan's actual annual increment in population increased from 894,000 in 1956 to 1,165,000 in 1968.

The significance of the increases lies in fact that even though growth rates decreased in Taiwan and Korea, and remained essentially constant in Japan, the actual number of additional people to be fed increased each year. Not only were more people added to the population each year,

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[84]Chi Soo Youk, "The Economic Program and Population," Korean Affairs, 1:35-36, February-March, 1962. Disputes the accuracy of the 1955 and 1960 census reports upon which the estimated growth rates were based.

but as illustrated, the magnitude of the increment grew with the passage of time. Thus even though growth rates decreased or remained at a low level, the demands for food placed upon agriculture increased at an increasing rate.

The demands placed upon agriculture are represented by the density of population per hectare of cultivated land (Table 2). In Taiwan the density increased forty-six percent between 1955 and 1968, due to high rates of population growth in combination with only small increases in the amount of land cultivated. The increases in Korea and Japan were considerably less, about fifteen percent in both countries. This was due primarily to significant increases in the amount of land cultivated in Korea and similar increases in Japan up to 1962 (Table 3). It is interesting that even though large increases in the amount of land cultivated occurred in Korea between 1963 and 1967, they served to provide only a temporary slackening in the burden placed on agricultural land. By 1968 the increases in population had pushed the population-cultivated land ratio above the previous high recorded in 1963 (Table 2).

Cultivated Area

Throughout the period for which comparable data is available both Taiwan and Korea increased their cultivated areas. Taiwan appears to have reached the upper limit in the amount of land that can be put into agricultural

Table 3

Cultivated Land, Farm Households, and Ratio of Land to Households

Year	Taiwan			Korea			Japan		
	Land	Households	Ratio	Land	Households	Ratio	Land	Households	Ratio
1955	873	732,555	1.19	N.A.	2,218,185	0.900	N.A.	6,076,000	N.A.
1956	876	746,318	1.17	N.A.	2,200,549	0.905	6,013	N.A.	N.A.
1957	873	759,234	1.15	1,999	2,210,914	0.904	6,045	N.A.	N.A.
1958	884	769,925	1.15	2,012	2,218,323	0.907	6,064	N.A.	N.A.
1959	878	780,402	1.12	2,016	2,267,419	0.889	6,073	N.A.	N.A.
1960	869	785,592	1.11	2,025	2,349,506	0.862	6,071	5,975,000	1.02
1961	872	800,835	1.09	2,032	2,327,116	0.874	6,086	5,923,000	1.03
1962	872	809,917	1.08	2,063	2,469,453	0.835	6,081	5,903,312	1.03
1963	872	824,560	1.06	2,080	2,415,593	0.861	6,060	5,855,682	1.03
1964	882	834,827	1.06	2,171	2,450,308	0.886	6,042	5,806,000	1.04
1965	890	847,242	1.05	2,256	2,506,899	0.900	6,004	5,665,000	1.06
1966	896	854,203	1.05	2,293	2,540,274	0.902	5,996	5,498,000	1.09
1967	902	868,731	1.04	2,312	2,586,864	0.894	5,938	5,419,000	1.10
1968	900	877,114	1.03	2,319	2,578,526	0.900	5,897	5,351,000	1.10

Cultivated Land in Thousands of Hectares.
N.A.--Not Available
Sources: Taiwan Statistical Data Book 1970, Taipei, Taiwan, 1970.
Economic Statistics Yearbook 1970, Seoul, Korea, 1970.
Japan Statistical Yearbook 1969, Tokyo, Japan, 1970.
Ratio Figures in Hectares

production. With one quarter of its 35,951 square kilometer area considered arable, the 900,000 hectares cultivated in 1968 represent utilization of all the arable land. However, by exploiting ". . . tidal land in western Taiwan and hillsides and riverbeds in eastern Taiwan . . ."[85] the cultivated area was increased to 914,000 hectares in 1969[86] (Figures 3 and 4). The prospects for further increases, though, appear to be slim.

At the same time that the total area under cultivation in Taiwan was increasing, urban expansion was removing agricultural land from production.[87] Between 1957 and 1966 a total of 6,866 hectares of agricultural land was converted to urban uses.[88] During the slightly

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[85] China Yearbook 1969-70 (Taipei, Taiwan: China Publishing Co., 1970), p. 188.

[86] Council for International Economic Cooperation and Development, Taiwan Statistical Data Book 1970 (Taipei, Taiwan: Executive Yuan, 1970), p. 27. Hereinafter cited as T.S.D.B. 1970.

[87] The changes in Taiwan described here closely resemble those simulated for Country X between the first and twenty-second years (see Table 1). All of the arable land, plus some marginal land, has been put into agricultural production. At the same time some agricultural land has been converted to urban uses.

[88] United Nations Study on Urban Land Use Policies and Land Control Measures in the ECAFE Region (compiled by the Urban and Housing Development Committee of CIECD, Republic of China, April, 1970), p. 49. Hereinafter cited as United Nations Study. Te Tsui Chang reports that "In the 18-year period, 1951-1968, more than 9,000 hectares of fertile farm land, mostly rice paddy fields, were converted to building sites." Te Tsui Chang, editor,

Figure 3. A Hillside Terraced Almost to the Top Near Mu Shan, Taipei Hsien, Taiwan, October, 1967.

Figure 4. Cultivated Land in the Bed of the Chung Chiang River Near Nan Chuang, Miao-Li Hsien, Taiwan, October, 1967.

longer period from 1956 through 1967 conversion of farm land in Taipei and its suburbs totaled 782 hectares, of which ninety percent was described as being "excellent agricultural land."[89] Assuming that all of the farm land changed to urban uses was previously used to produce rice, the 6,866 converted hectares represent a production loss of 41,000 metric tons annually.[90] The cost of replacing the lost production with imports would amount to approximately $81 million annually.[91] Fortunately, Taiwan produces more rice than is needed to meet domestic requirements and exports some of the surplus each year.

Long-Term Projections of Supply, Demand and Trade for Selected Agricultural Products in Taiwan (Taipei, Republic of China: National Taiwan University, October, 1970), p. 68. He also noted that during the same period " . . . approximately 4,000 hectares of originally good farm fields had been shifted annually to non-agricultural uses." (Emphasis added). Te Tsui Chang, op. cit., p. 48. Since the United Nations Study figure refers specifically to agricultural land converted to urban uses it will be used here in preference to the less precise approximate figure associated with land converted to "non-agricultural uses" or the more restrictive figure associated with conversion to "building sites."

[89] United Nations Study, Ibid.

[90] Computed on the basis of the 1968 average yield per hectare of 3,188 kilograms and the 1968 rate of utilization for cultivated land of 1.88. T.S.D.B. 1970, op. cit. pp. 28, 33.

[91] This figure was computed on the basis of a purchase price in the United States of $9.00 per 100 lbs. of brown rice estimated by the Rice Growers Association of California, and transportation costs of $10.00 per long ton from the west coast of the U.S. to Korea estimated by Boat Food Carriers, 425 California St., San Francisco,

In Korea the amount of land cultivated increased by 320,000 hectares, or sixteen percent, between 1957 and 1968 (Table 3). Most of the increase took place in the period from 1962 through 1966 in response to government programs aimed at increasing agricultural production. Part of the First Five-Year Economic Plan called for bringing under cultivation and/or irrigation land totaling 227,000 hectares in the 1962-1966 period.[92] At the end of the Plan period in 1966 the increase in cultivated area amounted to 213,000 hectares,[93] representing almost complete achievement of the Plan's goal. The amount of agricultural land converted to urban uses, however, cannot be determined due to the unavailability of published data.

California. Transportation costs for shipping rice to Taiwan are not available because shipments have not been made in recent years upon which to base an estimate. Both the Rice Growers Association and Boat Food Carriers indicated that the estimated costs could vary considerably depending upon market conditions at the time of purchase and the type of arrangements negotiated by the purchaser. Purchases of rice made under the provisions of Public Law 480 would cost less than the amount indicated here for open market purchases. Costs involved in purchasing and transporting American rice were used due to the unavailability of information on costs associated with obtaining supplies from the rice exporting nations of Asia such as Thailand and Burma.

[92] Summary of the First Five-Year Economic Plan 1962-1966 (Seoul, Korea: Economic Planning Board, 1962), p. 41. In addition to increasing agricultural production, the program to bring more land under cultivation was designed to make land available for settlement and thus stem the flow of landless farmers to the cities and entice those already there back to the rural areas.

[93] Economic Statistics Yearbook 1970 (Seoul, Korea: Bank of Korea, 1970), p. 198. Hereinafter cited as E.S.Y. (year).

Japan's experience with increasing the amount of land in agricultural production was somewhat different from that of either Taiwan or Korea. Following World War Two there was an influx of returning military personnel and colonists from areas held during and before the war. Not only were large numbers of people added to the population of the home islands, but the food stuffs that had been supplied by former colonies such as Taiwan were no longer available. A heavy burden was thus suddenly placed on the productive capabilities of Japanese agriculture. Part of the solution to the problem of supplying enough food for the country was to put more land into food production.

Plans designed to increase the cultivated area and safeguard existing agricultural lands from storms and floods were prepared and implemented.[94] As a result the cultivated area was enlarged, reaching a maximum of 6,086,000 hectares in 1961. Since then the amount of cultivated land has decreased, leaving the country with a net loss of cultivated land totaling 116,000 hectares for the 1956-1968 period. The loss from the peak year of 1961 through 1968 amounted to 189,000 hectares. Figure 5 shows the trend of Japanese population growth, changes in the amount of land cultivated, and the burden placed on the land as represented

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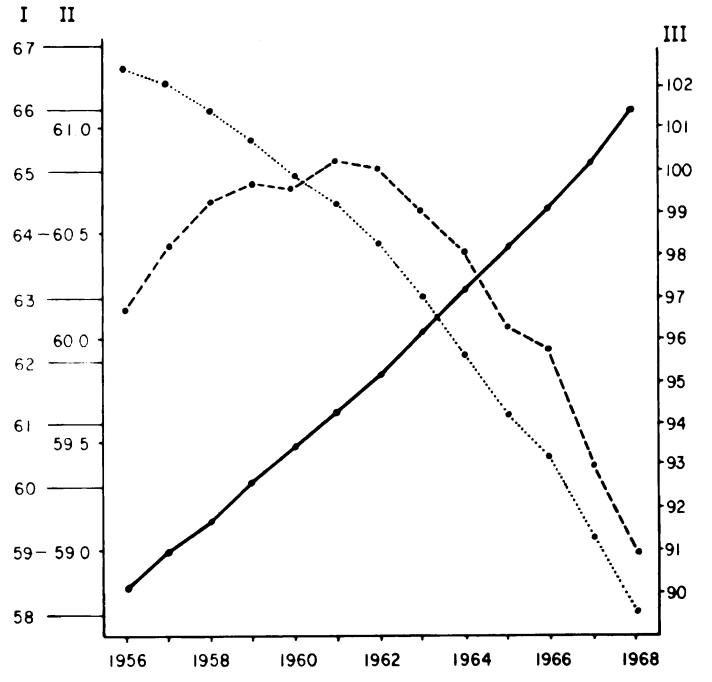
[94]Norio Hasegawa, "Recent Development of Regional Plannings in Japan," Science Reports of the Tohoku University (7th series), 18:137-142, March, 1969.

Figure 5. Japan, 1956 - 1968: Population, Cultivated Land, and Cultivated Land Per Thousand Population.

Figure 6. Cultivated Land Removed From Production by Natural Disasters and Artificial Dilapidation, 1958 - 1968.



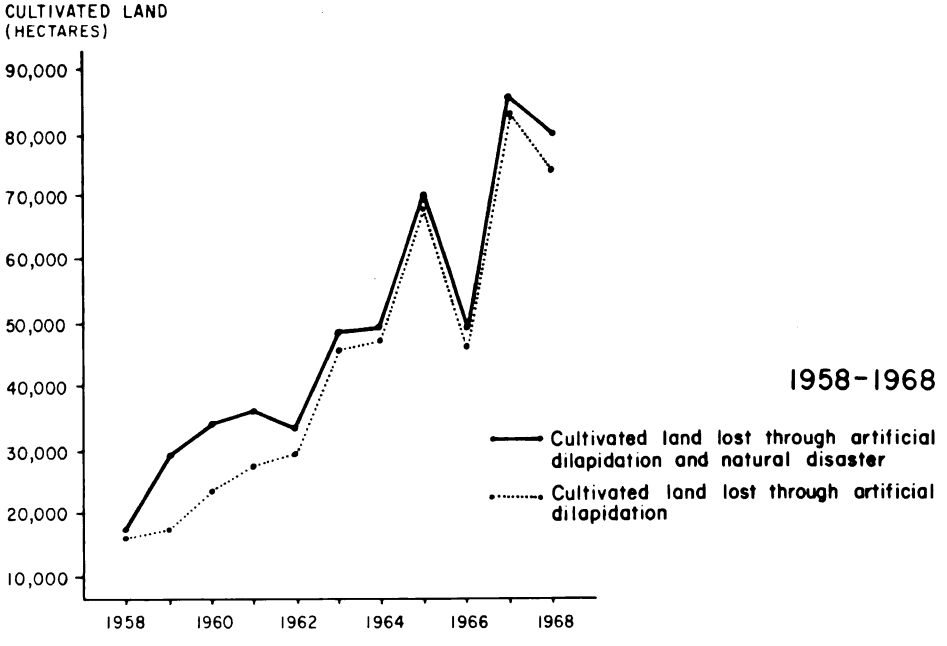
JAPAN

1956-1968

I ····· Cultivated land per thousand population (in hectares)

II – – – Cultivated land (in thousands of square kilometers)

III ——— Population (in millions)



1958-1968

——— Cultivated land lost through artificial dilapidation and natural disaster

····· Cultivated land lost through artificial dilapidation

by the ratio of cultivated land to population. Even though the amount of land being cultivated increased between 1956 and 1961, the area available to supply the needs of each person decreased. After 1961 the decrease continued, but at a faster rate, reflecting the combined effect of population growth and increasingly larger losses of cultivated land.

The loss of cultivated land attributable to urban expansion in Japan is difficult to ascertain. Information published by the government indicates two causes for the removal of agricultural land from production, natural disaster and artificial dilapidation. Losses due to natural disasters include those occasioned by floods, landslides, earthquakes and so forth. Artificial dilapidation is a broad term encompassing losses in cultivated land brought about by conversion " . . . to forests, wasteland, pastures, lakes, ponds, residential land, salt fields, spas and other lands."[95] The magnitude of the losses due to these two causes is shown in Figure 6. It is noteworthy that throughout the eleven year period for which data are available artificial dilapidation accounted for most of the land removed from production. Although it cannot be determined exactly how much agricultural land was converted to urban

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[95]Bureau of Statistics, Japan Statistical Yearbook 1969 (Tokyo, Japan: Office of the Prime Minister, 1970), p. 105. Hereinafter cited as J.S.Y. (year).

uses, it seems reasonable to assume that changes to residential and industrial uses accounted for a considerable portion of the total.

Food Production

While changes in population and cultivated area occurred in Taiwan, Korea, and Japan, changes in the production of rice, the staple food crop in all three countries, were also recorded (Table 4). In Taiwan and Korea the increases resulted from the combined effect of additional land being put into production and the spread of modern agricultural techniques. The fifty-six percent increase in Taiwan was due largely to the increasingly widespread use of fertilizers, pesticides and improved seeds[96] and the adoption of more efficient irrigation methods.[97] This resulted in higher per hectare yields which accounted for most of the increased production. The smaller increase in Korea was achieved mainly by putting more land into production and enlarging the area under irrigation.[98] The Japanese

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[96] Y. L. Hsueh, "Doubling the Rice Crop," Free China Review, 14:28-30, October, 1964.

[97] Canute Vandermeer, "Changing Water Control in a Taiwanese Rice-Field Irrigation System," Annals of the Association of American Geographers, 58:720-747, December, 1968. Credit is also given to the enlargement of the area under irrigation. Te Tsui Chang, op. cit., p. 67.

[98] Economic Survey 1968 (Seoul, Korea: Economic Planning Board, 1968), pp. 154-155.

Table 4

Rice Production: Total Yield, Yield Per Hectare, and Yield Per Person

Year	Taiwan			Korea			Japan		
	Total Yield	Yield Per Hectare	Yield Per Person	Total Yield	Yield Per Hectare	Yield Per Person	Total Yield	Yield Per Hectare	Yield Per Person
1955	1615	2151	177.9	N.A.	N.A.	N.A.	12073	3960	135.2
1956	1790	2284	190.6	N.A.	N.A.	N.A.	10647	3480	118.0
1957	1839	2348	189.7	N.A.	N.A.	N.A.	11882	3640	130.6
1958	1894	2434	188.6	N.A.	N.A.	N.A.	11689	3800	127.3
1959	1856	2392	177.9	N.A.	N.A.	N.A.	12158	3910	131.2
1960	1912	2495	177.1	3034	2680	121.4	12539	4010	134.2
1961	2016	2577	180.8	3463	3040	134.7	12138	3870	128.7
1962	2113	2660	183.5	3015	2630	114.0	12762	4070	134.0
1963	2109	2815	177.4	3758	3230	138.2	12529	4000	130.2
1964	2247	2937	183.3	3954	3280	141.5	12362	3960	127.3
1965	2348	3038	185.9	3501	2830	122.1	12181	3900	123.9
1966	2380	3017	183.1	3919	3160	133.4	12526	4000	126.4
1967	2414	3067	181.5	3603	2890	119.8	14257	4530	142.2
1968	2518	3188	184.4	3195	2750	103.9	14223	4490	140.2

Total Yield in thousands of Metric Tons, Yield Per Hectare and Per Person in Kilograms. N.A.--Not Available. Yield Per Person computed from Total Yield and Population figures.

Sources: Taiwan Statistical Data Book 1970, Taipei, 1970.
Economic Statistics Yearbook, Seoul, Korea, 1967 and 1970.
Japan Statistical Yearbook, Tokyo, Japan, 1962 and 1970.

achieved their increase through the conversion to rice production of fields previously used for other crops[99] and the greater use of fertilizers and pesticides.[100]

Although total production was raised in all three countries, only in Japan was there a real improvement in the rice supply situation during the 1955-1968 period. There the increases in per hectare and total yields led to a reduction of more than two-thirds in the amount of rice imported after 1965. This reduction in rice imports represented the saving of a large sum of money that could be made available for the improvement and expansion of the industrial sector of the economy.[101] The improvement in the rice supply situation is illustrated by the increase in yields per person shown in Table 4.

In Taiwan, a rice exporting country, both the volume and the value of rice exports declined after the peak year

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[99]Hideo Fukui, "Some Aspects of Recent Changes in Japanese Rice Farming," Science Reports of the Tohoku University (7th series), 15:25-27, March, 1966.

[100]Increased use of fertilizers and pesticides is evidenced by figures indicating constant or increased consumption of these materials even though the amount of land cultivated decreased after 1961. For example, the production of chemical fertilizers for domestic use (production minus exports) increased from 7.05 million metric tons to 7.24 million metric tons between 1960 and 1968. J.S.Y. 1969, op. cit., pp. 213, 296.

[101]Rice imports decreased between 1965 and 1968 from 967,000 to 271,000 metric tons, representing a decrease in costs from $145 million to $50 million. J.S.Y. 1969, op. cit., p. 298.

of 1965.[102] The decrease in the quantity of rice exported was brought about by increases in total consumption that outstripped increases in production. Not only was more rice needed to feed the growing population, but more was used in 1968 for feed and the making of wine than had been the case in previous years.[103] Also, larger reserves had to be kept on hand as a safeguard against crop failure than in earlier years because of the larger population to be provided for in case of an emergency. As a result, the exportable surplus dwindled even though the yield per person increased (Table 4). Furthermore, projections of rice production and consumption through 1980 indicate a further reduction in the size of the exportable surplus as the population grows.[104] Taiwan can therefore expect its earnings from the sale of surplus rice to decrease even more while the need for foreign exchange capital with which to finance its economic development continues. It can also expect to encounter a rice deficit sometime after 1980 as the

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[102]The volume of rice exports decreased from 257,000 metric tons in 1965 to 34,000 metric tons in 1969. Te Tsui Chang, op. cit., p. 78. The value of exports decreased from $43 million to $4 million during the same period. T.S.D.B. 1970, op. cit., p. 135.

[103]Te Tsui Chang, op. cit., pp. 73-74.

[104]Ibid., p. 84. The quantity of rice available for export (production minus consumption with no allowance made for a reserve) is projected to decline from about 300,000 metric tons in 1968 to 43,000 metric tons by 1980.

population continues to grow. The date that the deficit appears, however, will depend not only on the rate of increase in the population, but also on the rate at which agricultural land is removed from production.[105]

The Korean effort to increase rice production was less successful than those of either the Japanese or the Chinese. Even though large amounts of money and effort were expended, production failed to meet the country's needs and rice had to be imported to make up for the shortages. The shortages were not, however, due entirely to the failure of programs aimed at increasing agricultural production. At the end of the First Five-Year Economic Plan in 1966 overall food production had been raised to the point that the country was ninety-four percent self-sufficient in food. Drought in 1967 and 1968 reversed the trend toward self-sufficiency and necessitated the importing of large quantities of food grains.[106] While gains were made in the production of rice and other foods, therefore, they were not adequate to eliminate the burden placed on the

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[105]If the rate of conversion of agricultural land to non-agricultural uses noted in footnote 88 continues, production equivalent to 24,000 metric tons (at 1968 levels) will be lost each year. It is not indicated whether or not reductions in the area under cultivation due to conversion to non-agricultural uses have been allowed for in the projections of rice production through 1980.

[106]Economic Survey 1968, op. cit., pp. 153, 158.

economy by the need to import food.[107] Unless further efforts to increase the production of rice and other foods are successful, Korea's economic development will continue to be hindered by the need to invest foreign exchange capital in the feeding of its growing population. As in Taiwan, the success of efforts made to increase food production will depend to a certain extent on the amount of agricultural land taken out of production by urban expansion.

Farm Population

Changes in population and the amount of land under cultivation, while effecting imports and exports of rice as well as production and consumption, also had effects on the farm populations of the three countries under examination. One of the effects of population growth in Taiwan and Korea can be seen in the increased number of farm households. In Taiwan, where additions to the amount of cultivated land in use were small, this led to a thirteen percent reduction in the average size of farms. In Korea,

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[107] Imports of rice alone increased from 139,000 metric tons at a cost of $25 million in 1967 to 631,000 metric tons costing $120 million in 1969. Total expenditures for food imports increased from $93.5 million to $300 million during the same period. This represents a tripling of expenditures for food while the total amount spent for all imports did not quite double. E.S.Y. 1970, op. cit., pp. 310-311.

however, government sponsored projects to increase the area under cultivation made it possible for the average farm size there to remain relatively constant (Table 3). A second effect of population growth, an increase in farm household population densities, appeared in both countries (Table 5). Not only did the number of farm households increase but so did the average number of people in each of them. When combined, the result of these two changes was the placing of increased demands on the productive capabilities of agricultural land in terms of its ability to provide a livelihood for the growing farm populations. In 1955 the average farm household member in Taiwan had 1,900 square meters of agricultural land from which to secure a living, but by 1968 he had only 1,500 square meters available to him. The average Korean farm household member's share of the agricultural land decreased from 1500 to 1460 square meters. The small size of the reduction in Korea was due primarily to the addition of a large quantity of land to the cultivated area.[108]

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[108]The decrease in the number of Korean farm households and farm population in 1968 (Tables 3 and 4) was caused " . . . by the exodus of more than 200 thousand members of farm households from their farms." The "exodus" took place in 1967 as the result of drought which reduced agricultural production and made remaining on the land difficult for many farmers. Economic Survey 1968, op. cit., pp. 152-156. Using figures for 1967, the peak year for farm population, the decrease in the amount of land available per farm household member was a little larger, from 1,500 to 1,435 square meters.

Table 5

Farm Population, Farm Household Population Density, and the Ratio of Farm Population to Total Population in Percent

Year	Taiwan			Korea			Japan		
	Population	Density	Ratio	Population	Density	Ratio	Population	Density	Ratio
1955	4,603,000	6.28	50.7	13,299,812	6.00	61.9	36,468,990	6.00	40.8
1956	4,699,000	6.30	50.0	13,454,475	6.11	64.9	N.A.	N.A.	N.A.
1957	4,790,000	6.31	49.4	13,591,637	6.15	63.7	N.A.	N.A.	N.A.
1958	4,881,000	6.34	48.6	13,750,037	6.20	62.8	N.A.	N.A.	N.A.
1959	4,975,000	6.37	47.7	14,125,751	6.22	61.5	N.A.	N.A.	N.A.
1960	5,373,000	6.84	49.8	14,559,271	6.20	58.2	33,843,300	5.66	36.2
1961	5,467,000	6.83	49.0	14,508,504	6.23	58.2	33,166,800	5.60	35.2
1962	5,531,000	6.83	48.0	15,096,779	6.11	57.5	32,596,199	5.52	34.2
1963	5,611,000	6.80	47.2	15,266,325	6.33	56.2	31,890,222	5.45	33.2
1964	5,649,000	6.77	46.1	15,553,019	6.35	55.6	31,220,000	5.38	32.1
1965	5,739,000	6.77	45.4	15,811,575	6.31	55.2	29,559,000	5.22	30.1
1966	5,806,000	6.80	44.7	15,780,706	6.21	53.7	28,638,000	5.21	28.9
1967	5,949,000	6.85	44.7	16,078,086	6.22	53.5	27,904,000	5.15	27.8
1968	5,999,000	6.84	44.0	15,907,664	6.17	51.7	27,212,000	5.09	26.8

Density Figures for Taiwan and Japan are computed values.
N.A.--Not Available

Sources: Taiwan Statistical Data Book 1970, Taipei, Taiwan, 1970.
Economic Statistics Yearbook 1970, Seoul, Korea, 1970.
Japan Statistical Yearbook 1969, Tokyo, Japan, 1970.

In both countries the increasing pressure on the land caused people to leave farming because of their inability to make an adequate living from the available land. Many went to the cities in search of employment with which to support themselves and their families.[109] Although it cannot be accurately determined how many people left farms and moved to cities, an estimate can be made based upon the difference between expected and actual farm population increases. If farm population had increased at the same rate as the total population in Taiwan, it would have been almost one million persons larger in 1968 than it was. The Korean farm population would have been larger by approximately five million persons. The failure of farm population growth to keep pace with the growth of the general populations is reflected in the declining ratio of farm to total population shown in Table 4.

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[109] Increasing population pressure on the land and the resulting movement to the cities in Taiwan is described in: Bernard Gallin, Hsin Hsing, Taiwan: A Chinese Village in Change (Berkeley, California: University of California Press, 1966), pp. 120-126; Donald Monson, "Future Urban and Housing Development in Taipei," a lecture delivered to the Seminar on Modern Engineering and Technology, Chinese Institute of Engineers, New York, July, 1966, pp. 5-6. (Mimeographed). Similar discussions dealing with Korea may be found in: Kim Young-moon, "Population and Urban Movement," Korea Journal, 4:19-21, August, 1964; Duk Hee Lee, "The Origin and Growth of Urbanization in Korea," Bulletin of the Korean Research Center, 25:53-55, December, 1966; Korea Annual (Seoul, Korea: Hapdong News Agency, 1970), pp. 180-181.

The pattern of changing farm population and farm size in Japan was the reverse of that in Korea and Taiwan. As noted earlier, Japan's cultivated area decreased between 1956 and 1968. At the same time the farm population and the number of farm households also decreased. This was due mainly to the migration of people from rural areas to the urban centers. The migration was in response to increased opportunities for employment and higher income created by the expansion of the industrial and commercial sectors of the Japanese economy.[110] The changes were such that farm household population density decreased and the ratio of cultivated land to farm households increased slightly. In contrast to Taiwan and Korea, the average farm household member in Japan had more land available to him in 1968 than in 1960, the first year for which complete data are obtainable. The change was from 1,800 to 2,160 square meters, a twenty percent increase.

Urban Changes

The urban populations of Taiwan and Korea, as well as Japan, increased during the period from 1955 through

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[110] Indications are that somewhere between 400,000 and 600,000 people leave rural areas each year. The remainder from the approximate annual natural increase of 800,000 in the rural areas remain there to take over the farms of their parents or find employment in the villages and small towns. Glenn T. Trewartha, Japan: A Geography (Madison, Wisconsin: University of Wisconsin Press, 1965), p. 187.

1968 (Table 6). Unfortunately, the size of the increase in Taiwan and Korea is difficult to determine accurately due to the lack of concise definitions for urban population. For example, in Taiwan "There is no definition of urban used in the census."[111] Approximations of urban population have been derived, though, using the population of cities and towns of 50,000 or more people, as in Table 6. Estimates have also been made on the basis of the number of people living in cities and towns of 25,000 or more persons,[112] as well as those of more than 2,500 persons.[113] Whether estimates based upon only the larger cities or those including smaller towns and villages are used, however, one feature stands out: urban population in Taiwan has increased both in absolute terms and relative terms.

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[111] United Nations Study, op. cit., p. 24. Mr. T. K. Tsui, Director, Overall Planning Division, Council for International Economic Cooperation and Development, Executive Yuan, Republic of China, confirmed the lack of a definition for urban population by stating: "There is no formal definition of urban population in Taiwan." He therefore provided the data for cities and towns of 50,000 or more persons shown in Table 6. (Personal correspondence, February 15, 1971). The suitability of the lower limit of 50,000 in defining urban population centers in Taiwan is supported by a study which concluded that towns with smaller populations exhibit characteristics significantly different from those of the larger centers and may therefore be classified as rural. D. Y. Yuan, "The Rural-Urban Continuum: A Case Study of Taiwan," Rural Sociology, 29:246-260, September, 1964.

[112] Chen Cheng-siang, "The Urban Growth of Taiwan," Industry of Free China, December, 1962, pp. 5-6.

[113] United Nations Study, op. cit., pp. 24, 24-1.

Table 6

Urban Population and Percent of Population Classified Urban; Urban Area and Percent of Area Classified Urban

Year	Taiwan[1]				Korea[2]				Japan[3]			
	Pop. (1000's)	Per-cent	Area	Per-cent	Pop. (1000's)	Per-Cent	Area	Per-cent	Pop. (1000's)	Per-cent	Area	Per-cent
1955	2,760	30.4	N.A.	N.A.	8,862	41.2	11.8	11.9	50,288	54.4	67.7	18.0
1960	4,141	38.4	N.A.	N.A.	10,430	41.7	11.2	11.3	59,333	63.6	82.6	21.9
1965	5,708	45.2	N.A.	N.A.	12,858	44.8	9.4	9.5	66,919	89.6	88.1	23.3
1968	6,589	48.3	N.A.	N.A.	14,839	48.3	9.0	9.1	N.A.	N.A.	92.3	24.5

Area in Thousands of Square Kilometers N.A.--Not available

[1]Taiwan Urban Population data for cities and towns of 50,000 or more people only.

[2]Korean Urban Population data includes all persons not classified as being part of the Farm Population. Urban area includes both Urban Area and uncultivated arable land.

[3]Japanese Urban Population data available only for census years.

Sources: T. K. Tsui, Director, Overall Planning Division, Council for International Economic Cooperation and Development, Taipei, Taiwan.

Han-Sung Lee, Chief, Industrial Statistics Division, Statistics Department, Bank of Korea, Seoul, Korea.

Japan Statistical Yearbook, Tokyo, Japan. 1962, 1969.

The figures used here indicate a 139 percent increase in urban population between 1955 and 1968 in Taiwan, almost three times as much as the fifty percent increase in the population as a whole. The portion of the total population classified as urban grew by more than half during the same period. Thus even though a firm definition of urban population is lacking, it is evident that the urban portion of the population is growing rather quickly and with it the forces leading to the expansion of urban areas. In fact, it has been estimated that urban population in Taiwan will triple by the end of this century.[114]

One of the effects of urban population growth in Taiwan has been the enlargement of urban areas. As mentioned earlier, 6,866 hectares of agricultural land were converted to urban uses between 1957 and 1966. Other estimates indicate much larger losses. Depending upon which figures are used, the threat posed to agricultural land by urban expansion ranges from moderate to severe. If the average annual rate of conversion of 686 hectares continues,[115] about 20,000 hectares of agricultural land will have been changed to urban uses by the year 2000. Should the higher rate of conversion to "non-agricultural uses" prevail (approximately 4,000 hectares per year),[116] losses of agricultural land will

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[114] Monson, op. cit., p. 3.

[115] United Nations Study, op. cit., p. 49.

[116] Te Tsui Chang, op. cit., footnote 1, p. 48.

total about 120,000 hectares by the end of the century. These figures represent reductions in the cultivated area of two percent and thirteen percent respectively.

Even though it is known that a certain amount of agricultural land has been converted to urban uses and an estimate of total annual losses has been made, information about the amount of land actually occupied by urban centers is not available.[117] In the absence of such information it is difficult to determine where urban expansion is taking place or the rate at which agricultural land is presently being converted to urban uses. However, the information available on the growth of urban population and conversion of agricultural land indicates that urban expansion is taking place and will probably continue to do so in the foreseeable future.

Information on urban growth in Korea is less clear than that available for Taiwan. The data shown in Table 6 are of limited usefulness due to the fact that they include elements that are not strictly urban in character. The

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[117]The 1970 United Nations study on urban land use policies contained a question asking for information concerning the "Extent of increase (in acres/hectares/sq. kms.) in the territorial limits of the urban areas . . . during the last few years." The reply to the question was, "No Data." United Nations Study, op. cit., p. 48. Although I specifically requested information on urban area when writing the Council for International Economic Cooperation and Development in Taipei, neither data nor an explanation for the failure to provide data accompanied their reply. (Personal Correspondence, January 21, 1971 and February 15, 1971).

urban population figures, for example, represent all of the people who are not included in the farm population.[118] As a result, it is impossible to determine exactly how much the population of urban centers (i.e., cities and towns of 50,000 or more people) have grown.[119] The data for urban area are of limited usefulness because they include both urban area and uncultivated arable land.[120] The decrease between 1955 and 1968 shown in Table 6 can be attributed to the placing of uncultivated arable land into agricultural

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[118]Korean population data are divided into two groups, Farm and Non-Farm. The Farm group is clearly associated with cultivated land and farm households. Of the Non-Farm group, Mr. Han-Sung Lee, Chief, Industrial Statistics Division, Statistics Department, Bank of Korea, has said, " . . . you may regard the Non-Farm population as urban population. We usually call the people living outside the farm area urban people." (Personal correspondence, January 25, 1971).

[119]The population of cities of 50,000 or more people increased 539,983 persons, from 9,266,829 on December 1, 1965 to 9,806,812 on October 1, 1966. The city of Seoul absorbed 332,480 people, or sixty-two percent of the increase. Accompanying data shows the area of these cities to have been 3,487 square kilometers as of October 1, 1966, an increase of sixteen square kilometers over the figure for December 31, 1965. These figures are the only ones that could be found relating specifically to urban population and area. Korea Annual (Seoul, Korea: Hapdong News Agency, 1967), p. 268; Korea Annual (Seoul, Korea: Hapdong News Agency, 1970), p. 395.

[120]Korean land use data are divided into three categories: Cultivated Land, Forest, and Other. The types of land use included in the first two categories are indicated by their titles. The types of land use encompassed by " . . . Others includes the amount of land which is arable but not cultivated and the land devoted to urban uses." Han-Sung Lee, op. cit..

production as was discussed earlier. In the absence of data specifically related to urban area it is difficult to determine whether or not the urban centers have expanded. Clear indications that urban expansion has occurred are found, however, in comments on the rapid increase in urban population[121] and a limited amount of land use data available for Seoul and Pusan.

The populations of Seoul and Pusan increased tremendously during the last two decades. The increase in Seoul amounted to more than two hundred percent with the population growing from 1,467,000 in 1950 to an estimated 4,661,000 in 1970. In the same period the population of Pusan almost tripled, increasing from 542,000 to an estimated 1,592,000.[122] These figures alone indicate an increase in the pressures that lead to urban expansion. The growth of the urbanized areas of these cities, however, can only be inferred from the available information.

Data on land classified as residential for tax purposes in Korea show that the amount of such land increased

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[121]"In all probability, the population of cities with more than 1,000,000 inhabitants has increased as much as 20 percent in the past five years [1961-1965] and 14 percent for cities with 100,000 to 999,999 inhabitants." Duk Hee Lee, op. cit., p. 54; "The [population growth] figures indicate that a rapid expansion of the urban areas is underway, and this trend is expected to continue further." Korean Annual (Seoul, Korea: Hapdong News Agency, 1969), p. 422.

[122]HOUSING, BUILDING AND PLANNING: Problems and priorities in human settlements, Report of the Secretary General (New York: United Nations, Aug. 21, 1970), Table 2, pp. 47-51.

from 119,000 hectares to 139,000 hectares between 1962 and 1968. Within the administrative boundaries of Seoul the area classified residential increased 114 percent, from 4,272 hectares in 1962 to 9,163 hectares in 1968. During the same period the cultivated area within the city's boundaries decreased from 16,459 to 13,142 hectares, a reduction of 3,317 hectares. An apparent connection between the changes in Residential and cultivated area is supported by the fact that the changes were complementary during the 1965-1968 period. The Residential area increased 2,934 hectares while the cultivated area decreased 2,934 hectares.[123] It is difficult to discern whether this was simply coincidental or actually represented the conversion of agricultural land to urban uses. The data for Pusan, though, exhibit basically similar characteristics.[124]

The shortage of information related specifically to urban centers, and the limited usefulness of the data shown in Table 6, makes an accurate evaluation of urban growth in Korea difficult, if not impossible. Given the increases in urban population and taxed residential land, plus the decreases in the cultivated areas of Seoul and Pusan, however, it seems safe to conclude that urban expansion has occurred.

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[123] E.S.Y. 1963, op. cit., Table 2, p. 4; E.S.Y. 1964, op. cit., Table 92, p. 151; E.S.Y. 1970, op. cit., Tables 1 and 86, pp. 6, 198.

[124] Ibid.

In addition, the increasing ratio of urban to farm population indicates that it will continue to occur in the coming years.

Unlike the Chinese and Koreans, the Japanese have kept and published records of the changes in both urban population and urban area. The figures for Japan shown in Table 6 were derived from census taken in 1955, 1960, and 1965 and represent the total population and area of cities with 30,000 or more inhabitants. The increase in urban population between 1955 and 1965 amounted to thirty-four percent, while the urban area increased thirty percent,[125] leading to a small increase in urban population density from 743 to 760 persons per square kilometer. Urban expansion has thus clearly taken place in Japan, and at least part of it, as indicated earlier, was at the expense of agricultural land.

The data on urban growth in Japan do have one limitation. They are available, with the exception of area data for 1968, only for census years. The lack of information on urban centers for the intercensal years appears to represent a failure to either collect data or estimate

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[125]The increase in urban area between 1955 and 1968 totaled 24,600 square kilometers, or thirty-six percent.

changes.[126] This failure (or oversight) may be interpreted in a number of ways. The interpretation favored here, is that there is an apparent lack of appreciation of the seriousness of the urban expansion problem, especially as it is related to agricultural land. Consequently, attention is given to urban growth in the census years when it is convenient to do so and ignored in the intervening years.

This interpretation is supported by the fact that although information related to urban growth is available for census years, data on farm population, cultivated area, agricultural production and a large number of other categories have been available on an annual basis since 1960. The disparity in the available data reflects a justifiable concern with elements associated with agricultural production and a relative lack of concern with indicators of urban growth. In short, while the Japanese keep a careful watch on agricultural production and factors related to it, it is suggested here that they do not watch as carefully one of the factors that threatens to reduce agricultural production--urban expansion. In a heavily populated

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[126] It might also simply represent the failure to publish available information. Such a failure, though, would be inconsistent with the Japanese' practice of publishing annual data on virtually everything for which they have data. Indeed, the absence of annual data for urban centers is striking when compared with the plethora of information published each year on a wide variety of things associated with agriculture.

country that has only a small amount of agricultural land and adds more than a million people to its population each year, such an oversight is difficult to understand. This unavailability of annual data on urban growth does not, however, detract from the clearly evident trend toward urban expansion in Japan.

Summary

The information presented here indicates that the populations of Taiwan, Korea and Japan have been growing and can be expected to continue growing in the foreseeable future. The data also indicate that the ability of agricultural land to provide a livelihood for the growing farm populations is approaching its upper limits even though the productivity of the land itself has increased. This is evidenced in Taiwan and Korea by the increasing size of farm households, the decreasing amount of land available to each farm household and the failure of farm population growth to keep pace with the growth of the total population.[127] In addition, there are indications that the carrying capacity of agricultural land is being, or has already been, exceeded. Evidence of this is found in the dwindling rice exports of

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[127]This trend is readily apparent in the case of Taiwan where population has increased at a relatively high rate and there have been only small additions to the cultivated area in recent years.

Taiwan, the increasing amounts of food imported into Korea, and the continuing importation of food by Japan.

The limited ability of farm land to provide a livelihood has led, in part, to the migration of people from the rural areas to the cities, thereby causing urban populations to grow faster than populations as a whole. Pressure causing urban expansion created by rapidly growing urban population has thus appeared, or increased where it already existed. The response to this pressure has been urban expansion. The limited nature of the data on urban growth, however, makes it difficult to assess the extent to which urban centers have expanded and, in the process of expansion, removed agricultural land from production. Even for a developed nation like Japan, about which there is abundant information, exact figures on the amount of agricultural land converted to urban uses are not readily available. It would, therefore, be helpful to identify a set of variables that can be used in place of information on urban centers to identify areas where urban expansion may be occurring. The remainder of this study is devoted to an attempt at identifying such a set of variables.

PART II

THE JAPAN MODEL

CHAPTER I

JAPAN: A CASE STUDY

In order to be able to identify a set of variables that can be used to distinguish between urban and agricultural areas and identify transition areas a wide variety of information must be available. Because Japan meets the requirement of information availability it was selected as the subject country for this study (Figure 7). Japan also has the advantage of having been the subject of a number of investigations on a wide variety of topics.[1] A brief

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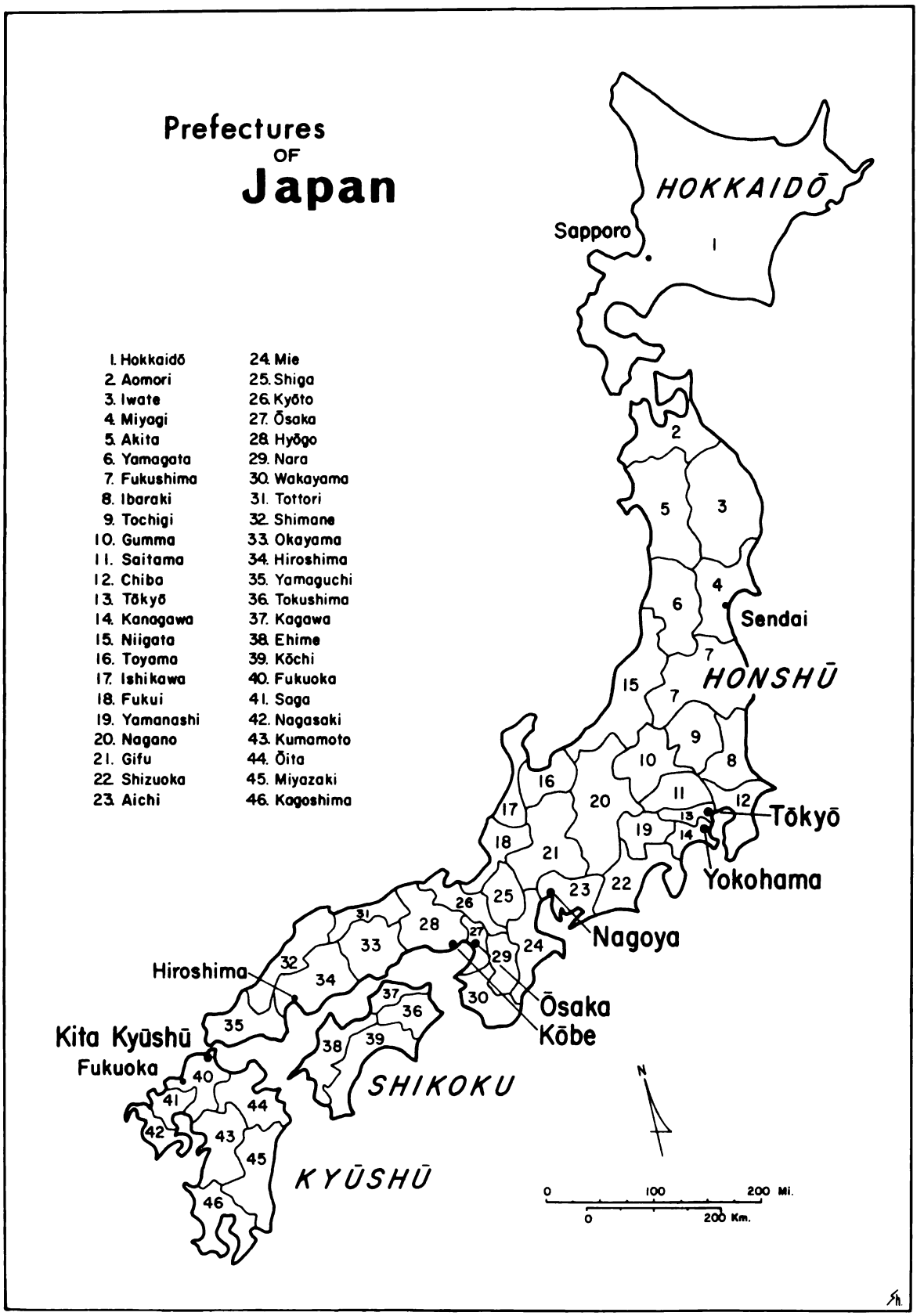
[1]Two general texts describing Japan, each with a slightly different emphasis, have been prepared by Trewartha and Dempster: Glenn T. Trewartha, Japan: A Geography (Madison, Wisconsin: University of Wisconsin Press, 1965); Prue Dempster, Japan Advances: A Geographical Study (London: Methuen and Co., Ltd., 1967). Irene Taeuber's The Population of Japan (Princeton, New Jersey: Princeton University Press, 1958), provides a detailed discussion of population changes in the first half of this century whose continuation is evidenced by the more recent data presented here. The results of studies related to economic growth are contained in: Ryutaro Komiya, Postwar Economic Growth in Japan (Berkeley, California: University of California Press, 1966); and Seymour Broadbridge, Industrial Dualism in Japan (Chicago: Aldine Publishing Co., 1966). An examination of changing social patterns is reported in a brief study by Edward Norbeck. Edward Norbeck, Changing Japan (New York: Holt, Rinehart and Winston, Inc., 1965).

Figure 7. Japan: Prefectures and Major Cities


Prefectures
OF
Japan
1. Hokkaidō
2. Aomori
3. Iwate
4. Miyagi
5. Akita
6. Yamagata
7. Fukushima
8. Ibaraki
9. Tochigi
10. Gumma
11. Saitama
12. Chiba
13. Tōkyō
14. Kanagawa
15. Niigata
16. Toyama
17. Ishikawa
18. Fukui
19. Yamanashi
20. Nagano
21. Gifu
22. Shizuoka
23. Aichi
24. Mie
25. Shiga
26. Kyōto
27. Ōsaka
28. Hyōgo
29. Nara
30. Wakayama
31. Tottori
32. Shimane
33. Okayama
34. Hiroshima
35. Yamaguchi
36. Tokushima
37. Kagawa
38. Ehime
39. Kōchi
40. Fukuoka
41. Saga
42. Nagasaki
43. Kumamoto
44. Ōita
45. Miyazaki
46. Kagoshima
HOKKAIDŌ
Sapporo
HONSHŪ
Sendai
Tōkyō
Yokohama
Nagoya
Ōsaka
Kōbe
Hiroshima
Kita Kyūshū
Fukuoka
SHIKOKU
KYŪSHŪ
N
0 100 200 Mi.
0 200 Km.

look at changes in population, the urban dynamics, and cultivated area in the prefectures of Japan will serve to illustrate the kinds of changes that have occurred. It will also help to point out some of the uncertainties about urban expansion that may exist even when relatively detailed data are available.

Population Change

In the period from 1955 through 1968 Japan's population increased thirteen percent, from 89 million to 101 million. As might be expected, the increase was not evenly distributed over the entire country. Instead some prefectures recorded large gains while others posted losses. A careful examination of the figures in Table 7 reveals that the gains and losses were evenly divided among the forty-six prefectures. Most of the prefectures that lost population were those at the northern and southern extremities of the country and rather distant from the Tokyo-Osaka industrial belt. Those gaining were the prefectures near Tokyo, Nagoya or Osaka. Three prefectures bordering Tokyo, for example, recorded the largest gains in both absolute and percentage terms. Saitama, Chiba and Kanagawa prefectures together had an annual average growth rate of over four percent during the 1960-1968 period and added 3,269,000

Table 7. Japan: Population by Prefecture, 1955-1968

PREFECTURE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
HOKKAIDO	4773	4851	4918	4984	5012	5039	5066	5092	5119	5145	5172	5193	5220	5239
AOMORI	1383	1402	1414	1425	1426	1427	1425	1423	1421	1419	1417	1420	1427	1432
IWATE	1427	1444	1449	1454	1451	1449	1441	1434	1426	1419	1411	1405	1402	1398
MIYAGI	1727	1748	1750	1752	1748	1743	1745	1747	1749	1751	1753	1759	1773	1787
AKITA	1349	1360	1354	1347	1341	1336	1324	1313	1302	1291	1280	1270	1265	1257
YAMAGATA	1354	1362	1354	1345	1333	1321	1309	1298	1286	1275	1263	1254	1251	1247
FUKUSHIMA	2095	2114	2104	2094	2073	2051	2038	2024	2011	1997	1984	1973	1972	1970
IBARAKI	2064	2082	2078	2073	2060	2047	2049	2051	2053	2054	2056	2051	2065	2082
TOCHIGI	1548	1559	1549	1538	1526	1514	1515	1517	1518	1520	1522	1522	1531	1543
GUMMA	1614	1625	1614	1602	1590	1578	1584	1589	1595	1600	1606	1608	1621	1635
SAITAMA	2263	2286	2314	2341	2386	2431	2548	2665	2781	2898	3015	3157	3318	3474
CHIBA	2205	2225	2242	2259	2283	2306	2385	2464	2543	2623	2702	2778	2889	3010
TOKYO	8037	8195	8591	8986	9335	9684	9921	10158	10395	10632	10869	11027	11166	11294
KANAGAWA	2919	2968	3071	3174	3309	3443	3641	3839	4038	4236	4434	4576	4763	4965
NIIGATA	2473	2493	2476	2459	2451	2442	2433	2425	2416	2408	2399	2391	2392	2390
TOYAMA	1012	1027	1040	1053	1043	1033	1031	1030	1028	1027	1025	1023	1025	1026
ISHIKAWA	966	973	972	971	972	973	975	976	978	979	980	982	988	995
FUKUI	754	759	756	753	753	753	752	752	751	751	751	748	749	750
YAMANASHI	807	810	801	792	787	782	778	775	771	767	763	762	765	766
NAGANO	2021	2030	2013	1995	1988	1982	1977	1972	1967	1963	1958	1953	1958	1963
GIFU	1574	1595	1598	1600	1619	1638	1651	1663	1676	1688	1700	1705	1720	1735
SHIZUOKA	2650	2681	2697	2712	2734	2756	2788	2819	2850	2881	2913	2934	2979	3022
AICHI	3769	3824	3921	4017	4112	4206	4325	4443	4562	4680	4799	4886	4998	5122
MIE	1486	1495	1490	1485	1485	1485	1491	1497	1503	1509	1514	1513	1516	1522
SHIGA	854	857	851	844	843	843	845	847	849	851	853	853	858	865
KYOTO	1935	1950	1965	1980	1987	1993	2015	2037	2059	2081	2103	2121	2154	2186
OSAKA	4618	4696	4894	5092	5298	5505	5735	5966	6196	6427	6657	6804	6991	7184
HYOGO	3621	3662	3724	3785	3846	3906	3987	4068	4149	4229	4310	4357	4419	4487
NARA	777	779	775	770	776	782	791	800	808	817	826	837	854	874
WAKAYAMA	1007	1013	1010	1006	1004	1002	1007	1012	1017	1022	1027	1029	1035	1041
TOTTORI	614	619	615	610	605	599	595	591	588	584	580	576	575	575
SHIMANE	929	932	924	916	902	889	875	862	849	835	822	810	802	794
OKAYAMA	1690	1700	1695	1690	1680	1670	1665	1660	1655	1650	1645	1649	1663	1676
HIROSHIMA	2149	2167	2175	2182	2183	2184	2203	2223	2242	2262	2281	2304	2337	2377
YAMAGUCHI	1610	1624	1629	1633	1618	1602	1590	1579	1567	1555	1544	1533	1528	1521
TOKUSHIMA	878	882	873	864	856	847	841	834	828	822	815	808	804	798
KAGAWA	944	950	944	937	928	919	915	912	908	904	901	898	902	906
EHIME	1541	1552	1545	1537	1519	1501	1490	1479	1468	1457	1446	1438	1434	1429
KOCHI	883	886	882	878	866	855	846	838	829	821	813	805	802	798
FUKUOKA	3860	3905	3957	4009	4008	4007	3998	3990	3981	3973	3965	3981	4001	4012
SAGA	974	983	975	967	955	943	929	914	900	886	872	869	866	857
NAGASAKI	1748	1772	1777	1781	1771	1760	1737	1713	1689	1665	1641	1635	1630	1617
KUMAMOTO	1896	1915	1911	1907	1882	1856	1839	1822	1805	1788	1771	1764	1761	1749
OITA	1277	1286	1277	1268	1254	1240	1229	1219	1208	1198	1187	1177	1173	1167
MIYAZAKI	1139	1153	1152	1151	1143	1135	1124	1113	1102	1091	1081	1079	1078	1075
KAGOSHIMA	2044	2064	2041	2017	1990	1963	1941	1919	1897	1875	1854	1837	1823	1799

POPULATION IN THOUSANDS VALUES FOR 1957, 1959, 1961, 1962, 1963, AND 1964 ARE INTERPOLATED VALUES.

people to their collective population.[2] A more detailed examination of changes that took place in the populations of cities will serve to illustrate the trends of population growth in these centers.

Generally speaking, the cities that gained population during the period for which data is available were those of 100,000 or more inhabitants, or satellites of the major urban centers. The cities that lost population had 50,000 or fewer inhabitants in 1955 and were almost without exception far from the major urban centers. The cities that gained population exhibit two particularly interesting characteristics. First, most of them are located on flat or nearly flat land, the type of terrain most easily and often used for agriculture. Second, all of the larger cities such as Tokyo, Nagoya, Osaka and Kobe showed striking differences in the amount of change in the populations of their internal divisions. The central divisions containing the older parts of the cities and their central business districts lost population between 1960 and 1965. The divisions bordering the central areas grew at about the same rate as the total population. Outer divisions and satellite cities, however, increased

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[2]The increase in these three prefectures accounted for forty-one percent of the increase in the total population during this period.

much more than the total population and in some cases by more than fifty percent. These dynamics can be illustrated by examining the changes that occurred in the Kobe-Osaka area.

Population Change in the Kobe-Osaka Area

Data on the population in selected satellite cities and internal divisions of Kobe and Osaka for the 1955-1965 period are shown in Table 8.[3] The localities selected represent a series extending from Akashi, a city west of Kobe, to a satellite city east of Osaka, Hiraoka. Although they do not rest on a straight line, the localities may be considered points on a line running from west to east but following the shoreline of Osaka Bay and passing through the centers of both Kobe and Osaka.[4]

All of the localities gained population between 1955 and 1960, and all but three gained during the 1960-1965 period. The seven localities that grew the most, in

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[3]The discussion of city population change in this section is based upon data for the 1955-1965 period contained in J.S.Y. 1966, op. cit., Table 10, pp. 20-31. A careful check of the locations of all of the cities listed was made with the aid of a series of maps in: Japan National Tourist Organization, Japan: The New Official Guide (Tokyo, Japan: Japan Travel Bureau, Inc., 1966), pp. 299, 357, 369, 569, 637, 643, 659, 723, 829, 887, 895, 949, 997.

[4]An exact straight line traverse from Akashi to Hiraoka would be of little use in illustrating population changes as about two-thirds of the line would pass over Osaka Bay.

Table 8

Kobe-Osaka Area: Population 1955-1965

Locality	Pop. 1955 (1000's)	Pop. 1960 (1000's)	Pop. 1965 (1000's)	% Change 1955-60	% Change 1960-65
Akashi	120.2	129.8	159.3	8.3	22.7
KOBE Internal Divisions					
Tarumi-ku	95.2	111.0	148.0	16.8	33.2
Suma-ku	80.1	93.6	103.6	17.5	10.6
Nagata-ku	189.8	202.3	214.3	6.3	5.9
Hyogo-ku	211.4	238.6	254.1	12.8	6.5
Ikuta-ku	81.5	85.4	76.9	4.9	-9.9
Fukiai-ku	74.6	93.3	94.9	24.0	1.7
Nada-ku	138.2	155.4	169.0	12.3	8.8
Higashinada-ku	108.5	134.3	155.9	24.1	16.0
Ashiya	51.0	57.0	63.2	11.8	10.5
Nishinomiya	210.2	262.6	336.9	24.8	28.3
Amagasaki	335.5	406.0	501.0	20.8	23.4
OSAKA Internal Divisions					
Nishiyodagawa-ku	94.0	116.7	121.2	25.5	3.4
Fukushima-ku	90.7	94.4	86.0	4.4	-8.5
Kita-ku	82.0	84.5	72.0	3.0	-14.3
Joto-ku	168.3	217.9	251.8	30.0	15.6
Fuse	176.1	212.8	251.8	21.0	27.7
Kawachi	44.8	55.1	91.9	22.2	67.0
Hiraoka	42.3	50.1	79.5	19.0	60.0

Source: Japan Statistical Yearbook 1966, Tokyo, Japan, 1967.

both absolute and percentage terms, during the 1960-1965 period were the suburban localities in the area between Kobe and Osaka and at either end of the traverse. The nine that grew at a moderate rate during the later period were those adjacent to the central portions of the two major cities. Those losing population in the 1960-1965 period were the older parts of the cities and the central business districts of Kobe and Osaka.

The percentage change in the population of each locality for both the 1955-1960 and 1960-1965 periods is illustrated in Figure 8. A definite wave-like pattern is seen in the lines connecting the population changes in the localities. These lines, particularly the one representing change between 1960 and 1965, fit the pattern described by Blumenfeld and Wolf as characterizing the metropolitan "tidal wave" of urban expansion.[5] The neo-urban zones of most rapid population growth are represented by the western division of Kobe, Tarumi-ku, and Osaka's eastern satellite city, Kawachi. The secondary wave crest between Kobe and Osaka, formed by Nishinomiya and Amagasaki, indicates a rapid filling in of the area between the two major cities. The peri-urban zones toward which the wave crests are moving are represented by the satellite cities of Akashi on the western end of the traverse and Hiraoka on the eastern end.

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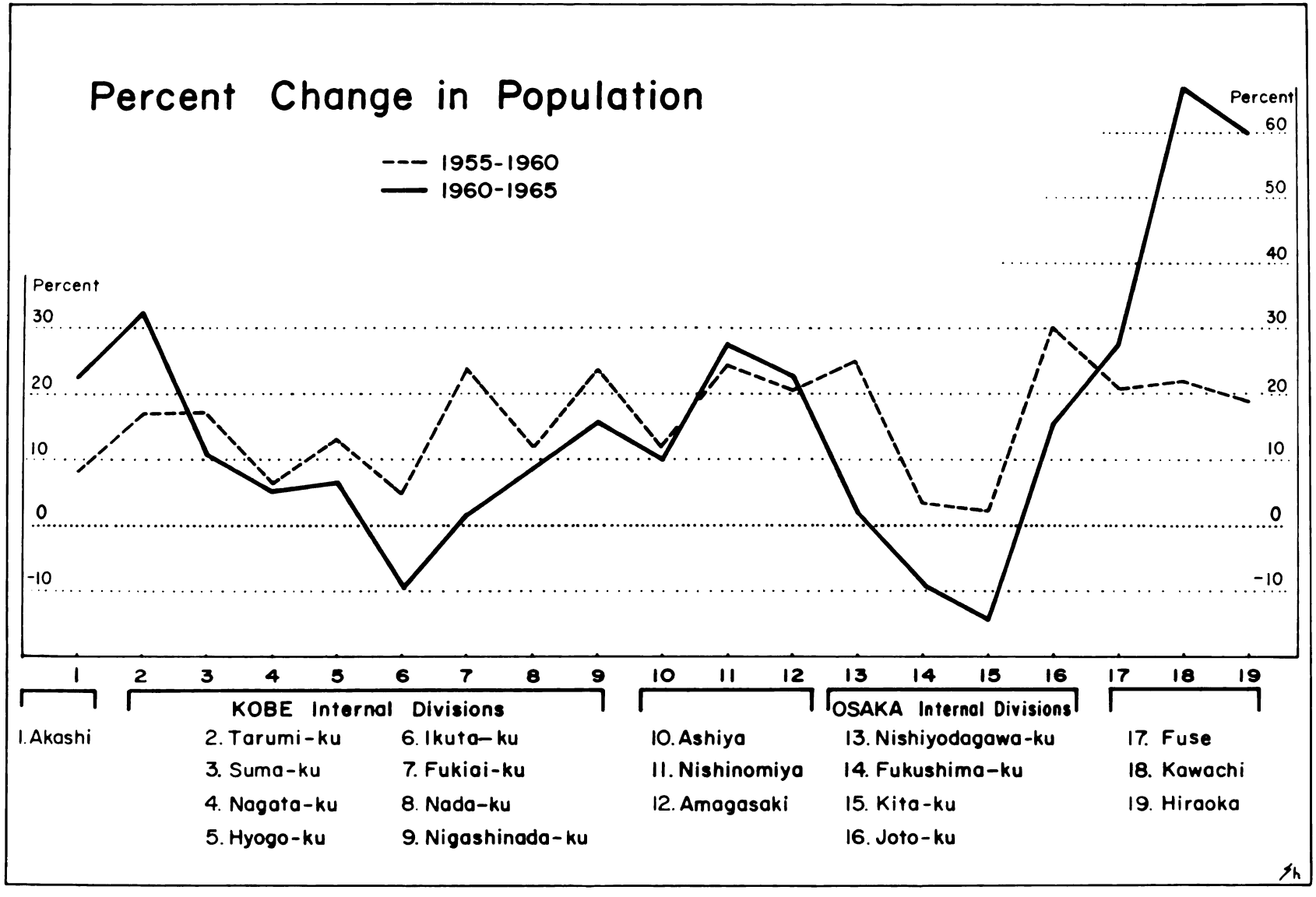
[5]Blumenfeld, op. cit.; Wolf, op. cit.

Figure 8. Percentage Changes in the Population of Selected Localities on an East-West Line in the Kobe-Osaka Area, 1955-60, 1960-65


Percent Change in Population
1955-1960
1960-1965
Percent
30
20
10
0
-10
Percent
60
50
40
30
20
10
0
-10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
KOBE Internal Divisions
OSAKA Internal Divisions
1. Akashi
2. Tarumi-ku
3. Suma-ku
4. Nagata-ku
5. Hyogo-ku
6. Ikuta-ku
7. Fukiai-ku
8. Nada-ku
9. Nigashinada-ku
10. Ashiya
11. Nishinomiya
12. Amagasaki
13. Nishiyodagawa-ku
14. Fukushima-ku
15. Kita-ku
16. Joto-ku
17. Fuse
18. Kawachi
19. Hiraoka

Patterns in the population data for Tokyo, Yokohama, Nagoya, Kyoto and Kitu-Kyushu are similar to those of Kobe and Osaka. Studies of major cities such as Tokyo,[6] Sendai,[7] and Sapporo,[8] have revealed a general population movement from the central parts of the cities and to the suburban areas. One of the consequences of this movement has been an increase in the amount of land devoted entirely to urban uses as indicated by increases in the areas described as "densely inhabited districts" of the cities.[9] Expansion of urban areas has also been noted in newly developed industrial

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[6]Hiroshi Kawabe, "The Study on the Areal Differences of Migration in Tokyo," Science Reports of the Tohoku University (7th series), 13:79-93, March, 1964.

[7]Ken-ichi Tanabe, "Housing Suburbs at the Northern Part of Sendai," Science Reports of the Tohoku University (7th series), 12:138-142, March, 1963; Norio Hasegawa, Spatial Variation of Land Value and Land Use--Case Study of Sendai and Hirosaki," Science Reports of the Tohoku University (7th series), 12:157, March, 1963; Setsuo Ogasawara, "Recent Changes in and Around the Urban Area of Sendai," Science Reports of the Tohoku University (7th series), 15:119-121, March, 1966.

[8]Setsuo Ogasawara, "Population Movement in Sapporo Metropolitan Area," Science Reports of the Tohoku University (7th series), 16:85-93, March, 1967.

[9]"A densely inhabited district is a group of contiguous [census] enumeration districts with high population density (4000 inhabitants or more per square kilometer) delinated [sic] within the boundary of city, town or village constituting an agglomeration of 5000 inhabitants or more. . . ." The total area included in densely inhabited districts increased 73,970 hectares between 1960 and 1965. J.S.Y. 1966, op. cit., pp. 20-21.

cities along the northwestern coast of Honshu.[10] Indeed, data related to urban areas on the prefectural level show that it increased in all prefectures during the 1955-1968 period (Table 9). A conclusion that may be drawn from this data is that urban expansion has been and is going on in Japan and most likely will continue to occur in the coming years. The effects of this expansion, that is, where it will most likely affect agriculture and changes in the amount of cultivated land available, are suggested by changes in the amount of cultivated land.

Change in Cultivated Area

Information on the amount of cultivated land in each prefecture in the years from 1955 through 1968 is presented in Table 10. A careful examination of the data reveal three separate periods of change within the fourteen year period covered. Between 1955 and 1957 twenty-three of the forty-six prefectures registered decreases in their cultivated areas.[11] The losing prefectures were fairly

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[10]Ken-ichi Tanabe, "Some Examples of the Type of Urbanization Under the Influence of Industrialization," Science Reports of the Tohoku University (7th series), 13:147-156, March, 1964.

[11]Cultivated land includes all lands devoted to agricultural production. In successive editions of the Japan Statistical Yearbook cultivated land is reported as being equal to arable land. See, for example: J.S.Y. 1969, op. cit., Table 55, p. 104, and Table 62, p. 113. Since land temporarily taken out of production could reasonably

Table 9. Japan: Urban Area by Prefecture, 1955-1968

PREFECTURE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
HOKKAIDO	7653	7656	7659	7662	8934	10207	10445	10683	10921	11159	11397	11688	11979	12271
AOMORI	1728	1728	1728	1728	1977	2225	2230	2234	2239	2244	2248	2248	2248	2249
IWATE	3622	3623	3624	3626	3806	3987	3985	3983	3982	3980	3978	3978	3978	3979
MIYAGI	790	791	791	792	989	1187	1187	1187	1187	1187	1187	1207	1226	1245
AKITA	1797	1797	1797	1797	1810	1823	1823	1823	1823	1823	1823	1851	1878	1906
YAMAGATA	2105	2105	2105	2105	2544	2983	2996	3010	3023	3037	3050	3104	3157	3210
FUKUSHIMA	1597	1597	1597	1597	1741	1886	2075	2264	2453	2642	2831	3200	3570	3939
IBARAKI	1161	1161	1161	1162	1362	1562	1562	1562	1562	1563	1563	1563	1563	1563
TOCHIGI	1747	1744	1740	1736	1848	1959	2000	2041	2082	2123	2164	2164	2164	2163
GUMMA	841	841	841	841	937	1033	1044	1054	1064	1075	1085	1098	1111	1124
SAITAMA	1019	1019	1019	1019	1204	1388	1392	1396	1400	1404	1408	1422	1436	1450
CHIBA	1367	1367	1367	1367	1449	1530	1580	1629	1678	1727	1777	1866	1956	2046
TOKYO	919	919	919	919	974	1030	1053	1076	1099	1122	1145	1154	1163	1173
KANAGAWA	1176	1176	1176	1176	1227	1277	1286	1295	1304	1313	1322	1324	1325	1327
NIIGATA	3019	3028	3037	3046	3249	3452	3470	3488	3506	3524	3542	3542	3542	3542
TOYAMA	916	916	916	916	943	970	1005	1039	1073	1107	1142	1160	1178	1197
ISHIKAWA	1064	1064	1064	1064	1360	1656	1670	1684	1697	1711	1724	1724	1725	1725
FUKUI	1350	1350	1350	1350	1423	1496	1505	1514	1523	1532	1541	1570	1599	1628
YAMANASHI	1106	1106	1106	1106	1110	1114	1114	1114	1114	1114	1114	1114	1114	1114
NAGANO	1867	1865	1864	1863	2227	2591	2663	2735	2807	2879	2952	3018	3084	3150
GIFU	1349	1349	1350	1350	1443	1535	1558	1581	1604	1627	1650	1655	1660	1666
SHIZUOKA	1775	1775	1775	1775	2112	2448	2509	2570	2631	2692	2753	2767	2781	2795
AICHI	1592	1592	1592	1592	1739	1887	1914	1942	1970	1998	2026	2072	2118	2164
MIE	1734	1734	1734	1734	1800	1866	1866	1867	1867	1867	1868	1881	1895	1909
SHIGA	422	422	422	422	433	443	443	443	444	444	444	502	560	619
KYOTO	1806	1806	1806	1806	1916	2026	2026	2026	2026	2026	2026	2026	2026	2026
OSAKA	977	977	977	977	1145	1312	1322	1332	1342	1351	1361	1374	1387	1401
HYOGO	1938	1943	1948	1953	2162	2371	2373	2375	2378	2380	2382	2443	2504	2565
NARA	250	250	250	250	440	630	634	637	640	644	647	647	647	647
WAKAYAMA	368	368	368	368	467	565	585	606	626	646	667	667	667	668
TOTTORI	475	475	475	475	488	501	504	506	508	510	512	518	525	531
SHIMANE	1311	1311	1311	1311	1401	1490	1491	1492	1492	1493	1493	1493	1493	1493
OKAYAMA	1623	1623	1623	1623	1654	1685	1690	1694	1698	1703	1707	1709	1711	1712
HIROSHIMA	1104	1103	1102	1101	1313	1525	1530	1535	1540	1545	1550	1552	1555	1557
YAMAGUCHI	1997	1997	1996	1995	2033	2071	2100	2129	2159	2188	2217	2261	2306	2350
TOKUSHIMA	248	248	248	248	394	541	541	541	541	542	542	568	593	619
KAGAWA	238	238	238	238	315	391	391	392	392	392	393	407	421	435
EHIME	1228	1228	1228	1228	1378	1527	1535	1542	1549	1556	1564	1564	1564	1564
KOCHI	1523	1523	1523	1523	1756	1990	1990	1990	1990	1991	1991	1991	1991	1991
FUKUOKA	1425	1425	1425	1425	1458	1491	1510	1529	1548	1568	1587	1599	1612	1624
SAGA	878	878	878	878	883	888	889	889	889	889	889	889	889	889
NAGASAKI	1057	1057	1057	1057	1089	1121	1139	1156	1174	1191	1208	1209	1210	1210
KUMAMOTO	999	999	999	999	1186	1373	1375	1378	1381	1384	1387	1388	1390	1391
OITA	1381	1381	1381	1381	1394	1406	1452	1497	1543	1588	1634	1695	1756	1817
MIYAZAKI	1416	1416	1416	1416	1601	1786	1865	1943	2022	2100	2179	2204	2229	2254
KAGOSHIMA	1743	1743	1743	1743	2025	2308	2322	2336	2350	2364	2378	2378	2378	2379

AREA IN SQUARE KILOMETERS VALUES FOR 1956, 1957, 1959, 1961 THROUGH 1964, 1966 AND 1967 ARE INTERPOLATED VALUES.

Table 10. Japan: Cultivated Area by Prefecture, 1955-1968

PREFECTURE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
HOKKAIDO	7608	7750	7892	8419	8947	9475	9524	9572	9568	9566	9524	9583	9613	9673
AOMORI	1336	1323	1311	1422	1533	1644	1659	1673	1680	1684	1690	1722	1710	1697
IWATE	1265	1322	1379	1476	1573	1670	1694	1717	1713	1721	1727	1734	1719	1726
MIYAGI	1347	1366	1385	1498	1610	1723	1726	1729	1726	1727	1715	1716	1703	1721
AKITA	1285	1283	1282	1353	1425	1496	1505	1514	1523	1532	1541	1552	1544	1559
YAMAGATA	1283	1302	1321	1373	1424	1476	1482	1488	1489	1490	1503	1515	1528	1539
FUKUSHIMA	1706	1729	1751	1869	1986	2104	2107	2110	2109	2106	2105	2104	2092	2079
IBARAKI	1933	1981	2030	2109	2189	2268	2303	2337	2342	2338	2343	2343	2328	2316
TOCHIGI	1281	1319	1357	1400	1442	1485	1494	1502	1500	1500	1501	1506	1522	1528
GUMMA	1110	1091	1073	1120	1168	1215	1219	1222	1221	1215	1204	1197	1191	1181
SAITAMA	1398	1433	1469	1517	1565	1613	1600	1587	1563	1547	1516	1498	1463	1430
CHIBA	1702	1689	1676	1763	1851	1938	1941	1944	1933	1928	1921	1912	1895	1875
TOKYO	341	342	343	348	354	359	346	333	316	296	277	265	236	216
KANAGAWA	580	553	527	559	590	622	608	593	561	544	509	493	450	418
NIIGATA	2131	2133	2134	2276	2417	2559	2553	2547	2538	2527	2514	2490	2457	2416
TOYAMA	819	801	783	813	842	872	870	868	885	880	877	872	867	855
ISHIKAWA	634	626	617	648	679	710	708	706	701	695	686	682	669	656
FUKUI	514	517	520	548	576	604	604	603	600	598	594	591	585	580
YAMANASHI	448	452	456	472	489	505	507	508	509	505	502	497	489	484
NAGANO	1650	1638	1627	1707	1786	1866	1860	1854	1830	1821	1800	1786	1764	1746
GIFU	866	866	866	917	969	1020	1012	1004	999	991	983	976	964	950
SHIZUOKA	1192	1145	1098	1192	1285	1379	1369	1359	1340	1325	1302	1286	1263	1241
AICHI	1361	1334	1307	1378	1450	1521	1503	1485	1471	1456	1411	1391	1350	1322
MIE	936	924	911	958	1005	1052	1050	1048	1043	1037	1028	1026	1006	998
SHIGA	659	671	684	708	733	757	753	748	745	741	739	741	743	739
KYOTO	459	461	464	499	533	568	564	560	559	552	541	537	515	509
OSAKA	392	376	361	391	420	450	436	421	410	397	381	368	349	338
HYOGO	1055	1043	1030	1111	1191	1272	1266	1259	1253	1248	1239	1229	1209	1184
NARA	394	367	341	367	393	419	417	415	412	406	401	395	390	386
WAKAYAMA	422	407	393	426	458	491	492	492	489	484	484	484	487	488
TOTTORI	443	443	443	470	498	525	525	525	524	522	522	522	511	511
SHIMANE	637	657	677	702	727	752	751	750	749	741	739	738	724	712
OKAYAMA	1106	1092	1077	1147	1218	1288	1288	1288	1277	1278	1254	1236	1203	1188
HIROSHIMA	926	946	967	1019	1071	1123	1120	1116	1107	1104	1083	1081	1075	1071
YAMAGUCHI	854	817	780	829	879	928	925	922	918	917	903	900	882	858
TOKUSHIMA	462	463	464	483	502	521	527	533	540	536	533	535	530	521
KAGAWA	486	483	480	505	530	555	555	554	553	550	548	544	540	536
EHIME	723	732	742	780	818	856	863	870	878	886	893	900	903	900
KOCHI	502	499	496	529	563	596	589	581	581	578	568	563	550	534
FUKUOKA	1206	1207	1207	1236	1266	1295	1295	1295	1295	1290	1285	1286	1278	1279
SAGA	648	636	623	669	716	762	767	771	784	793	801	808	805	800
NAGASAKI	754	745	736	788	841	893	894	894	896	897	898	895	876	864
KUMAMOTO	1428	1375	1322	1402	1483	1563	1571	1579	1560	1564	1566	1596	1568	1565
OITA	779	779	779	835	892	948	948	947	948	950	951	955	937	937
MIYAZAKI	861	864	868	924	980	1036	1038	1039	1033	1031	1027	1027	1019	999
KAGOSHIMA	1482	1417	1353	1547	1742	1937	1939	1941	1930	1925	1915	1906	1881	1843

AREA IN SQUARE KILOMETERS VALUES FOR 1956, 1958, 1959 AND 1961 ARE INTERPOLATED VALUES.

evenly distributed throughout the entire country except for the northern portion of Honshu and Hokkaido. Only two among the ten northernmost prefectures, Aomori and Akita, lost cultivated land. Even though the cultivated area in half of the prefectures decreased, the losses were more than offset by gains in other prefectures thereby resulting in overall net increases in cultivated area.

The second period of change occurred between 1958 and 1960. In these years all prefectures recorded increases in their cultivated area. However, beginning in 1961, the first year of the third period, losses were reported once again, first in the prefectures in and near the Tokyo-Osaka industrial belt and later throughout the entire country. In 1967 thirty-nine prefectures reported decreases in their cultivated areas totaling 58,000 hectares. In 1968 fewer prefectures reported losses (thirty-six), but the total decrease in cultivated area was still quite large--41,000 hectares. Throughout the entire fourteen year period only Yamagata prefecture in northern Honshu did not report decreases in its cultivated area.

Two points must be made concerning the data in Table 10 and its interpretation. First, it represents net

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be expected to be recorded as a decrease in cultivated area, and only land permanently removed from production could be expected to effect the amount of arable land available, the inference that may be made from the available data is that the decreases in cultivated area are of a permanent rather than a temporary nature.

changes in the cultivated area of each prefecture. Consequently, it cannot be determined how much land was taken out of production in one place and new land in another place put into production to replace it. Secondly, there are at least two basic reasons for the decreases in cultivated area, especially in the years from 1961 through 1968. The decreases in the industrial belt that stretches from the Tokyo area to Osaka and Kita-Kushu were probably due in large part to urban expansion. In the outlying prefectures however, a large portion of the losses should probably be attributed to abandonment of marginal farm land by people who migrated to the cities. In several prefectures on the islands of Kyushu and Shikoku and on the western side of Honshu the decreases in agricultural land were accompanied or preceded by decreases in population. For example, the decreases in cultivated area that started in 1963 in Miyazaki and Kagoshima prefectures on Kyushu were preceded by population decreases that started in 1957 and continued through 1968. A similar pattern is present in the data for Shimane and Niigata prefectures on the western coast of Honshu.

In light of these two points it would be a mistake to conclude that no new land has been put into agricultural production in those prefectures that lost population in recent years. It would also be a mistake to conclude on the basis of these data that all land removed from agricultural

production was the victim of urban expansion. Thus even with available detailed data related to the population and the urban area and cultivated area it is difficult to determine where, and to what extent, growing urban centers have encroached on agricultural land in Japan. A means of sorting out the differences between the urban and agricultural prefectures, identifying their distinguishing characteristics, and clarifying the uncertain patterns in the population and areal data are needed. An examination of a series of variables related to urban and agricultural functions would seem to be a reasonable way to accomplish such a task. Two descriptive mathematic techniques, factor analysis and discriminant analysis, provide a means of testing the appropriateness of groupings of prefectures made on the basis of selected variables.

CHAPTER II

FACTOR ANALYSIS: THE RESULTS

The data was factor analyzed and the principal axis solution yielded seven factors with eigenvalues greater than 1.0 that accounted for 88.05 percent of the total variance. These factors were then rotated using the varimax method.[12] The seven rotated factors were assigned names on the basis of the variables with the highest loading on each factor. The factors are listed in Table 11 with the proportion of total variance accounted for by each.

Each of the factors represents a particular set of variables which in turn measure specific characteristics. The grain factor for example represents the variables measuring grain production throughout Japan. The factor scores associated with the grain factor may be considered as a

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[12] James Peterson, Glenn Foster, and Robert Paul, FACTOR AA (Technical Report No. 34.1), (East Lansing, Michigan: Computer Institute for Social Science Research, Michigan State University, May, 1969); Leighton A. Price and James Peterson, Control Cards For Programs on the New 6500 CISSR Library System (Technical Report No. 70-4), (East Lansing, Michigan: Computer Institute for Social Science Research, Michigan State University, June, 1970). A discussion of Factor Analysis, Discriminant Analysis and the data used in this study may be found in Appendix B.

Table 11

Factors and Proportion of Total Variance Accounted for by Each Factor

Factor	Proportion of Variance
Urban	35.90
Grain	13.73
Agricultural Employment	11.99
Farm	10.13
Unemployment	6.60
Elderly Population	5.08
Orchard Land	4.62

single measure of grain production. By mapping these scores, the prefectures in which grain production is prominent may be easily discerned. Similarly, the scores associated with the other factors may be mapped to locate the prefectures in which their characteristics are most pronounced. Since one of the objectives of this study is to differentiate urban from agricultural areas, a consideration of the factor scores is appropriate.

Only the scores associated with the factors were mapped that individually accounted for ten percent or more of the total variance in the data. Because the urban and agricultural employment factors contain dichotomies that represent opposite poles of an urban-agricultural spectrum, they will be considered first.

Tokyo, Kanagawa and Osaka Prefectures have the highest positive scores on the urban factor (Figure 9).[13] The high scores indicate the presence in these prefectures of the characteristics represented by the variables that have high positive loadings on the urban factor. Aichi Prefecture has a somewhat lower score but still stands out among the others as an urban prefecture. Each of these prefectures contains a major city of over one million inhabitants, several with over 100,000 inhabitants, and very few having populations of less than 50,000.[14] A review of the raw data revealed that they also have an abundance of transportation facilities, high population densities in both DID's and the prefectures as a whole, and higher average income per household than other prefectures. Conversely, comparatively little of their population or area is classified rural. The proportion of the population and households counted in the farm classification is also low. The urban nature of these four prefectures was, therefore, quite clear and they were readily classified urban. In the prefectures that had only moderate positive scores the urban characteristics are not particularly prominent. Consequently, to classify them as urban on the basis of this factor would be, at best, a tenuous decision.

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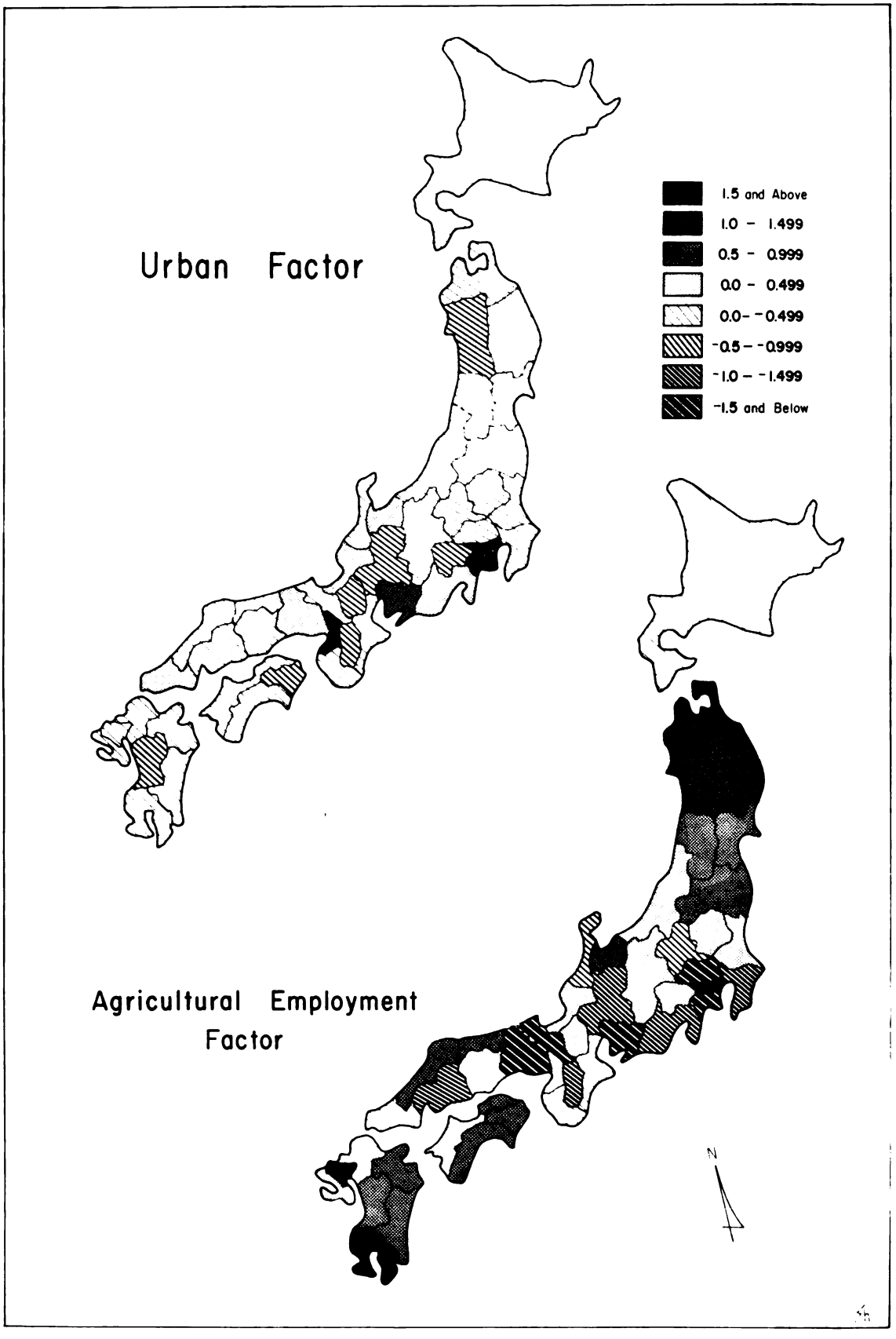
[13] A complete listing of the factor scores may be found in Appendix E.

[14] J.S.Y. 1966, op. cit., Table 10, pp. 23-24, 26-28.

Figure 9. Factor Scores: The Urban Factor

Figure 10. Factor Scores: The Agricultural Employment Factor


Urban Factor
1.5 and Above
1.0 - 1.499
0.5 - 0.999
0.0 - 0.499
0.0- -0.499
-0.5- -0.999
-1.0- -1.499
-1.5 and Below
Agricultural Employment Factor
N

Several prefectures have moderate negative scores on the urban factor, indicating the presence of variables that loaded negatively on this factor. An examination of the data showed that the prefectures with scores between -0.50 and -0.99 have comparatively large proportions of their area and population classified rural. In addition, their farm populations are larger than those of most other prefectures, and the percent of the labor force employed in agriculture well above the national average. Finally, each of these prefectures has a large proportion of its cities in the under 50,000 population category and a large percentage of its population living in these smaller cities. Even though their factor scores are not high,[15] it seemed reasonable to tentatively classify the prefectures with scores between -0.50 and -0.99 as agricultural.

The dichotomy represented by the agricultural employment factor is strikingly revealed by the map of its factor scores (Figure 10). The most notable feature of the map is the concentration of prefectures with high negative scores in the central portion of Honshu and the complementary concentration of positive scores in the northern and southern parts of the country. The prefectures with

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[15]The use of the descriptive terms "high" and "low" should be interpreted as indicating the absolute values of factor scores rather than the signed values. For example, a negative score of -1.3 is considered high while a score of -0.3 is considered low.

high positive scores have large portions of their labor force employed in agriculture, have been the beneficiaries of large government expenditures on a per capita basis, and have experienced considerable population decreases. Those with moderate scores between 0.50 and 0.99 also exhibit these characteristics although not as strongly as the prefectures with the highest scores.

Prefectures having high negative scores also exhibit some distinguishing characteristics. First of all the percent of the labor force engaged in manufacturing is higher than in other prefectures. Secondly, income per household is also higher than elsewhere in the country. Third, these prefectures experienced population increases of as much as twenty-eight percent during the 1960-1965 period. Finally, government expenditures per capita were considerably below the national average.[16]

On the basis of the scores associated with the agricultural employment factor, it was possible to confirm further the urban or agricultural nature of several prefectures. Akita Prefecture, for example, has a moderate negative score on the urban factor and a high positive score on the agricultural employment factor. Therefore, it was labeled

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[16]The average government expenditure per capita in the five prefectures having the highest negative scores was more than 1.5 standard deviation units below the national average, a difference representing $25.79.

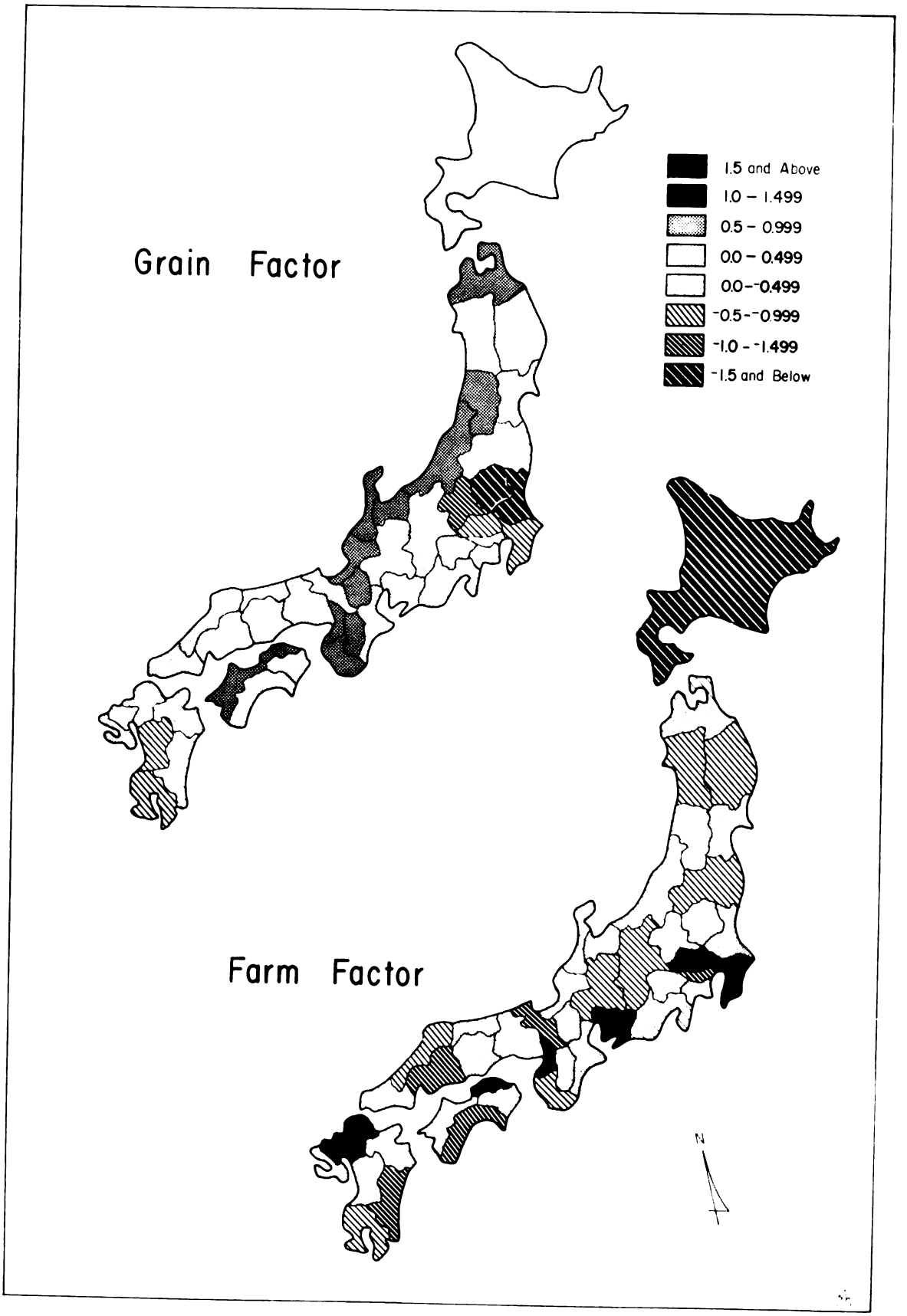
an agricultural prefecture. Similarly, the urban nature of Kanagawa Prefecture is confirmed by its high negative score on the agricultural employment factor. Labeling other prefectures, however, presented some problems.

Tokyo Prefecture, for example has high positive scores on both factors discussed thus far, indicating the strong presence of both urban and agricultural characteristics. The data showed that in Tokyo Prefecture government expenditures per capita were quite high, a characteristic associated with agricultural rather than urban prefectures. On other variables measuring agricultural qualities, however, the figures for Tokyo were similar to those of other urban prefectures. Furthermore, the figures on manufacturing employment, income, and population increase approximated those recorded for Kanagawa, Aichi and Osaka Prefectures. Therefore, the anomalous score on the agricultural employment factor was disregarded and Tokyo Prefecture was retained with those previously classified urban. Other prefectures such as Gifu and Nara presented problems in classification that could not be satisfactorily resolved by referring to the data. Consequently, no final decision was made as to whether they, as well as others, are urban or agricultural prefectures.

The scores for the grain factor highlight two areas of grain production (Figure 11). The prefectures of the Kanto Plain, including all or parts of Ibaraki, Tochigi,

Figure 11. Factor Scores: The Grain Factor

Figure 12. Factor Scores: The Farm Factor


Grain Factor
1.5 and Above
1.0 – 1.499
0.5 – 0.999
0.0 – 0.499
0.0 – -0.499
-0.5 – -0.999
-1.0 – -1.499
-1.5 and Below
Farm Factor
N

Gumma, Chiba, Saitama, Tokyo and Kanagawa, comprise the most important group based on factor scores and actual production. Ibaraki and Tochigi Prefectures have the highest scores and are in fact the primary grain producing prefectures in the country. The second group is made up of Kumamoto and Kagoshima Prefectures on Kyushu, but their status as grain producers is notably below that of the Kanto Plain group.

Although the grain factor does identify at least two prefectures, Ibaraki and Tochigi, as primary grain producers and indicates the prominence of several others, it does little else. It is a narrowly specific factor representing one aspect of agriculture with a high degree of selectivity. Of the prefectures having positive scores on this factor (indicating a relative "lack" of grain production) little can be said other than that they are the less prominent producers of grain. By itself, the grain factor is limited in its usefulness to indicating where a particular type of agricultural activity is prevalent.

The map of scores of the farm factor basically shows the prefectures that have large proportions of their area under cultivation (Figure 12). This explains why they have a larger number of farm households and farm machines per square kilometer than other prefectures. All the variables representing these items have high loadings on the farm factor. The map of the scores of the farm factor

indicates the prefectures that have proportionally large amounts of farm land available and in use within their boundaries. It is noteworthy that two of the prefectures already classified urban, Osaka and Aichi, have high scores on this factor. Two others, Saitama and Chiba, are contiguous with Tokyo Prefecture. Finally, all seven of the prefectures with high scores are characterized by having part or all of a large plain within their borders on which large and growing cities are located.[17] The data for urban area in Table 9 reveals that, with the exception of Fukuoka and Saga Prefectures, increases in urban area ranging from thirty-five to eighty-two percent occurred in these prefectures between 1955 and 1968. Thus, the prefectures with the highest scores on the farm factor exhibit characteristics that are both urban and agricultural. Moreover, since this group contains the prefectures that have been classified urban and others that are contiguous with an urban prefecture it might be concluded that these are prefectures in which urban expansion onto agricultural land probably is occurring.

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[17]Saga Prefecture on the island of Kyushu may be the exception to this statement. While it has a large area of what may be considered plain, the major city, Saga, had a population of 135,000 in 1965 and barely qualifies as a "large" city when compared with the others. In addition, its population increased only seven percent during the 1955-1965 period while the national population increased ten percent.

Hokkaido Prefecture's high negative score stands out on the map of the farm factor and merits an explanation. Because of Hokkaido's large size, the measures standardized on the basis of area have consistently low values. The high negative score on the farm factor therefore represents an anomaly in the data rather than an actual "lack" of farm land and the things associated with it. Indeed, a review of the data presented in Table 10 reveals that Hokkaido has a larger cultivated area than any of the other prefectures. Standardizing the data on the basis of total prefectural area, however, resulted in an overcompensation and distortion in the case of Hokkaido Prefecture. In the absence of a satisfactory method for correcting the distortion, it was simply accepted as one of the limits of the data.[18]

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[18]Several attempts were made to derive a constant that could be applied to the areally based variables to reduce the effect of Hokkaido Prefecture's large area. None of them, however, proved to be satisfactory. They tended to result in selective distortions less acceptable than those caused by the large area value alone. Consequently, the large area value was used as the basis for standardization even though it resulted in a certain degree of misrepresentation. To test for the effect of the low values for several variables on the results of the factor analysis the analysis was repeated with Hokkaido Prefecture excluded from consideration. The variable measuring households per thousand population was also dropped from the data set in order to maintain the symmetry of the data matrix. This variable was selected for exclusion because of its relatively low loadings in the original factor analysis. The results of the analysis of the modified data set were virtually identical to those of the original analysis. The same factors were derived and the factor loadings and scores had a high degree of similarity with those obtained earlier. The percent of total variance accounted for

The scores of the unemployment, elderly population, and orchard land factors revealed patterns among the prefectures that correspond closely with patterns in the few variables they represent. The islands of Kyushu and Shikoku stand out as areas of "high" unemployment along with Wakayama and Hokkaido Prefectures. Northern and central western Honshu contain prefectures experiencing a "low" rate of unemployment.[19] The elderly population factor is most prominent in the prefectures of southwestern Honshu and Shikoku. This is generally the part of the country that has been settled the longest. It is also the area which experienced population decreases during the 1965-1968 period. The more recently settled "frontier" prefectures of northern Honshu and Hokkaido have much smaller proportions of their populations in the sixty-five and over age bracket and have negative scores on the elderly population factor. Finally, the prefectures having the largest portion of their cultivated areas planted to orchard crops are pinpointed by the orchard land factor. Gumma, Saitama, Yamanashi and Nagano constitute the largest group of contiguous prefectures in which

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declined slightly from 88.05 to 86.23. Since the difference between the results of the two analyses were slight, the results with Hokkaido Prefecture included were selected for discussion and evaluation.

[19]Unemployment in 1965 ranged from 0.44 percent in Niigata Prefecture to 2.09 percent in Fukuoka Prefecture.

orchard land and crops, as well as silk production, are prominent. Wakayama and Ehime have slightly lower scores, but are still among the prominently orchard oriented prefectures.

After carefully evaluating the results of the factor analysis and reviewing the data set, I assembled five groups of prefectures primarily on the basis of their factor scores (Table 12). Three of the groups contained prefectures exhibiting agricultural characteristics represented by the urban, agricultural employment, unemployment, grain and elderly population factors. These groups contained most of the prefectures in northern and southern Honshu, Shikoku and Kyushu. The northern and west coast group represented prefectures with negative scores on the urban and elderly population factors and positive scores on the agricultural employment and unemployment factors. The southern group included prefectures with negative scores on the urban and unemployment factors and positive scores on the agricultural employment and elderly population factors. The third agriculturally oriented group was made up of the prominent grain producing prefectures on the Kanto Plain.

The fourth group of prefectures contained those with either high positive scores on the urban factor or high negative scores on the agricultural factor, both of which indicated the presence of urban qualities. Fukuoka

Table 12

Prefectural Groupings Based On Factor Scores

Northern & West Coast	Southern	Grain	Urban	Undefined
Hokkaido	Tokushima	Ibaraki	Tokyo	Yamanashi
Aomori	Kagawa	Tochigi	Kanagawa	Nagano
Iwate	Ehime	Gumma	Aichi	Gifu
Miyagi	Kochi	Saitama	Kyoto	Shizuoka
Akita	Saga	Chiba	Osaka	Mie
Yamagata	Nagasaki		Hyogo	Shiga
Fukushima	Kumamoto		Fukuoka	Nara
Niigata	Oita			Wakayama
Toyama	Miyazaki			Okayama
Ishikawa	Kagoshima			Hiroshima
Fukui				Yamaguchi
Tottori				
Shimane				

Prefecture was placed in the urban group because it was the only prefecture on Kyushu or Shikoku with a negative score on the agricultural employment factor, with a high score on the farm factor, and containing a city of over one million people. The fifth group comprised all of the remaining prefectures which did not seem to fit into any of the other four groups. The factor scores for all five groups were then submitted to discriminant analysis to test the appropriateness of the groupings.

CHAPTER III

DISCRIMINANT ANALYSIS: THE RESULTS

The results of the discriminant analysis indicated that some of the prefectures had not been properly assigned.[20] Several had high probabilities of belonging to groups other than those to which they originally had been allocated. Therefore, the groups were altered and a second discriminant analysis model tested. After several alternative groupings were tested, the one which yielded the highest probabilities for each group was selected for discussion and evaluation.[21] The importance of each of the factors in discriminating between the groups is indicated by the coefficients of the linear discriminant functions (Table 13). The signs of the coefficients are associated with the signs of the factor scores. The negative sign of the coefficient for the urban factor in the Northern and West Coast group, for example,

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[20] Kevin Kay and Rodney C. Kirk, BMD05M--Discriminant Analysis For Several Groups (Technical Report 31), (East Lansing, Michigan: Computer Institute for Social Science Research, Michigan State University, June, 1967).

[21] A complete listing of the probabilities of each prefecture belonging to each group may be found in Appendix F.

Table 13

Coefficients of Linear Discriminant Functions

Group / Variable	Northern and West Coast	Grain Basket	Urban/ Industrial	Semi-Industrial	Southern and Inland Sea
Urban Factor	-3.78498	2.56098	7.87660	-0.41828	-1.50024
Grain Factor	2.81762	-7.48897	-3.05627	0.76992	0.73008
Unemployment Factor	3.12134	-0.27873	-3.38055	0.11676	-1.50813
Farm Factor	-2.19598	1.46272	3.41198	-0.34697	0.06541
Elderly Population Factor	-1.40369	-0.14803	0.42679	0.75264	0.91412
Agricultural Employment Factor	4.76817	-4.20762	-8.36572	-0.77253	2.17772
Orchard Land Factor	1.73021	-0.89798	-1.50916	-0.91839	-0.02654

indicates that negative factor scores were important in distinguishing the members of this group from the other prefectures. Similarly, positive scores on the agricultural employment factor were also important in distinguishing the members of this group. The magnitude of the coefficients of the urban and agricultural employment factors indicates those most important in discriminating between the groups. The prefectures comprising each group together with the slightly revised group labels are shown in Table 14.

Reassignment of Prefectures

As can be seen by comparing Tables 13 and 14, three prefectures, Shiga, Saitama and Yamaguchi, were placed in groups different from those to which they were originally assigned. Placing Shiga and Yamaguchi Prefectures in the decidedly agricultural Northern and West Coast and Southern and Inland Sea Coast groups respectively was reasonable on the basis of their probabilities of belonging with those groups.[22] In addition, their factor scores and values in the data set are similar to others in their respective groups.

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[22]The appropriateness of Shiga Prefecture's membership in the Northern and West Coast group is almost a certainty, as is reflected by the .97 probability of its belonging with this group. The probability associated with Yamaguchi Prefecture's membership in the Southern and

Table 14

Five Groups Derived Through Discriminant Analysis of Factor Scores

Northern & West Coast	Southern & Inland Sea Coast	Grain Basket	Urban/ Industrial	Semi-Industrial
Hokkaido	Yamaguchi	Ibaraki	Saitama	Yamanashi
Aomori	Tokushima	Tochigi	Tokyo	Nagano
Iwate	Kagawa	Gumma	Kanagawa	Gifu
Miyagi	Ehime	Chiba	Aichi	Shizuoka
Akita	Kochi		Kyoto	Mie
Yamagata	Saga		Osaka	Nara
Fukushima	Nagasaki		Hyogo	Wakayama
Niigata	Kumamoto		Fukuoka	Okayama
Toyama	Oita			Hiroshima
Ishikawa	Miyazaki			
Fukui	Kagoshima			
Shiga				
Tottori				
Shimane				

The reassignment of Saitama Prefecture from the agriculture oriented Grain Basket group to the Urban/Industrial group was surprising, although not unexpected. Its original placement in the Grain group was based upon high factor scores on the grain and orchard land factors. The high negative score on the agricultural employment factor was discounted because of the very low score on the urban factor. The possibility that Saitama might actually be a prefecture having more urban than agricultural qualities was not, however, disregarded. When it was found to have a surprisingly high probability (.97) of belonging in the Urban/Industrial group an explanation was sought in both the data and the literature.

Data on urban population showed that a sixty-seven percent increase occurred between 1955 and 1965 in the population of cities of over 30,000 inhabitants. Three of the cities closest to Tokyo had a population increase of more than one hundred percent.[23] In addition, data used in the factor analysis showed Saitama to have labor force and population characteristics more like those of the

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Inland Sea Coast group is somewhat lower, being only .65. It also has a .35 probability of belonging to the Semi-Industrial Group. This secondary association most likely reflects the influence of the industrial cities of Shimonoseki and Ube which lie across the Straits of Shimonoseki opposite Kita-Kyushu, the iron and steel center of southwestern Japan.

[23] J.S.Y. 1966, op. cit., Table 10, p. 22. All three are less than 20 kilometers from the city limits of Tokyo.

Urban/Industrial group than the Grain Basket group. Finally, the literature describing the prefecture indicates that it has been "invaded" by industry and large numbers of people who commute to work in Tokyo.[24] Its importance as a grain producing prefecture notwithstanding, therefore, the reassignment of Saitama to the Urban/Industrial group was both reasonable and understandable.

The Semi-Industrial Group

While the characteristics of the agriculture oriented groups and the Urban/Industrial group have been made clear by the discussion of the factors and factor scores, those of the prefectures in the Semi-Industrial group are not so readily apparent. The name used to identify group, however, is indicative of their general nature. All of the prefectures in this group have scores on the urban and agricultural employment factors indicating urban qualities. They are not as high, though, as those of the prefectures

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[24] A study by John D. Eyre based on research conducted during 1958 and 1961 and containing a number of useful references was published in 1963. In it the commuting range of and facilities available to commuters are discussed and maps showing the concentration of various industries in the districts bordering Tokyo Prefecture presented. John D. Eyre, "Tokyo Influences in the Manufacturing Geography of Saitama Prefecture," Economic Geography, 39: 283-298, October, 1963.

in the Urban/Industrial group. The results of the discriminant analysis do indicate however that the prefectures of the Semi-Industrial group constitute a viable group of and by themselves.

Most prefectures classified in the Semi-Industrial group have probabilities of belonging to it which range from .64 to .99, indicating some secondary associations with other groups. However, three prefectures are associated with those of the Southern and Inland Sea Coast group and Nagano Prefecture has a secondary association with the Northern and West Coast group.[25] Associations with either the Grain Basket or Urban/Industrial groups are virtually nonexistent. Thus, although the Semi-Industrial group can be considered viable, four of its members are linked with two of the agricultural groups.

Two features characterize the prefectures of the Semi-Industrial group. Firstly, when the group is compared to the nation as a whole its average values on most of the variables in the factor analysis approximate the national averages. These averages, however, have a noticeable tendency to favor the urban end of what might be called the

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[25]Nara, Wakayama and Okayama Prefectures have probabilities of .20, .21 and .36 respectively of belonging in the Southern and Inland Sea Coast group. Nagano Prefecture has a .20 probability of belonging in the Northern and West Coast group.

urban-agricultural spectrum.[26] Secondly, each of the prefectures, with the exception of Hiroshima, is contiguous with one or more of the Urban/Industrial prefectures and has only one or two cities of 100,000 or more population.[27] These cities are located either on major transportation routes or near the major urban centers of neighboring Urban/Industrial prefectures.[28] They function as secondary industrial and residential centers serving the needs of their metropolitan neighbors.[29] The remaining cities are considerably smaller, comparatively distant from major urban centers and serve as centers of agricultural activity. The prefectures of the Semi-Industrial group are characterized by secondary urban-industrial centers, while still retaining agricultural qualities. With the discriminating "power"

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[26]Such a spectrum was constructed by ranking the prefectures according to their values on each variable. Noticeable trends in the grouping of prefectures at either end of the spectrum were found. Prefectures of the Semi-Industrial group were located rather consistently on the urban side of the mean value for each variable.

[27]J.S.Y. 1966, op. cit., Table 10, pp. 25-29. Shizuoka and Hiroshima Prefectures are exceptions in that they contain several cities of over 100,000 inhabitants.

[28]The cities of Gifu in Gifu Prefecture and Yokkaichi in Mie Prefecture, for example, are both less than 40 kilometers from the major urban center of Nagoya in Aichi Prefecture.

[29]A discussion of the development of a secondary industrial center in Nagano Prefecture is contained in: John D. Eyre, "Industrial Growth in the Suwa Basin, Japan," The Geographical Review, 53:487-502, October, 1963.

of the factors indicated, the reclassification of prefectures described and accounted for, and the nature of the Semi-Industrial group in mind an evaluation of the groups is in order.

Evaluation and Conclusion

The map of the five groups (Figure 13) illustrates their distribution. Several noticeable patterns are immediately apparent. First of all the pattern of the groups is very similar to the major patterns exhibited in the maps of the factor scores. In effect, the map is a composite of the patterns found in the scores of all seven factors. Secondly, with the exception of Fukuoka Prefecture, the two sets of basically agricultural and urban prefectures constitute contiguous agglomerations of prefectures. The separation of the northern and southern agricultural groups by Hyogo and Kyoto Prefectures is the result of the positions of boundaries rather than of any actual differences in the coastal area. If a coastal prefecture existed linking Fukui and Tottori it would most likely be classified in the Northern and West Coast group.[30] A third feature that

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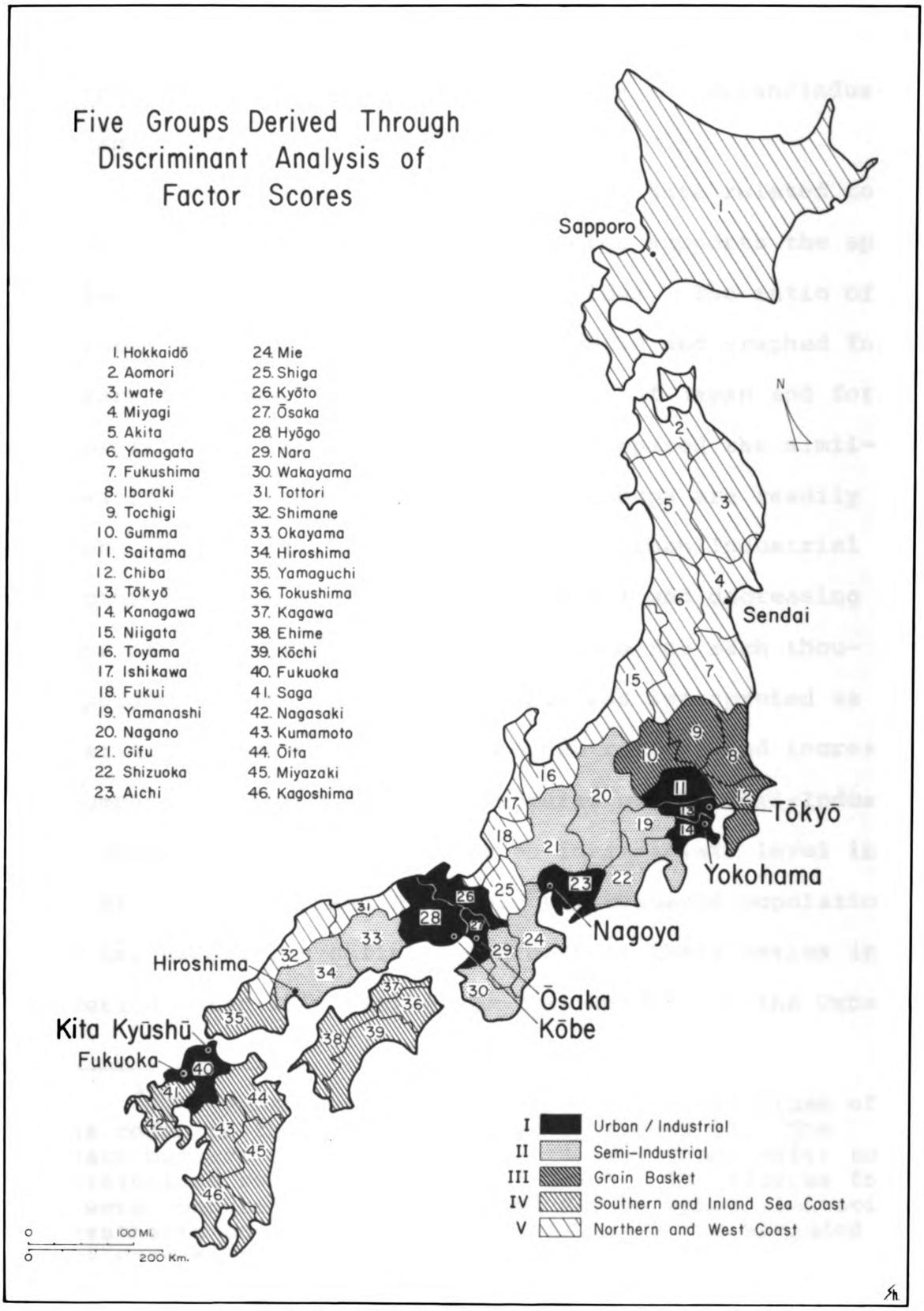
[30]The population characteristics of the cities and towns in the coastal portions of Hyogo and Kyoto Prefectures follow the same pattern as those in Shimane, Tottori and Fukui Prefectures. The pattern is one of low population density and decreasing numbers of inhabitants.

Figure 13. Five Groups Derived Through Discriminant Analysis of Factor Scores


Five Groups Derived Through Discriminant Analysis of Factor Scores
1. Hokkaidō
2. Aomori
3. Iwate
4. Miyagi
5. Akita
6. Yamagata
7. Fukushima
8. Ibaraki
9. Tochigi
10. Gumma
11. Saitama
12. Chiba
13. Tōkyō
14. Kanagawa
15. Niigata
16. Toyama
17. Ishikawa
18. Fukui
19. Yamanashi
20. Nagano
21. Gifu
22. Shizuoka
23. Aichi
24. Mie
25. Shiga
26. Kyōto
27. Ōsaka
28. Hyōgo
29. Nara
30. Wakayama
31. Tottori
32. Shimane
33. Okayama
34. Hiroshima
35. Yamaguchi
36. Tokushima
37. Kagawa
38. Ehime
39. Kōchi
40. Fukuoka
41. Saga
42. Nagasaki
43. Kumamoto
44. Ōita
45. Miyazaki
46. Kagoshima
Sapporo
Sendai
Tōkyō
Yokohama
Nagoya
Ōsaka
Kōbe
Hiroshima
Kita Kyūshū
Fukuoka
N
I Urban / Industrial
II Semi-Industrial
III Grain Basket
IV Southern and Inland Sea Coast
V Northern and West Coast
100 Mi.
200 Km.

stands out is the series of alternating areas of high and low urban concentration as represented by the Urban/Industrial and Semi-Industrial groups respectively.

The comparison of the groups with data related to changes in population and cultivated area supports the appropriateness of the prefectural groupings. The ratio of cultivated land to population was computed and graphed for the years from 1956 through 1968 for all of Japan and for each prefecture. When the graphs are compared the similarities of the prefectures within the groups are readily apparent (Figure 14).[31] Graphs for the Urban/Industrial prefectures (Group I) indicate that small and decreasing amounts of cultivated land were available for each thousand persons in the population. This was interpreted as indicating the presence of high concentrations and increasing numbers of people. The prefectures of the Semi-Industrial group (Group II) represent an intermediate level in terms of cultivated land available per thousand population. There is, however, a definite decrease in their ratios in the period after 1960 similar to that evident in the Urban/

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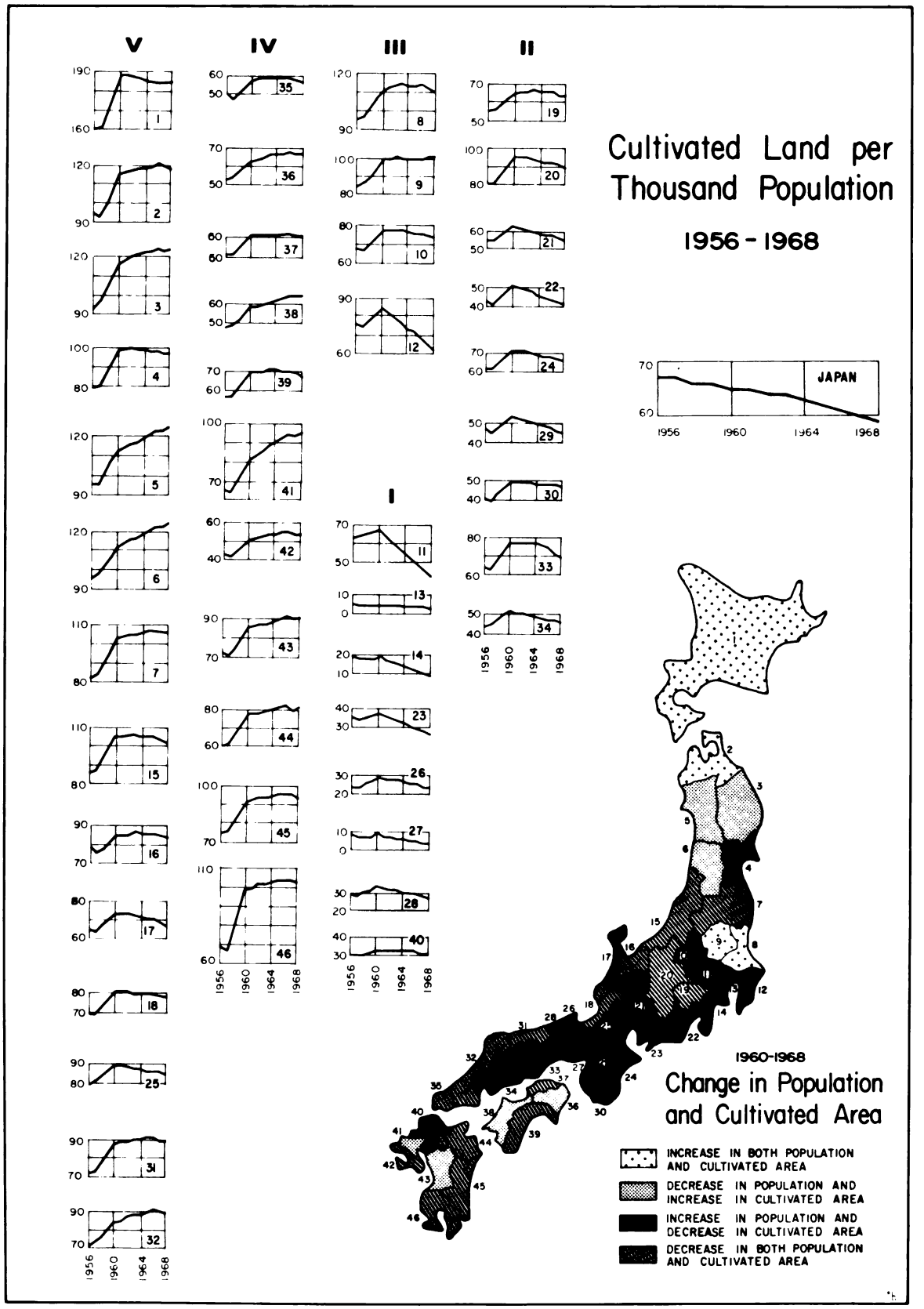
[31]The Roman numerals at the top of each column of graphs refer to the groups as shown in Figure 13. The boldface numbers on the right side of each graph refer to the prefecture represented by that graph. The figures for 1955 were computed but not included due to space limitations and aesthetic considerations. In all cases the excluded values were similar to those for 1956.

Figure 14. Japan: Changes in Population, Cultivated Area and Cultivated Land Per Thousand Population


V
IV
III
II
I
Cultivated Land per Thousand Population
1956 - 1968
JAPAN
1956
1960
1964
1968
1960-1968
Change in Population and Cultivated Area
INCREASE IN BOTH POPULATION AND CULTIVATED AREA
DECREASE IN POPULATION AND INCREASE IN CULTIVATED AREA
INCREASE IN POPULATION AND DECREASE IN CULTIVATED AREA
DECREASE IN BOTH POPULATION AND CULTIVATED AREA

Industrial group. The graphs for the prefectures in the three agricultural groups (Groups III, IV and V) are quite different. They show generally increasing ratios throughout the entire period and, in addition, indicate the availability of comparatively large amounts of cultivated land. The increases in the agricultural prefectures were not sufficient to offset losses that occurred and the effect of a growing population. The steady downward trend of the ratio illustrated in the graph representing the entire nation is indicative of the increasing burden being placed on the cultivated area of the country.

Two prefectures, Saitama (11) and Chiba (12), stand out as unusual because of the marked decline in the ratio shown in their graphs. The changes taking place in Saitama Prefecture have already been mentioned. The magnitude of those changes is such that the relationship of the population to the cultivated area has been rapidly altered. Between 1955 and 1960 population grew at a slow rate as increases in cultivated area kept well ahead of the growth. After 1960, however, the amount of cultivated land decreased while the population increased at a faster rate.[32] Between 1960 and 1968 the population increase totaled more than one million (forty-three percent), the urban area grew and

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[32]Between 1955 and 1960, 168,000 people were added to the population. In the 1960-1968 period, 1,043,000 were added.

encompassed an additional 36,900 hectares, and the cultivated area decreased 17,300 hectares. These changes clearly illustrate a rapid urbanization of the prefecture and account for the declining population-cultivated land ratio.

Similar changes have taken place in Chiba Prefecture, one of the members of the Grain Basket group. Here the change in population was less but the size of the annual increment has increased since 1965 to the point where over 100,000 people were added in 1967 and in 1968. During the 1960-1968 period urban area increased 51,600 hectares. The largest amount of cultivated land available was recorded in 1962. Between that year and 1968 the cultivated area decreased 6,900 hectares with the largest decreases recorded between 1965 and 1968.[33] These changes, when considered along with Chiba Prefecture's .32 probability of belonging in the Urban/Industrial group, indicate rapid urbanization and the likelihood that it is in transition from an agricultural to urban status.

The map showing changes in both population and cultivated area between 1960 and 1968 indicates that, with two exceptions, all of the prefectures in the Urban/Industrial and Semi-Urban groups experienced increases in

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[33]Based on figures contained in Tables 7, 9 and 10 plus those in J.S.Y. 1966, op. cit., Table 10, pp. 22-23.

population and decreases in cultivated area (Figure 14).[34] The appearance of several agricultural prefectures in the same category as the urban prefectures possibly indicates a trend toward urbanization, however, the changes in these prefectures have been small, and therefore, may be misleading.[35] Hokkaido and the portions of northern Honshu that experienced increases in both population and cultivated area are the "frontier" portions of the country where people have been drawn by the availability of land and employment opportunities in the forest and fishing industries. Even in these areas though data on urban centers indicate population decreases in the more remote and smaller cities.

The variables used in this study were well suited to the task of identifying and differentiating urban from agricultural prefectures in Japan. This conclusion is supported by the trends in the data discussed above as well as by descriptions of Japan contained in a variety of reference materials.[36] In addition to the basic division between urban

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[34]The 1960-1968 period was selected because it was the period in which decreases in cultivated land and rapid increases in urban area and urban population occurred.

[35]With the exception of Chiba, the populations of these prefectures grew at a rate less than that of the national population. Decreases in cultivated area were small, the largest loss being 5,400 hectares in Ishikawa Prefecture.

[36]The descriptions of farming and industrial characteristics contained in Dempster, op. cit., pp. 62-307, were particularly useful as background information upon which to base conclusions. Trewartha's discussion of the

and agriculturally-oriented prefectures shades of difference between the component parts of the divisions also can be distinguished. For example, the differences between the three groups that constitute the agricultural portion of the urban-agricultural dichotomy illustrate the high level of discrimination that can be achieved by using this set of variables. Thus the variables used in this analysis constitute a rather complete group of valid indicators of the urban and agricultural attributes prominent in the prefectures of Japan.

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commonly recognized regional subdivisions of Japan were also of considerable help. Trewartha, op. cit., pp. 311-606.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Three main conclusions may be reached on the basis of this study. The first of these is that urban encroachment on agricultural land has occurred in most of the nations of the world and will doubtlessly continue unless steps are taken to preserve agricultural land. Even though the elements contributing to urban expansion are generally recognized there is little evidence that effective efforts are being made to control the conversion of agricultural land to urban uses. There are at least two reasons for the apparent lack of concern for the fate of agricultural land near growing urban centers. The first involves the amount of arable land still available for use in some nations. In developed nations such as the United States which possess large amounts of unused arable land that can be put into production, the need to preserve land already in use has not been felt. Serious problems in assuring adequate food supplies have not yet been encountered. Secondly, the ability of most developed nations to purchase needed food with the proceeds from the sale of their industrial products has

reduced their dependence on domestic agricultural production. Consequently, plans for urban development have frequently stressed the planned and orderly conversion of agricultural land to urban uses rather than its orderly preservation from urban encroachment.[37] In these countries urban encroachment on agricultural land has generally meant the relocation of farm families on "new" land or their absorption into the business or industrial labor forces.

In the densely populated developing nations the situation is somewhat different. Such countries as Taiwan and Korea are rapidly approaching the upper limit of the carrying capacity of the agricultural land. There, shortages in domestic food production will be experienced either in the stomachs of the people or in the countries' foreign exchange reserves. If political instability and a general physical weakening of the population is to be avoided, food supplies to counter domestic production shortages will have to be purchased. The money spent for these purchases thus will not be available for economic development projects and development may be retarded.

Urban encroachment on agricultural land only hastens the day when food shortages will appear. Yet there are few indications that the role of urban expansion in

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[37]Buchanan, op. cit.; Higbee, op. cit.; Steiner, op. cit..

reducing cultivated area, and thereby food supplies, is recognized in the developing nations. Indeed, the dearth of available information on urban population, urban area, and the changes that have taken place in them leads to the second main conclusion: The responsible officials and agencies in the developing nations do not know how much, how fast or where agricultural land is being converted to urban uses.

The comparative lack of information on urban growth in developing nations indicates a major weakness in their planning efforts and development projects, resulting from their concentration on increasing food production and industrial output and controlling the growth of population. I am not saying however, that the responsible government officials and agencies are unaware of problems that may be created by shortages in food supplies. The amount of planning effort, money and time expended on increasing food production and controlling population growth are indicative of their awareness of the potential problems and their desire to avoid them if possible. Nevertheless, their successes in increasing food production and slowing the rate of population growth have had the effect of reducing their concern for the preservation of agricultural land. When combined with the desire to increase industrial capacity and the need to provide housing and employment for their still growing populations, the consequence has been

to give the preservation of agricultural land low, if any, priority in their development plans.[38] Inattention to the problem of urban encroachment on agricultural land will eventually have to be paid for when food needs begin to outstrip food production capabilities.

My third conclusion concerns the means by which urban and agricultural areas may be identified and singled out for further study. In the absence of data related to the growth of urban centers a number of variables may be used to identify urban and agricultural areas. Based on the results of my analysis of these variables in Japan, I have concluded that they are valid indicators of the nature of each observational unit. Moreover, the analytical techniques used here were well suited to the task of identifying and distinguishing between areas that are basically urban or agricultural.

The techniques used, however, do have a basic limitation imposed by data availability that merits consideration. If the multivariate analytic techniques of factor

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[38]Monson commented on the repeated recommendation made to the government of Taiwan that certain lands be preserved from the effects of urban expansion and the failure to implement plans designed to carry out that recommendation. Monson, op. cit., p. 12. Responses to questions contained in the United Nations study of urban land use policies indicate that control measures that exist in Taiwan do not extend beyond the official limits of cities. United Nations Study, op. cit..

analysis and discriminant analysis are to be useful, variables representing a wide range of characteristics are necessary. In addition, the data should be available for units of observation smaller than the major national divisions of states or prefectures. The results of the analysis of Japan's prefectures make this clear. Although the classification of prefectures into groups could have been accomplished with a reasonable degree of accuracy through a simple examination of the data, at the scale of the more numerous lesser civil divisions classification by visual examination of the data would be very difficult and time consuming. Also, through the use of data based on more numerous local divisions, such as counties or census tracts, the nature of a relatively small area and the types of land use found within it can be accurately determined.

For example, an analysis of the Taipei Basin on the basis of li and ts'un, the smallest political units in each county, could be expected to yield a detailed map indicating the location of predominantly urban and agricultural areas. By repeating the analysis for different time periods the areas of most rapid urbanization could be pinpointed and the direction of urban expansion determined. A basis could therefore be established upon which to formulate plans for controlling urban growth in the basin and preserving any agricultural land threatened by the expansion of Taipei or other cities. Thus, while the analysis of Japan serves to

illustrate the use of these techniques, greater value lies in their application to the problem of identifying and distinguishing between urban and agricultural areas on a local basis. If the problem of securing data for small observational units can be overcome, a means of determining the extent and direction of urban expansion in the absence of data on urban growth is available.

Recommendations

More studies of the actual extent and effect of urban encroachment on agricultural land are needed in order to accurately determine the magnitude of the problem. This is particularly true in the case of densely inhabited developing nations where the uncontrolled progress of urban expansion could have undesirable effects on economic development. Other nations, however, should not be overlooked in such studies. As the world's population continues to grow it is not difficult to foresee a time when the nations producing food surpluses will no longer be able to fill their own while helping to fill those of food deficient nations. Even if new, higher yielding types of plants are produced, they may not be able to satisfy the world's food requirements if there is not sufficient agricultural land available on which to raise them. The present store of knowledge provides only a slight indication of the extent to which urban encroachment on agricultural

land has occurred. My tentative conclusion, however, is that considerable amounts of cultivated land already have been converted to urban uses. Furthermore, the conversion process seems likely to continue into the foreseeable future.

A second recommendation follows from the first and involves the application of the techniques used in this study in the recommended investigations of urban expansion on a world wide basis. Since the use of factor analysis and discriminant analysis proved to be satisfactory in the examination of Japan, I recommend their use in a field study. Such a study using these analytic techniques would serve two purposes. First, a better estimation of their usefulness could be obtained by testing them in a location and situation such as that of the Taipei Basin described earlier. Second, the results of such a study would probably be of use to the officials and agencies responsible for development planning in the area investigated. In any case, the result would be an increase in the fund of knowledge related to urban expansion and encroachment on agricultural land.

The problems associated with urban expansion and the removal of cultivated land from production, as presented here, have received surprisingly little attention. Whether this is due to a lack of concern or simply a lack of awareness of the problems is uncertain. Regardless of the reason,

the time has come for a more detailed investigation of this phenomenon and its causes, effects and implications for the developing nations and the world as a whole. For as William Bronson noted in his discussion of urban expansion in California, "Agriculture, like fishing, is a process that can be carried into the reaches of time, provided we husband the land resource."[39] From the nature of the situation discussed here, it is evident that something less than a careful husbanding of the land resource is currently being practiced throughout the world.

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[39]Bronson, op. cit., p. 146.

APPENDICES

APPENDIX A

SIMULATION PROGRAM AND DATA

SIMULATION PROGRAM

```
      PROGRAM SIM
C
C   A = AREA
C  AA = PCT. OF AREA (A) THAT IS ARABLE
C  AL = AMOUNT OF ARABLE LAND
C   B = PCT. OF ARABLE LAND THAT IS CULTIVATED
C  BB = MINIMUM PCT. OF CL TO WHICH CL CAN DECREASE
C   C = CONSUMPTION (P * CR)
C  CL = CULTIVATED LAND
C CLD = RATE OF DECREASE IN CULTIVATED LAND (PCT. OF CL
C         REMOVED)
C CLI = RATE OF INCREASE IN CULTIVATED LAND (PCT. OF CL
C         ADDED)
C CLP = UNITS OF CULTIVATED LAND PER CAPITA
C  CR = CONSUMPTION RATE - CONSUMPTION PER CAPITA PER TIME
C         PERIOD
C   I = INCREMENT IN KNT AT EACH ITERATION
C KNT = BEGINNING VALUE OF THE TIME PERIOD (NT)
C   N = NUMBER OF ITERATIONS
C  NA = AREAL UNITS - HECTARES, ACRES, ETC.
C NP1 = NAME OF PLACE BEING SIMULATED (FIRST 8 CHARACTERS)
C NP2 = NAME OF PLACE BEING SIMULATED (SECOND 8 CHARACTERS)
C  NT = TIME PERIOD - HOUR, MONTH, YEAR, ETC.
C  NU = YIELD UNITS - POUNDS, KILOGRAMS, TONS, ETC.
C   P = POPULATION
C PC1 = MAXIMUM RATE OF POPULATION INCREASE
C PC2 = MINIMUM RATE OF POPULATION INCREASE
C PC3 = AMOUNT OF CHANGE IN POPULATION INCREASE RATE
C   R = RATE OF UTILIZATION OF CULTIVATED LAND
C           1 = 100 PCT. UTILIZATION
C           GREATER THAN 1 MEANS MORE THAN 1 CROP PER NT
C           PER UNIT OF CL
C  SD = FOOD SURPLUS - DEFICIT STATUS (TY - C)
```

SIMULATION PROGRAM (Cont.)

```
C    TY = TOTAL YIELD FOR THE ENTIRE AREA (COUNTY, STATE,
C           COUNTRY, ETC.)
C     Y = BEGINNING YIELD PER UNIT OF CULTIVATED LAND
C    YC = RATE OF INCREASE IN X
C   YMX = MAXIMUM VALUE TO WHICH Y CAN INCREASE
C
C   ASSUMPTIONS
C      NO DISASTERS (WAR, DROUGHT, DISEASE, ETC.)  OCCUR TO
C         ALTER CONDITIONS
C      TECHNOLOGY REMAINS CONSTANT
C      ALL CL IS PLANTED TO ONE CROP
C      CL INCREASES AT THE RATE OF CLI PCT. OF AL UNTIL CL = AL
C         (NOTE - UNTIL CL = AL, CL IS INCREASING AT THE RATE
C            OF CLI + CLD)
C      CL STARTS DECREASING UNTIL CL = BB PCT. OF AL
C      Y INCREASES AT THE RATE OF YC PCT. OF Y UNTIL Y = YMX
C      P INCREASES AT A RATE DECREASING FROM PC1 TO PC2 IN
C         INCREMENTS OF PC3
C
C
       LZ = 0
    55 READ(60,1) A,AA,B,CLD,CLI,CR,P,PC1,PC2,PC3,R,BB,Y,YC,
      1YMX,N,NT,NA,NU,NP1,NP2,KNT,I
     1 FORMAT(3(5F16.3,/),I4,5A8,I5,I3)
       LZ = LZ + 1
       WRITE(61,100) LZ
   100 FORMAT(*2*,//////////* *,*DATA SET NUMBER *,I2//)
       WRITE(61,101)A,AA,B,CLD,CLI,CR,P,PC1,PC2,PC3,R,BB,Y,
      1YC,YMX,N,NT,NA,NU,NP1,NP2,KNT,I
   101 FORMAT(*0A = *,F16.4,6X,*AA = *,F7.5,6X,*B = *,F7.5,
      16X,*CLD = *,F7.5,6X,*CLI = *,F7.5,6X,*CR =*,F4.0,6X,
      2*P = *,F12.0,/*0PC1 =*,F7.5,6X,*PC2 = *,F7.5,6X,*PC3 = *,
      3F7.5,6X,*R = *,F5.3,6X,*BB = *,F6.3,6X,*Y = *,F5.0,
```

SIMULATION PROGRAM (Cont.)

```
  46X,*YC = *,F6.4,6X,*YMX = *,F5.0,/*0N = *,I4,6X,
  5*NT = *,A8,6X,*NA = *,A8,6X,*NU = *,A8,6X,*NP1 +
  6NP2 = *,2A8,6X,*KNT = *,I5,6X,*I = *,I3)
   IF (A) 33,33,44
44 Z = 0.
   WRITE(61,2)
 2 FORMAT(*1*,////////*0*,59X,*SIMULATION*)
   WRITE(61,3) NP1,NP2
 3 FORMAT(*0*,38X,*AGRICULTURAL PRODUCTION AND POPULATION
  1IN *,2A8,//)
   WRITE(61.8) NT
 8 FORMAT(*0*,A8,*  POPULATION  CULTIVATED  PCT. ARABLE
  1AREA  CULTIVATED AREA  YIELD   TOTAL YIELD  CONSUMP
  2TION  SURPLUS - DEFICIT*)
   WRITE(61,9)
 9 FORMAT(* *,26X,*AREA       CULTIVATED      PER CAPITA*,
  150X,*STATUS*//)
   AL = AA * A
   DO 99 K=1,N
   CL = B * AL
   TY = Y * CL * R
   C = P * CR
   SD = TY - C
   CLP = CL/P
   Q = B * 100.
   MP = P
   MCL = CL
   MY = Y
   MTY = TY
   MC = C
   MSD = SD
   WRITE(61,10) KNT,MP,MCL,Q,CLP,MY,MC,MSD
```

SIMULATION PROGRAM (Cont.)

```
 10 FORMAT(* *,I5,5X,I9,5X,I8,9X,F6.2,13X,F5.4,8X,I5,
   14X,I11,4X,I11,6X,I11)
    KNT = KNT + 1
    IF(Z.EQ.O) GO TO 11
    B = B - CLD
    IF(B.LT.BB) B = BB
    GO TO 12
 11 IF(B.LT.1.) B = B + CLI
    IF(B.GE.1.) Z = 1.
    IF(B.GT.1.) B = 1.
 12 IF(Y.GE.YMX) TO TO 13
    Y = Y + (Y * YC)
 13 P = P + (P * PC1)
    IF(PC1.LE.PC2) GO TO 99
    PC1 = PC1 - PC3
 99 CONTINUE
    WRITE(61,987) NA
987 FORMAT(*0*,*CULTIVATED AREA FIGURES IN *,A8)
    GO TO 55
 33 STOP
    END
```

DATA

A	= 5000000	NP2	= X
AA	= 0.25	NT	= YEAR
B	= 0.80	NU	= KILOGRAM
BB	= 0.90	P	= 45000000
CLD	= 0.0025	PC1	= 0.03
CLI	= 0.01	PC2	= 0.01
CR	= 120	PC3	= 0.001
I	= 1	R	= 1.55
KNT	= 1	Y	= 3000
N	= 35	YC	= 0.03
NA	= HECTARES	YMX	= 4500
NP1	= COUNTRY		

APPENDIX B

FACTOR ANALYSIS AND DISCRIMINANT ANALYSIS

FACTOR ANALYSIS AND DISCRIMINANT ANALYSIS

Factor Analysis

Factor analysis is a multivariate statistical technique designed to simultaneously analyze the relationships between a number of variables. Through the use of mathematical formulas[1] a matrix of product-moment correlations is analyzed and groupings of variables are derived. Each of these groupings, or factors, contains a set of related variables that represent a particular pattern of association within the data. For example, a factor might be derived that could be labeled the "urban" factor on the basis of its containing several variables that measure urban qualities such as population density and the number of people employed in manufacturing and service industries. A second factor containing variables such as farms per unit of area and measures of agricultural production might also be derived that could be labeled the "agricultural" factor. The strength of the presence or absence of these factors in

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[1] Full and detailed discussions of the various features of factor analysis and the formulas involved may be found in: H. H. Harman, Modern Factor Analysis (second edition; Chicago: University of Chicago Press, 1967); and Paul Horst, Factor Analysis of Data Matrices (New York: Holt, Rinehart and Winston, Inc., 1965). A brief and simplified description of factor analysis is contained in R. J. Rummel's article, "Understanding Factor Analysis," Journal of Conflict Resolution, 11:444-480, December, 1967.

the original units of observation (e.g., counties, states or prefectures) indicates whether each unit may be considered urban or agricultural in nature, or perhaps be placed in an intermediate category.

Several measures indicating a variety of relationships are involved in factor analysis. Basic to the whole analysis is the correlation matrix that is factor analyzed. It contains the correlation coefficients indicating the degree and direction (positive or negative) of the association between all pairings of the variables. When the correlation matrix is analyzed a principal axis solution is obtained which derives the basic patterns in the data. Eigenvalues are computed representing the amount of variation in the data accounted for by each factor obtained by the principal axis solution. The number of factors to be rotated may be decided on the basis of these values. Rotating factors derived through the principal axis solution serves to minimize the variance between variables associated with a factor and maximize the variance between the factors themselves. "Through this rotation the factor interpretation shifts from unrotated factors delineating the most comprehensive data <u>patterns</u> to factors delineating the distinct <u>groups</u> of interrelated data."[2] (Emphasis added).

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[2]Rummel, <u>op. cit.</u>, p. 474.

The variables that make up these rotated factors are indicated by the factor loadings which represent the degree and direction of association of each variable with each factor.

Two measures of the "explanatory power" of the factors provide an indication of the amount of variation in the individual variables and the data set as a whole that is accounted for by the factors. Communalities indicate the amount of variation in each variable that is accounted for by the factors. A variable with a communality of .95, for example, has 95% of its variance "explained" by the factors. The percent of variance is a measure of how much of the variance in the entire data set is accounted for by each factor. Together, these two measures give an indication of how much reliance may be placed upon the factors as representatives of the data set as a whole.

The degree of importance of each rotated factor in each observational unit is indicated by factor scores, which are standardized so that they have means of zero and standard deviations of one. Units that have scores greater than $\pm$ 1.0 for a given factor are those in which the factor is most strongly represented or lacking, depending upon the signs of the factor loadings and factor scores. An observational unit, for example, with a score of 1.5 on the urban factor mentioned earlier can be considered to be an "urban" unit in which the characteristics represented by the factor are notably strong. Conversely, a unit with a score of

-1.5 may be considered a non-urban unit in which "urban" characteristics are lacking. By mapping the scores for each factor it is possible to discern and evaluate patterns among the observational units. This procedure has a drawback, however, in that a unit may have a high score on more than one factor. When this situation is encountered it creates the problem of deciding which of the factors best represent the nature of the unit. Discriminant analysis provides a means of resolving this problem and, in addition, may be used to test the appropriateness of groups assembled on the basis of the results of factor analysis.[3]

Discriminant Analysis

Discriminant analysis, unlike factor analysis, requires the use of multivariate normal data, i.e., variables that are statistically independent and normally distributed. Since factor scores meet both of these requirements they may be used as data for the analysis. Discriminant analysis also requires that the observational units be assigned to groups before the analysis is started. The analysis itself

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[3]Leslie J. King, Statistical Analysis in Geography (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969), pp. 204-215. For a discussion of recent developments in the use of discriminant analysis see: Leslie J. King, "Discriminant Analysis: A Review of Recent Theoretical Contributions and Applications," Economic Geography (Supplement), 46:367-378, June, 1970.

involves the computation of a linear discriminant function for each group on the comparison of each observational unit with each group function. On the basis of this comparison probabilities are computed indicating the likelihood of an observation belonging in each group. In the ideal situation each observational unit will have a probability of 1.0 of belonging to a particular group and probabilities of 0.0 of belonging to the others.

A measure of the importance of each variable (factor) in discriminating between the groups is given by the coefficients of the linear discriminant functions. A coefficient is computed for all pairings of variables and functions. The magnitude of the coefficient indicates the importance of each variable in distinguishing one group from another. It is thus possible to check not only on the appropriateness of the groups originally designated for analysis, but also to determine which variables (factors) are most important in discriminating between the groups. The useful qualities of discriminant analysis, along with those of factor analysis, lend themselves to the problem at hand. Both were employed, therefore, in attempting to identify a set of variables that can be used to distinguish between urban and agricultural prefectures in Japan and those in transition from one group to another.

The Data

A set of 112 variables representing urban and agricultural characteristics was assembled. The year 1965 was chosen as the study year because it was the most recent year for which census data were available. The raw data were converted to ratio form based on area and population in order to standardize the data in terms of area and population and achieve a more accurate representation of the nature of each prefecture.[4] Once the data had been standardized, the 112 variables were carefully evaluated. Those not representing a characteristic that could be adequately measured throughout the entire country were discarded.[5] Also discarded was one member of each

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[4]An example of the effect of converting the data from raw to ratio form illustrates the reason for standarizing the data. In 1965, 18.29 million people were employed in manufacturing in Tokyo Prefecture, representing thirty-three percent of the employed labor force. In neighboring Kanagawa Prefecture less than half that number, 7.65 million, representing thirty-six percent of the prefectures labor force, were employed in manufacturing. On the basis of the number of people employed it might be concluded that manufacturing in Kanagawa Prefecture was not as important a source of employment as in Tokyo Prefecture. When the proportion of the labor force employed in manufacturing in each prefecture is considered, however, it is evident that they were quite similar in terms of manufacturing employment. The difference in the actual numbers of people employed in manufacturing masks a similarity in the structure of the labor force in these prefectures. Data were converted to ratio form order to detect such similarities and bring out actual differences among the prefectures that might be hidden by the magnitude of the values in the raw data.

[5]For example, variables measuring the amount of cultivated land devoted to orchard crops such as tree fruits,

complementary pair of variables, such as urban and rural population that measured the same characteristic and redundant variables measuring the same characteristic in different forms.[6]

The resulting set of variables was divided into two groups on the basis of trends evident in the data and their hypothesized relationships to the urban or agricultural qualities of the prefectures.[7] I anticipated that at least twenty-five of the variables would have high loadings on one factor indicating the presence or absence of urban qualities in each prefecture via the factor scores. Variables in this group included those measuring population as a proportion of the nation's population living in each prefecture, population density, and change in population between 1960 and 1965. Variables related to the number of cities of various sizes and the percent of the population living in them were included to distinguish

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mulberry and tea were discarded in favor of a single variable measuring the amount of land devoted to all orchard crops. The more detailed data was discarded because each of the crops involved was raised in only a few of the prefectures.

[6]Data on cultivated area, for example, was originally collected in the form of both acres and hectares. The metric unit of measure was finally chosen due to the fact that the data on various types of cultivated land (paddy fields, orchards, etc.) were recorded in metric units.

[7]A brief description of each of the variables selected is contained in Appendix C. A copy of the data set itself may be obtained upon application.

the prefectures characterized by large urban centers from those lacking them. The variables representing the smaller cities and their populations could be expected to load on the urban factor in opposition to those representing the large urban centers.

Other population oriented variables included measures of urban concentration and two variables related to age composition and marital status. I hypothesized that the urban prefectures would not only have a high percentage of their populations living in densely inhabited districts (DID), but that the population density outside of these districts would also be high. In addition, the urban prefectures could be expected to have a small percentage of their populations in the 65 and over age bracket and a relatively large proportion represented by young unmarried people. This situation is explained by the migration of young, single persons from rural to urban areas, resulting in a comparative concentration of older people and a lack of young unmarrieds in the areas of emigration.[8]

Variables related to transportation facilities, income and employment were added to the population variables as further measures of urban qualities. I hypothesized that highway and rail facilities would be more

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[8]These characteristic effects of migration are discussed briefly in: Glenn T. Trewartha, A Geography of Population: World Patterns (New York: John Wiley and Sons, Inc., 1969), pp. 137-140.

prevalent and that they would carry more freight in the urban prefectures. Income, government expenditures, manufacturing employment and unemployment were also expected to be higher in the urban prefectures and therefore help to distinguish them from the agricultural prefectures.

The variables in the second group were selected as measures reflecting the agricultural characteristics of the prefectures. The general variables rural population and rural area were included with more specific variables such as cultivated area, farm population, and farm households per square kilometer. Specific types of agricultural land use were incorporated in the data set on the hypothesis that the ratio of farmed land and land use types to population would be high in agricultural prefectures and low in the urban prefectures. Grain production variables standardized on the basis of both area and population were also included based on a similar hypothesis. Finally, data related to agricultural employment and two kinds of farm equipment were added to this variable set.

Overall, the variables in these two groups were assumed to be valid measures of the agricultural and urban characteristics of Japan's prefectures. Factor analysis will substantiate whether or not the variables selected constitute groups of characteristics that can be used to classify prefectures as predominantly urban or predominantly agricultural.

Almost all of the variables reflecting urban characteristics have high loadings on the urban factor.[9] The population density variable, all of the transportation facilities variables except the one measuring unpaved roads, and the variable representing the percent of the cities in each prefecture with 100,000 or more inhabitants have positive factor loadings of over .90. These are accompanied by variables with loadings between .70 and .89. Included in this series are the percent of national population living in the prefecture, percent of prefectural population living in DID's and cities of 100,000 or more inhabitants, population density in the areas outside of the DID's, and the percent of the population over fifteen years of age and single.[10] Variables with loadings between .50 and .69 include number of households per thousand population, income per household, percent change in population in the 1960-1965 period, and percent of the labor force employed in manufacturing.

The variables that have negative loadings on the urban factor are those associated with the number of smaller

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[9]A complete listing of the rotated factor loadings may be found in Appendix D.

[10]Although it was not its highest loading, the variable measuring the percent of the population 65 years of age and over had a loading of -.57 on this factor. This was interpreted as indicating the expected difference between the proportions of the populations of the population made up of older people and young unmarried persons in urban areas.

cities and towns in each prefecture and the percent of the prefectural population living in them. These variables have loadings ranging from -.54 to -.91. Five variables measuring agricultural and rural characteristics also load negatively on the urban factor. They are the measures of rural population and area, the farm population variable, percent of households classified farm households, and percent of the labor force employed in agriculture. The range of the loadings extends from -.67 to -.78.

The urban factor may be interpreted as representing a dichotomy between decidedly urban measures and variables related to rural, small town, and farm characteristics. This dichotomy is evident in the strong positive loadings of variables representing definitely urban qualities and the negative loadings of the variables associated with the smaller cities and towns, their populations, and the farm population. When interpreting the factor scores for this factor, therefore, it will be possible to distinguish urban prefectures as well as those that can be characterized as rural, small town prefectures with relatively large farm populations.

While most of the variables measuring urban characteristics have high loadings on the urban factor those selected to reflect agricultural characteristics are spread over four factors. Some of them, as already mentioned load negatively on the urban factor. Most of the remaining

variables load on the grain, agricultural employment and farm factors which together account for 35.85 percent of the total variance in the data.

The grain factor is loaded almost exclusively by the variables measuring grain production in terms of both population and area. Also included on this factor is the highest loading for the unpaved road variable. Since all of the high loadings are negative the interpretation of the factor scores for this factor will be the reverse of the usual interpretation. Negative scores in this case will be interpreted as indicating the presence of the grain factor and positive scores its absence.

Although the variables measuring agricultural employment did not have its highest loading on the agricultural employment factor its presence in conjunction with other agriculture and rural oriented variables indicates the appropriateness of the name. Along with the agricultural employment variable are those representing the amount of farmed land and rice land per thousand population and government expenditures per capita. Variables measuring the percent of the prefectural population living in cities and towns of less than 50,000 and less than 30,000 have moderate positive loadings on this factor. The manufacturing employment, income, and population change variables load negatively, thus creating a dichotomy, as in the case of the urban factor, between basically

agricultural land manufacturing employment. By extension this factor may also be considered as one differentiating between urban and agricultural prefectures on the basis of positive and negative factor scores.

The farm factor represents five variables with loadings between .70 and .82. Number of farm households per square kilometer, farmed land, wheat production per hectare of area, and the two farm equipment variables have their highest loadings on this factor. Since the loadings of these variables are all positive the interpretation of the factor scores will be such that a positive score indicates the presence of the farm factor and a negative score its absence in each prefecture.

The three remaining factors each represent only two or three variables. The unemployment and percent of the available labor force not in the active labor force[11] variables constitute the unemployment factor. The elderly population factor represents the percent of the population sixty-five years of age and over, and the percent of the cities and towns having less than 10,000 inhabitants. Variables representing the percent of farmed land in orchard

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[11]This variable represents people 15 years of age and over who are considered part of the available labor force because of their age, but are not actively seeking employment. These people are primarily housewives, students and disabled persons.

crops and silkworm cocoon production have negative loadings on the orchard land factor. The variable measuring the amount of farmed land in rice production loaded positively. A third dichotomous factor is thus present. The dichotomy in this case may be interpreted as being between types of terrain since orchards in Japan are generally situated on hillsides and rice fields on flat or nearly flat land.

APPENDIX C

DEFINITION OF VARIABLES

DEFINITION OF VARIABLES

PERCENT	Percent of the national population living in each Prefecture (2)
POP CHANGE	Percent change in the Prefectural population between 1960 and 1965 (2)
POP DENSITY	Population per square kilometer (2)
100,000 +	Percent of the cities, towns, and villages having 100,000 population or more (2)
UNDER 50	Percent of the cities, towns, and villages with less than 50,000 population (2)
UNDER 30	Percent of the cities, towns, and villages with less than 30,000 population (2)
UNDER 10	Percent of the cities, towns, and villages with less than 10,000 population (2)
POP 100 +	Percent of the population living in cities of 100,000 or more population (2)
POP 50 -	Percent of the population living in cities, towns, and villages of less than 50,000 population (2)
POP 10 -	Percent of the population living in cities, towns, and villages of less than 10,000 population (2)
D.I.D. POP	Percent of the population living in Densely Inhabited Districts* (2)

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*Densely Inhabited District - a group of contiguous enumeration districts having a population density of 4,000 persons per square kilometer within the boundary of a city, town, or village having a population of at least 5,000 persons. (1)

DEFINITION OF VARIABLES (Cont.)

NON D.I.D.	Population density in areas other than Densely Inhabited Districts (2)
65 AND OVER	Percent of the population 65 years of age and over (1)
SINGLE POP	Percent of the population 15 years of age and over that is unmarried (1)
HOUSEHOLDS	Number of households* per thousand population (1)
RAIL KM2	Kilometers of railroad track per square kilometer (3)
H-WAY KM2	Kilometers of paved highway per square kilometer (3)
ROAD KM2	Kilometers of unpaved road per square kilometer (3)
TRUCK FRGT	Metric tons of freight carried by truck per kilometer of paved highway and unpaved road combined (3)
$ INCOME	Average monthly income per household in dollars (1)
GOV'T EXP	Government expenditure in dollars per capita (1)
MANUFACT EMP	Percent of the employed labor force engaged in manufacturing (1)
UNEMPLOYMENT	Percent of the active labor force unemployed (1)
NOT IN LABOR	Percent of the available labor force (persons 15 years of age and over) not in the active labor force (1)

*Household - a group of two or more persons sharing living quarters and living expenses, or a person who lives by himself and occupies a house. (2)

DEFINITION OF VARIABLES (Cont.)

RURAL AREA	Percent of the total area classified rural (1)
RURAL POP	Percent of the total population classified rural (1)
FARM POP	Percent of the total population classified farm household members (1)
FARM DENSITY	Farm households per square kilometer (1)
FARM HOUSES	Percent of the total number of households classified farm households (1)
FARMED LAND	Percent of the total area that is cultivated (1)
RICE LAND	Percent of the farmed land that is classified paddi field (1)
ORCHARD LAND	Percent of the farmed land that is classified orchard land (4)
CULT - POP	Farmed land per thousand population in hectares* (1)
RICE - POP	Rice land per thousand population in hectares (1)
GRAIN PER HA	Tons of grain produced per hectare of total area (1)
RICE PER HA	Tons of rice produced per hectare of total area (1)
WHEAT PER HA	Tons of wheat produced per hectare of total area (1)
BARLEY PER HA	Tons of barley produced per hectare of total area (1)

*Hectare - One hectare is composed of 10,000 square meters. One hectare equals 2.45 acres. One hundred hectares equal one square kilometer.

DEFINITION OF VARIABLES (Cont.)

GRAIN POP	Tons of grain produced per thousand population (1)
RICE POP	Tons of rice produced per thousand population (1)
WHEAT POP	Tons of wheat produced per thousand population (1)
COCOONS KM2	Kilograms of silkworm cocoons produced per square kilometer (1)
ANI CULTIV	Number of animal powered cultivators per square kilometer (1)
POW CULTIV	Number of motor powered cultivators per square kilometer (1)
AGRICULT EMP	Percent of the employed labor force engaged in agriculture (1)

The numbers in parentheses refer to the sources of data from which the values for the variables were derived.

1. Bureau of Statistics, Japan Statistical Yearbook, 1966, (Tokyo, Japan: Office of the Prime Minister, 1967).

2. Bureau of Statistics, 1965 Population Census of Japan, (Tokyo, Japan: Office of the Prime Minister, 1966).

3. Mr. E. Aramaki, Engineer of the Planning Division, Road Bureau, Ministry of Construction, Tokyo, Japan.

4. Office of Agricultural Product Statistics, Department of Statistical Survey, Ministry of Agriculture, Tokyo, Japan.

APPENDIX D

ROTATED FACTOR LOADINGS

KEY TO THE ROTATED FACTOR LOADINGS

Factor 1	The Urban Factor
Factor 2	The Grain Factor
Factor 3	The Unemployment Factor
Factor 4	The Farm Factor
Factor 5	The Elderly Population Factor
Factor 6	The Agricultural Employment Factor
Factor 7	The Orchard Land Factor

ROTATED FACTOR LOADINGS

Variable	Factor 1	Factor 2	Factor 3	Factor 4
PERCENT	.8619*	-.0689	-.1407	-.0465
POP CHANGE	.5850	-.0729	.1339	.2217
POP DENSITY	.9725*	-.0228	-.0675	.0791
100,000 +	.9159*	.0219	-.0670	.0772
UNDER 50	-.8977*	.0193	-.0469	-.1496
UNDER 30	-.9124*	.0692	-.0822	-.1592
UNDER 10	-.5416	.3485	-.0553	-.2416
POP 100 +	.7789*	.1083	-.3216	.0014
POP 50 -	-.7675*	-.0790	.1749	-.0871
POP 30 -	-.7770*	-.0617	.0985	-.0942
POP 10 -	-.5796*	.2326	.0337	-.1485
D.I.D. POP	.8126*	.1253	-.2178	-.0010
NON D.I.D.	.7620*	-.1267	-.1073	.5432
65 AND OVER	-.5695	.0628	-.0489	-.0337
SINGLE POP	.7551*	-.0059	-.0105	.0775
HOUSEHOLDS	.5286*	.1706	-.4811	-.1690
RAIL KM2	.9456*	.0091	-.0695	.2348
H-WAY KM2	.9475*	-.0141	-.0498	-.0158
ROAD KM2	.3132	-.5339*	.0472	.5103
TRUCK FRGT	.9715*	.1161	-.0312	.0181
$ INCOME	.6348*	-.1104	.2415	-.0100
GOV'T EXP	-.0811	.2592	.2190	-.3274
MANUFACT EMP	.5408	.0767	.2287	.1979
UNEMPLOYMENT	.0877	.0900	-.8923*	.1243
NOT IN LABOR	.2299	.0834	-.8135*	.0755
RURAL AREA	-.7846*	.0079	.0056	-.2294
RURAL POP	-.7809*	-.1362	.1282	-.0093
FARM POP	-.7189*	-.1257	.3207	-.0521
FARM DENSITY	.3101	-.2588	-.0714	.8239*
FARM HOUSES	-.6959*	-.1110	.3469	-.0532
FARMED LAND	.0476	-.5384	.0391	.7397*

ROTATED FACTOR LOADINGS (Cont.)

Variable	Factor 1	Factor 2	Factor 3	Factor 4
RICE LAND	-.2290	.2456	.1083	.2604
ORCHARD LAND	-.0993	.1589	-.1890	.0560
CULT - POP	-.5235	-.1810	.2164	-.2834
RICE - POP	-.4946	.0404	.4310	-.0509
GRAIN PER HA	-.0032	-.8407*	-.0620	.4983
RICE PER HA	.0712	-.9564*	.1069	-.0111
WHEAT PER HA	-.0369	-.5508	-.2809	.7079*
BARLEY PER HA	.0165	-.8995*	.2030	.2205
GRAIN POP	-.2111	-.8981*	.0140	.2118
RICE POP	-.0971	-.9116*	.1096	-.1047
WHEAT POP	-.2568	-.6516*	-.2139	.4187
COCOONS KM2	-.0928	-.2522	.2827	.1283
ANI CULTIV	.2464	.0512	-.1113	.8054*
POW CULTIV	.1457	-.4503	.2146	.7043*
AGRICULT EMP	-.6670*	-.2229	.2310	-.0946
Proportion of Variance	.3590	.1373	.0660	.1013
Cumulative Proportion of Variance	.3590	.4963	.5623	.6636

* Indicates the highest loading for that variable

ROTATED FACTOR LOADINGS (Cont.)

Variable	Factor 5	Factor 6	Factor 7	Communalities
PERCENT	-.1645	-.1833	-.0462	.8324
POP CHANGE	-.1600	-.6277*	-.1079	.8459
POP DENSITY	.0622	.0062	-.0757	.9667
100,000 +	-.0789	-.1258	-.0673	.8763
UNDER 50	.1510	.1714	-.0119	.8832
UNDER 30	.1857	.1166	-.0617	.9213
UNDER 10	.5903*	.0421	-.2221	.8758
POP 100 +	-.1324	-.4303	-.0105	.9237
POP 50 -	.1492	.5025	-.0602	.9118
POP 30 -	.1797	.5054	-.1064	.9251
POP 10 -	.5688	.3136	-.2125	.8803
D.I.D. POP	-.1279	-.4566	.0270	.9490
NON D.I.D.	-.0145	-.2114	-.0888	.9560
65 AND OVER	.7082*	.2581	.0655	.9043
SINGLE POP	-.0604	-.5501	-.1178	.8964
HOUSEHOLDS	.4619	-.1930	.0103	.8192
RAIL KM2	.0246	-.1106	.0166	.9673
H-WAY KM2	.0976	.0433	-.0908	.9204
ROAD KM2	.0160	-.4020	-.1791	.8397
TRUCK FRGT	.0076	.0470	.0119	.9611
$ INCOME	-.0758	-.6010	.1228	.8560
GOV'T EXP	.4154	.6408*	.0873	.8198
MANUFACT EMP	.1003	-.7115*	-.0686	.9107
UNEMPLOYMENT	.1684	.0671	.0173	.8605
NOT IN LABOR	-.1650	-.1568	-.0780	.7852
RURAL AREA	.0498	.1948	-.1285	.7253
RURAL POP	.1099	.4888	-.0733	.9012
FARM POP	.1452	.5458	-.0052	.9572
FARM DENSITY	.1169	-.2008	-.0372	.9025
FARM HOUSES	.2096	.5325	.0018	.9473
FARMED LAND	-.2333	-.0534	.0418	.8998

ROTATED FACTOR LOADINGS (Cont.)

Variable	Factor 5	Factor 6	Factor 7	Communalities
RICE LAND	.3220	-.1621	.6097*	.6940
ORCHARD LAND	.1623	-.0253	-.7960*	.7345
CULT - POP	-.3516	.5257*	.1209	.8485
RICE - POP	-.1810	.5113*	.4411	.9233
GRAIN PER HA	-.0549	-.0718	-.0797	.9735
RICE PER HA	-.0540	-.0008	-.0044	.9343
WHEAT PER HA	-.0548	-.0217	-.1298	.9050
BARLEY PER HA	-.0354	-.1438	-.0097	.9212
GRAIN POP	-.0253	.1445	-.0634	.9219
RICE POP	-.1278	.1277	.0667	.9005
WHEAT POP	.0048	.2126	-.1847	.7909
COCOONS KM2	.0032	-.1646	-.7413*	.7452
ANI CULTIV	-.1295	-.0005	.1293	.7578
POW CULTIV	-.0495	-.3319	-.1233	.8938
AGRICULT EMP	.0120	.6171	.0138	.9380
Proportion of Variance	.0508	.1199	.0462	
Cumulative Proportion of Variance	.7144	.8343	.8805	

*Indicates the highest loading for that variable.

APPENDIX E

FACTOR SCORES

FACTOR SCORES

Prefecture	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Hokkaido	-0.168	0.190	-1.022	-2.259	-2.308	-0.140	-0.075
Aomori	-0.348	0.536	-0.307	-0.464	-1.849	1.111	-0.376
Iwate	-0.336	0.007	0.547	-0.832	-1.500	1.109	0.228
Miyagi	-0.299	0.026	-0.059	0.018	-1.651	0.507	0.648
Akita	-0.547	0.365	0.629	-0.571	-1.162	1.122	0.888
Yamagata	-0.165	0.656	1.182	-0.152	-1.501	0.959	0.547
Fukushima	-0.499	-0.125	0.452	-0.596	-0.678	0.506	-0.467
Ibaraki	-0.180	-5.169	0.409	0.206	0.538	0.124	0.559
Tochigi	-0.023	-2.367	0.400	-0.286	-0.817	0.004	1.343
Gumma	-0.406	-1.226	0.660	-0.214	-0.277	-0.609	-2.853
Saitama	-0.008	-0.964	1.187	2.805	-0.522	-1.664	-1.768
Chiba	-0.059	-0.996	0.209	1.240	-0.283	-1.025	0.437
Tokyo	4.880	-0.494	-0.220	-1.291	0.817	1.259	-0.683
Kanagawa	1.921	-0.137	-0.391	0.268	-0.844	-1.535	-0.710
Niigata	-0.177	0.667	1.735	-0.029	-0.118	0.345	0.959
Toyama	0.248	0.939	1.148	0.129	-1.764	0.753	0.192
Ishikawa	-0.061	0.570	1.291	-0.273	0.307	-0.682	1.350
Fukui	0.113	0.653	1.779	-0.330	1.015	0.108	1.352
Yamanashi	-0.559	0.402	0.713	-0.368	0.748	0.234	-3.503
Nagano	-0.367	0.343	1.355	-0.512	0.789	0.176	-1.495

FACTOR SCORES (Cont.)

Prefecture	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Gifu	-0.559	0.323	0.859	-0.747	0.503	-1.169	-0.076
Shizuoka	0.097	0.436	0.245	-0.243	-1.129	-1.003	-0.944
Aichi	0.601	0.318	0.652	1.147	-0.659	-1.755	0.116
Mie	-0.159	0.442	0.206	0.334	0.257	-0.239	0.326
Shiga	-0.528	0.565	1.515	0.489	1.032	0.166	0.817
Kyoto	-0.103	0.293	-0.679	-1.131	0.325	-2.893	0.973
Osaka	3.637	0.861	0.200	1.163	0.210	0.232	0.403
Hyogo	0.110	0.467	-0.839	-0.367	-0.296	-2.085	1.204
Nara	-0.617	0.531	-0.283	-0.487	0.250	-1.059	0.217
Wakayama	-0.352	0.688	-1.079	-0.716	0.820	-0.415	-1.243
Tottori	-0.304	0.410	0.516	-0.215	1.295	0.838	0.159
Shimane	-0.310	0.345	0.809	-0.531	1.897	0.980	0.444
Okayama	-0.442	0.034	0.235	0.418	1.311	-0.207	0.567
Hiroshima	-0.364	0.319	-0.376	-0.799	1.096	-1.315	0.314
Yamaguchi	0.005	0.250	-0.927	-0.422	0.590	-0.272	1.037
Tokushima	-0.621	0.322	-0.691	-0.100	0.870	0.540	-0.570
Kagawa	-0.367	0.535	-0.311	3.212	0.675	0.822	0.161
Ehime	-0.341	0.603	-1.121	-0.098	0.279	0.130	-1.066
Kochi	-0.317	0.202	-1.423	-1.101	2.294	0.578	0.511
Fukuoka	-0.037	-0.023	-3.212	2.011	-0.641	-0.320	0.727

FACTOR SCORES (Cont.)

Prefecture	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Saga	-0.441	-0.042	-0.854	3.015	-0.159	1.788	0.105
Nagasaki	-0.406	0.173	-1.749	0.346	-0.299	0.287	-0.711
Kumamoto	-0.587	-0.635	-1.203	0.168	0.069	0.708	-0.422
Oita	-0.311	-0.233	-0.933	-0.165	0.404	0.863	0.001
Miyazaki	-0.095	-0.299	-0.755	-1.031	-0.306	0.882	0.311
Kagoshima	-0.172	-0.762	-0.496	-0.638	0.370	1.254	0.065

Factor 1 The Urban Factor
Factor 2 The Grain Factor
Factor 3 The Unemployment Factor
Factor 4 The Farm Factor
Factor 5 The Elderly Population Factor
Factor 6 The Agricultural Employment Factor
Factor 7 The Orchard Land Factor

APPENDIX F

GROUPS DERIVED THROUGH DISCRIMINANT ANALYSIS

GROUPS DERIVED THROUGH DISCRIMINANT ANALYSIS:

The Probabilities of Each Prefecture Belonging to Each Group*

Prefecture	No.	Group 1	Group 2	Group 3	Group 4	Group 5
Group 1--Northern and West Coast						
Hokkaido	1	0.88394	0.00000	0.00000	0.08182	0.03424
Aomori	2	0.99448	0.00000	0.00000	0.00047	0.00505
Iwate	3	0.99987	0.00000	0.00000	0.00002	0.00010
Miyagi	4	0.97597	0.00000	0.00000	0.00511	0.01892
Akita	5	0.99997	0.00000	0.00000	0.00000	0.00002
Yamagata	6	0.99999	0.00000	0.00000	0.00001	0.00001
Fukushima	7	0.93777	0.00000	0.00000	0.03714	0.02509
Niigata	15	0.99969	0.00000	0.00000	0.00026	0.00005
Toyama	16	0.99984	0.00000	0.00000	0.00011	0.00004
Ishikawa	17	0.76568	0.00000	0.00000	0.22943	0.00490
Fukui	18	0.99415	0.00000	0.00000	0.00537	0.00048
Shiga	25	0.97070	0.00000	0.00000	0.02277	0.00653
Tottori	31	0.70463	0.00000	0.00000	0.06402	0.23135
Shimane	32	0.91075	0.00000	0.00000	0.01683	0.07242
Group 2--Grain Basket						
Ibaraki	8	0.00000	1.00000	0.00000	0.00000	0.00000
Tochigi	9	0.00001	0.99996	0.00000	0.00002	0.00001
Gumma	10	0.00000	0.83871	0.00043	0.16046	0.00041
Chiba	12	0.00000	0.68021	0.31552	0.00412	0.00015
Group 3--Urban/Industrial						
Saitama	11	0.00000	0.02867	0.97133	0.00000	0.00000
Tokyo	13	0.00000	0.00000	1.00000	0.00000	0.00000
Kanagawa	14	0.00000	0.00000	1.00000	0.00000	0.00000
Aichi	23	0.00000	0.00004	0.99979	0.00016	0.00000
Kyoto	26	0.00000	0.00002	0.99896	0.00102	0.00000
Osaka	27	0.00000	0.00000	1.00000	0.00000	0.00000

GROUPS DERIVED THROUGH DISCRIMINANT ANALYSIS (Cont.)

Prefecture	No.	Group 1	Group 2	Group 3	Group 4	Group 5
	Group 3--Urban/Industrial (cont.)					
Hyogo	28	0.00000	0.00002	0.99524	0.00471	0.00003
Fukuoka	40	0.00000	0.00000	0.99581	0.00004	0.00416
	Group 4--Semi-Industrial					
Yamanashi	19	0.00042	0.00000	0.00000	0.98087	0.01871
Nagano	20	0.19190	0.00000	0.00000	0.78742	0.02068
Gifu	21	0.00706	0.00001	0.00000	0.98877	0.00416
Shizuoka	22	0.00051	0.00025	0.00961	0.98571	0.00392
Mie	24	0.02965	0.00001	0.00001	0.76873	0.20161
Nara	29	0.00174	0.00000	0.00002	0.94649	0.05175
Wakayama	30	0.00002	0.00000	0.00001	0.78763	0.21233
Okayama	33	0.00560	0.00002	0.00000	0.63556	0.35881
Hiroshima	34	0.00003	0.00003	0.00087	0.97460	0.02446
	Group 5--Southern and Inland Sea Coast					
Yamaguchi	35	0.00188	0.00001	0.00007	0.35117	0.64688
Tokushima	36	0.00456	0.00000	0.00000	0.11430	0.88115
Kagawa	37	0.00017	0.00000	0.00000	0.01871	0.98111
Ehime	38	0.00025	0.00000	0.00000	0.33629	0.66345
Kochi	39	0.00017	0.00000	0.00000	0.02185	0.97798
Saga	41	0.00060	0.00000	0.00000	0.00054	0.99887
Nagasaki	42	0.00044	0.00000	0.00001	0.06549	0.93446
Kumamoto	43	0.00041	0.00002	0.00000	0.02974	0.96982
Oita	44	0.00541	0.00000	0.00000	0.02971	0.96488
Miyazaki	45	0.29985	0.00000	0.00000	0.03928	0.66087
Kagoshima	46	0.08859	0.00000	0.00000	0.02299	0.88842

*Group numbers in this table are not identical with the group numbers used in the text. The group titles are identical.

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