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Studies on the Future
of Cities in Asia

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Center for Planning and
Development Research

Institute of Urban and
Regional Development

University of California,
Berkeley

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July, 1966

PREFACE

This investigation is a continuation of a series of studies upon the scientific and technological contributions to regional development and resources planning. The earlier output was published as monographs of the Conservation Department, School of Natural Resources, University of Michigan, so that this piece may be regarded as the sixth such item.¹ As with the preceding studies, the material that follows evolved as the product of a problem-solving, multi-disciplinary assessment of the future in conjunction with students.

Those participating this time were attracted by the program of the College of Environmental Design. They were enrolled in City and Regional Planning Course No. 227, "The Future of Urbanism and Cities," and in the Architecture Course No. 298, "Special Study for Graduate Students." The contributing students were Shlomo Angel, Krishna Bhattacharya, Alvin Bonnet, Nabil Faltas, Arvind V. Garde, Donald E. Hunter, Tsuto Kimura, Dimitri Koussios, Lawrence A. Moss, Jeff Stubbs, Yan-ho Tse, and Athanassios Zervos. They were enrolled in the departments of architecture, city planning, civil engineering, and management science. Altogether eight nationalities were represented. Each made a significant contribution. Their reports have been checked, amended, and digested while being combined with my own. Wherever their work is paraphrased directly or used unchanged, credits are given. However, in all instances, the responsibility for errors remains solely my own.

Several apologies must be entered for irregularities in the presentation of the argument. The first of these is the casual

combination of various units of measurement. It is in part due to the fact that the areas studied most intensively were in the process of shifting to the metric system, but mostly because engineering is still taught in modified English units in the United States. The units quoted were those in which experts at hand usually thought and made comparisons. Thus we used rupees but not annas. Unfortunately the rupee was devalued about the time the study was being completed, so the rupee has a value set by the exchange rates and price levels around May 1.

An explanation must be made also for the style of writing employed. A terse, almost telegraphic presentation jars anyone whose mother tongue is English because the ideas are introduced quite abruptly. This is most true of the first section. One reason is that the introductory arguments are modest extensions at best of ideas already reported and cited. A more important reason, however, arises from the fact that half of those working with me this time, and an equal fraction of the probable readers of this report, use English as a second or third language and experience shows that this style transmits technologically-oriented ideas more effectively than a polished prose.

Finally, I must express my thanks to the faculties of the College of Environmental Design, especially Professor M. M. Webber, Acting Chairman of the Center for Planning and Development Research, whose comments and queries and directions were of great assistance in the completion of this report. I am also indebted to Lawrence Moss for his service in preparing the report for this publication, and acknowledgement is due to Mark Trembley, Fred Shell and John Daish for their assistance with the graphic material.

June, 1966
Berkeley, California

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I. PRELIMINARIES TO URBAN SYSTEM DESIGN

1. The Top Priority Tasks for the New Urbanism

The implications of massive urbanization, the conditions when virtually everyone has moved to the city that wishes to do so, have never really been investigated. Most designers and planners imagine cities of the future to be like cities of today, although more spacious, and therefore many times larger. But this is impossible. Calculations based upon the present per capita consumption of key resources, such as energy, water, and air, will show that requirements would far exceed the supply of resources available. Substitutes can be found, and advanced techniques of conservation introduced, so that the scarcities can be overcome, but the innovations bring with them striking changes in the appearance and organization of cities.

Massive urbanization appears to be the easiest way out of a moral dilemma. Over the past half century the civilized world became committed to the prevention of human suffering from war and starvation. Concepts of the welfare state came into being. Scientific knowledge regarding the means of achieving these ends has piled up. However, the knowledge is relatively ineffective in illiterate communities scraping a subsistence from the land. If the newly-acquired experience is to be diffused and used, a greater social investment must be made in individuals, primarily in the form of education and health. A marked improvement in the quality of life is expected as a consequence of public action in these directions.

The other horn of the dilemma is an outgrowth of our biological constitution. Whenever a species achieves increased mastery over its

environment, its biomass expands. The individuals become fatter for a while and shortly thereafter the population increases. Eventually the new carrying capacity of the environment is reached, and the welfare of the individual returns to what it was before. Man's knowledge permits him to understand why it is that improvements in technology have their greatest impact in an increase in numbers, even to comprehend what needs to be done to prevent the increase, but the lag in implementing such wisdom is expected to take at least one to three generations. Tardiness in the control of population growth creates an oversupply of people on land where they cannot be productive.

Surplus people obviously do not know that their existence may be attributed to improvident knowledge. Their horizons are limited to a search for necessities, for security, and an opportunity to improve their lot. The city, they hope, will provide these minimum requirements.

Population pressures are greatest in Asia. Previous innovations there have raised population densities on agricultural land up to the highest reported anywhere in the world. Moreover, these same populations are growing by $2-3\frac{1}{2}\%$ per year. Therefore, the urbanization pressures in Asia will be the most intense of all (Table 1). Cities must receive streams of immigrants on a scale never before experienced. Somehow most of them must be converted into producers of goods and services, capable of providing for at least their own requirements, within a matter of months. The alternative is a series of Malthusian catastrophes--famines, epidemics, aggressive wars, political disorders--so large in scale they threaten to engulf the world. If means can be found to create enough jobs and homes in Asian cities, the urbanization

Table I
For footnotes and sources, see p. 107.

ASIAN URBAN GROWTH: POPULATION OF METROPOLITAN AREAS
 (000)

Metropolitan Area	Total Population		Prospective Annual Growth in 1970's ³
	Year of Estimate	Number ²	
Tokyo-Yokohama	1964	15,400	400
Osaka-Kobe	1964	8,700	300
Shanghai	1964	7,600	400
Calcutta	1964	6,700	400
Bombay	1964	4,700	300
Peking	1964	4,200	300
Tientsin	1964	3,400	250
Hong Kong	1964	3,275	120
Seoul	1964	3,200	200
Djakarta	1964	3,150	250
Delhi	1962	2,750	300
Manila	1962	2,650	200
Madras	1962	2,050	140
Karachi	1962	2,000	200
Bangkok	1962	1,800	200
Tehran	1962	1,590	150
Saigon	1962	1,550	150
Singapore	1962	1,480	100
Taipei	1962	1,375	150
Lahare	1962	1,325	150
Ahmedabad	1962	1,300	150
Bangalore	1962	1,225	150
Pusan	1962	1,185	130
Surabaya	1962	1,075	150

problems elsewhere can be solved in a more leisurely fashion using the same principles.

The challenge then is to fit the present stock of knowledge to the task of designing the kind of cities for Asia that can cope with the population and with the scarcity of resources. If a single technically feasible formula can be found, we will presume that a set of solutions exist and that some of them will be preferred by the residents to others. The exercise that follows should be regarded primarily as a test of feasibility, and subsequently, an early indicator of what it is expected people will choose to construct for themselves. We have now argued ourselves up to the point where specific criteria for feasibility can be stated.

Henceforth cities must pay a great deal of attention to food. They must earn enough to pay for it and maintain transportation to carry it. Very likely they will produce the fertilizers that increase output, and packaging materials that prevent spoilage. Because agriculture itself can now be industrialized, many cities of the future may be expected to produce an important share of their own food.

The emphasis upon food focuses attention on its major input--water. Ordinary domestic needs for water are presently very difficult to supply in many cities of Asia. Producing food would increase the urban demand for water several fold, although not necessarily during the driest month when the flow in the aqueducts may dwindle to a trickle. Reclamation of water from urban wastes must become one of the most sophisticated industries in the cities of the future.

Immigrants to the cities need homes, but neither the incoming worker nor the city can afford decent housing. Therefore, most of the settlers will accept a lot with access to services where they are encouraged to build their own shelter, investing their savings as well as their family effort. Spacing and servicing should be planned so that the quality of the housing will improve over time as the investment accumulates.

Surprising as it may seem, many emigrate to the city because it promises an opportunity to preserve customs, religion, and other aspects of life style. Virtually all varieties of exotic enclaves continue to survive in cities because large cities have a multitude of walls, and walls produce privacy. As cities become better organized they can also provide improved security from unlawful acts, but generally the demand for such services grows with the length of time of settlement and the acquisition of a stake in the urban system.

Cities must generate productive social roles, primarily jobs in enterprises. They can do this only by planning an environment in which enterprises thrive well enough to accumulate capital for reinvestment. The jobs need to become increasingly productive so that the surplus can be ploughed back and provide new jobs for the newcomers.

The dimensions of the task for cities can be put in another way. In Asia recent population growth implies that cities must soon grow by 6-8% per year in population, and 7-15% per year in output. This means roughly doubling the population every decade, on the average, and tripling or quadrupling the income. Only then can Asian countries

keep far enough ahead to pay their own way. Asian cities must be virtually self-sufficient in capital formation because the resources of the rest of the world would be minuscule as compared with the needs of all the territories when once they have begun to develop.

It is apparent by now to anyone acquainted with the quantities involved that the problem is insoluble using traditional approaches. They miss by a large margin. Therefore, the only possible avenue is through tapping technologies and procedures that are known but not yet used. The designs for communities, utilities services, and institutions must be fitted to the scale of the demand and to the specific resource scarcities known to exist.

The intent here is to explore technically feasible futures for the growth of cities in Asia. One method of testing feasibility is to set up a simple population growth model, checking it against resources.

2. A Way of Exploring the Future

A comprehensive approach to assessing the future of a constellation of urban centers on a continent would require a set of independent forecasts of the growth pressures upon each of them. Then an analysis would be made of the constraints affecting each. Does this growth require building into a flood plain? Are water supplies available? Later an evaluation would be made of the interactions between the centers. Does the growth projected for one depend on a slice of the international trade pie counted upon by another? Are they all dependent upon the same source of new enterprises and capital? Then some readjustments would be made, and each urban region would have a more realistic appraisal of the outlines of its future.

This highly desirable overview is impossible at the moment. The amount of effort required is too large, being at least an order of magnitude greater than is available at the professional level in the developing countries. Nor can the work be conducted satisfactorily at a distance where investigators are in reasonably adequate supply.

The method that can be employed begins with the store of knowledge that has been organized and is open to all. The bulk of the information is heavily technological or scientific in its mode of exposition. Any initial expression of needs and priorities (as in Chapter One) causes us to search this literature and the current expositions for innovations and unused techniques. How might the most promising of these be fitted to the typical case? What are the prerequisites, the costs, the co-products, and the further implications? How does one know whether something better will not come along? I have taken up such methodological questions along with many others in earlier work on technological change and planning projections.⁴ These procedures are in advance of what is presently undertaken routinely by demographers, economists and other statistically based academic forecasters because they take into account a wider range of events and facts. They also go beyond what is done conventionally by planners because advanced practice is not enough; the most recent researches must also be appraised. In order to be comprehensive in coverage the new methodology recommends a number of search strategies calculated to minimize the number of surprises experienced by policy makers.

How can the decision maker be confident that the advice he has received is reliable? He needs independent confirmation that the

forecasts, before and after planned intervention, can be validated. One convincing way is to set several independent specialists onto the same forecasting task, and then observe how they adjust to each other's findings. (If little or no consensus is achieved, the future is most likely indeterminate.) Olaf Helmer has succinctly summed up the current possibilities, including those that lead to the design of simulations.⁵ Both gaming and computer simulations can be used to explore policies for urban development, but the computer simulation is too inflexible to be of real value in understanding directions for city development in Asia.⁶ The political situation is so unclear most of the other forms of simulation are also inapplicable. We are left with the predecessor to a simulation, a simple model that grows step by step into the future, each step representing what seems to be the most economical forward movement for that interval of time.

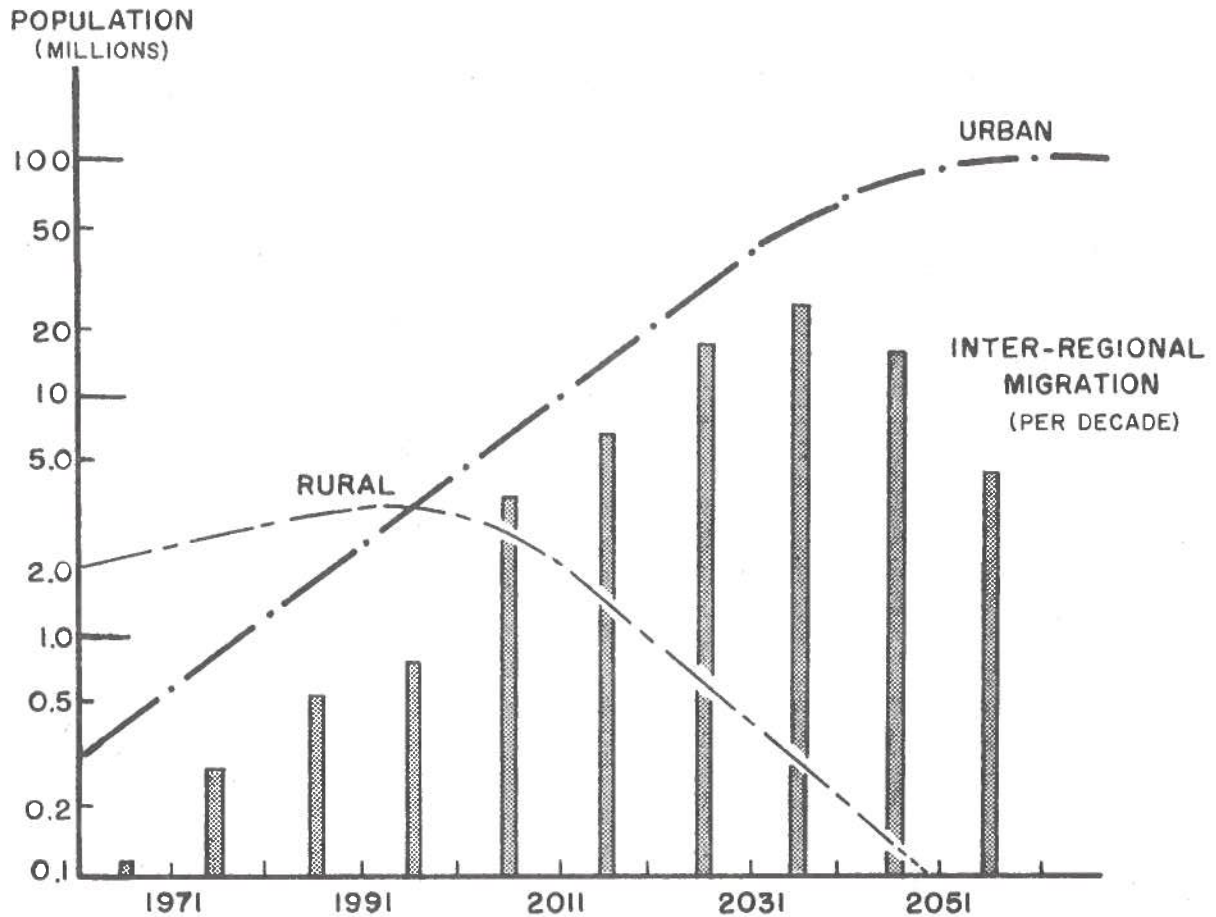
Two models are utilized in the chapters to follow. One of them is intended to discover the potentialities and severest limitations of land-based urbanism, while the other admits eventual defeat on the land and explores the possibilities of moving cities out to sea. One model spells out the implications of ways of life evolved in India and the Hindu-influenced cultures, while the other employs characteristics of the cosmopolitanized Chinese culture. Operation of these projections should acquaint us with the salient problems of massive urban growth from Karachi on the west, Harbin on the north, and Surabaya to the east. Each of the models has been handled in "pure" form at this stage, although the findings now suggest that the next time around a hybridized urban region, an amphibian megalopolis, is the urban structure that should eventually be chosen in both instances.

One of them is a revisiting and updating of the model employed earlier in a paper for an international seminar on Indian urbanization.⁷ In it the metropolis of Madras was expanded from its 1960 population of two millions, doubling each decade thereafter for a half century before filling out to a megalopolis of 60-80 millions. All residents were expected to achieve a minimum adequate standard of living within a reasonable time after their arrival on the scene, so that the requirements of food, water, transport, housing, and services could be calculated. It appears now that the assumptions regarding tolerable population density and investment allocation were too conservative. To an important extent the shift in outlook can be traced to a reduced need for safety factors in the allocation of scarce resources due to greater certainty of technological estimates.

The all-India conditions are assumed to follow the medium projections of Kingsley Davis, who anticipates a population for all of India of 1.0 billion people by 2000 A. D., with growth continuing, but subsequently at a slowing rate. Since many cities are poorly located for the support of a flood of immigrants, the favorably located centers must make up for the deficiency by growing 6-8% per year.

Very briefly, we begin with two cities in Andhra, Vishakhapatnam and Vizianagaram, which lie on the major freight route between the outside world and both the Calcutta-Bombay axis and the rapidly industrializing state of Mysore. Their total population is estimated at 600,000 for 1971. They are "grown" by a combination of natural increase and immigration. People nearby are absorbed first in the expansion but the metropolis acquires national prominence about the turn of the century. (Figure 1).

FIGURE 1



PROPOSED GROWTH OF MEGALOPOLIS AROUND VIZAG (1961-2061)

Population is shown with a logarithmic scale to illustrate the significance of the "doubling every decade" assumption. In this model most of the growth is drawn from the immediate area until about 2000 A.D., whereupon a sharp influx from outside the region is needed to maintain growth. Birth control takes effect in the urban population (2-child family predominates) after 1980, and in the rural areas after 1990 (but 3-child family preferred). Continuously improving governmental performance is implicit in this projection.

Two types of urbanism are recognized. The present cities are expected to be redeveloped and attract a relatively educated and cosmopolitan component of the population. The remainder of the immigrants would be assigned to "urban villages" at the expanding fringe. Each village is expected to fill to capacity in five to fifteen years. Once reconstructed, the centers will grow by accreting the oldest urban villages and densifying the settlement. Their population would grow even more rapidly than that of the megalopolis itself (say 8-11% per year). Other centers are needed in the later stages.

Each decade the requirements for transportation, water, heavy industry, and recreation would be considered in as quantitative terms as possible. Only flat land is accepted as urbanizable, the remainder being allocated to parks or quarries. The details will be taken up as they are relevant.

The model for Hong Kong is simpler. Natural growth rates are exceedingly high (greater than 3% per year) but the influx of refugees is low, except in times of extreme distress. The costs of settling the sea are indeterminate because we do not have information on the investment needed for protecting the waters of the most desirable bays, but they appear to be most suited to the middle-middle and upper-middle income groups. Thus we are faced with a typical "new town" problem arising within a competitive housing market.

We chose an attractive bay large enough to support an amphibian community. Then every feature was scrutinized in the hope that costs could be reduced, or a larger share of the population could be served. Service problems were envisaged, and then reasonable solutions in

the form of modifications of tested ideas were sought. Preliminary designs were often undertaken as a means of discovering the shifts in emphasis brought about by the occupation of a marine surface. It was evident from the exploration that a number of new lifestyles were likely to evolve, so we could not anticipate consumption patterns very well, and were only able to gauge the range of options that were technically feasible.

3. Resource Constraints Affecting Asian Urban Growth

The major countries in South and East Asia possess at the moment no more than a tenth of the natural resources, on a per capita basis, that are available in the United States and the Soviet Union. Asian countries are also less well endowed than Western Europe (Table 2). In the future the disparity will be much worse due to the extraordinary population growth under way in Asia, and because further minerals exploration is turning up only minor additions to the deposits previously identified. Somehow a formula for urbanization, industrialization and economic development must be found that evades these shortages. Fortunately, a review of the experience since World War II suggests that times have changed so that countries without resources can now develop themselves.⁸

Rapid economic and social expansion is presently achievable primarily through creating open societies, quick to grasp opportunities in international trade, emphasizing balance in investment between physical capital and human resources, and paying greatest attention to the creation of innovative institutions.⁹ The urban

Table 2

STOCKS OF NATURAL RESOURCES AVAILABLE IN ASIAN COUNTRIES (1963 Dollars)¹⁰
(Per Capita Basis)

Nation	Ag., Forests & Fisheries	Coal Reserves	Iron Ore	Oil	Non-Fuel Non-Ferrous	Hydro	Total
Kuwait	-	-	-	210,000	-	-	210,00
U. S. S. R.	70	35,000	240	9,000	6	490	44,00
Iraq	30	-	-	3,800	-	11	3,80
Malayan Fed.	890	4	40	-	13	1,700	2,60
Iran	60	-	-	1,940	-	40	2,00
Burma	100	-	-	7	4	800	91
Philippines	200	5	450	-	27	200	88
India	13	340	260	-	3	80	70
Korea	2	590	32	-	-	5	63
Japan	43	440	-	1	-	73	57
Israel	360	-	-	-	32	90	48
Ceylon	380	-	-	-	-	45	42
Afghanistan	49	-	-	-	-	200	25
Formosa	150	-	-	-	-	87	27
Thailand	140	-	1	-	24	34	24
Indonesia	65	11	12	33	8	12	14
Viet Nam	52	-	-	-	-	52	10
Pakistan	24	5	-	-	-	70	10

(Comparable total for the United States is \$30,000)

environment for these institutions must allow them to function despite the resource scarcities. Some altogether new ways of economizing in resource use, including the introduction of substitutes and synthetics, will be required in order to overcome the "vicious circles" and "equilibrizing forces" that keep a people poor against their will. Specific problems of conservation can be taken up resource by resource, so that the major substitutibilities and trade-offs between them are revealed, and the most promising strategy becomes evident.

The most immediate shortage is water. The older sectors of most Asian metropolises are likely to be poorly served when the reservoirs are low. The example of Tokyo is quite typical. Older reservoirs have silted in, so their capacity is smaller, while at the same time industrial and commercial demand in the pre-WWI areas has risen. Pipelines are decrepit, leaky, and subject to breaks. Rapid growth of the metropolis has left the water supply system unconsolidated, so that drinking water cannot be pumped about the service area as need arises. At times in a hot summer the water supply in the taps and hydrants is reduced to a few hours per week.

Chains of reservoirs moving up the accessible watersheds must be planned further into the future than any other urban service. A twenty to forty year horizon is not unusual. When the population of an urbanizing area doubles each decade its water requirements may triple in the same period of time, so the search for future water supply takes on strange and radical dimensions. For example, trees and bushes give way to grass or even bare rock on slopes of hills and mountains. Aquifers and cave systems are studied in exhaustive detail, so that underground potentials are not overlooked.

The best policy is to develop habits of rational water conservation among the users by setting prices for "water commodities" that reflect not the present equilibrium between supply and demand but the expected values a decade or so later. Thus a price of 10¢ per metric ton of pure, treated water (approximately \$125 per acre-foot) would appear to be quite reasonable a charge to a community distribution system. A ton should supply a prudent population with 10-12 person-days of water use. A variable price, one that could rise several fold over the dry months, makes possible a water use rationality that far exceeds anything in practice today but may well be necessary in the future.

If the cost of water rises significantly, even over short periods, the large scale users (mainly intensive horticultural production and heavy industries) are forced to look for substitutes. One possibility that industry would consider is the circulation of treated sea water as a means of cooling exothermic processes and disposing of chemical wastes. Another is to process sewage and aqueous wastes so that the water is readily re-used. Many alternative techniques can already be found in the water engineering literature; almost all of them become interesting when the price for water rises above the dime-a-ton level.

The spotlight has been upon desalination for more than a decade. Most of the figures on cost are quite misleading, if applied directly to Asian cities outside of desert areas. The facilities are capital-intensive, so that interest rates often need to be doubled. In addition, the monsoon or typhoon season will assure relatively cheap water for six to eleven months of the year, so that the desalinization plant should be in largely standby status. Extra costs are incurred when its water must be pumped inland and up slope. Thus a net price of \$1.00 per

thousand gallons in large volume (more than 25¢ per ton) is a more realistic appraisal of the market it could serve. The best desalinization system would use the "waste heat" of a nuclear power reactor.¹¹ Dependence upon desalinization would add 25-50% to the capital requirements for urbanizing immigrants to the city, the major proportion of it taking the form of energy production facilities, which introduces a conservation issue to be taken up shortly. We conclude then that desalinization should be considered a last resort, a means of preventing loss of capital invested in an urban site due to miscalculation, or evidence that poverty has at last been conquered and capital is no longer as scarce as it had once been.

Soil resources in India must henceforth be evaluated in terms of response to synthetic fertilizer. That in turn focuses attention upon water control and water storage, so that multiple cropping becomes the rule. Hydroponic gardening within the city may by-pass the soil, but it cannot dispense with water. With present "best practice" one person's annual diet at adequacy will require 200-500 tons of water per year. It is possible that some economies can be achieved through technologies now in early stages of development, where attempts are made to provide optional conditions for photosynthesis and fruiting of plants, but such speculations do not warrant quantitative, production-scale estimations at this time. Obviously, the seasonal water used for agricultural crops in India is worth only 2-4¢ per ton.

It is quite surprising to discover that the most important procedure for water conservation on a region-by-region basis turns out to be the recommendation that cities grow almost all of the perishable foods consumed by their own populations. Closeness to points of consumption

also reduces investment in refrigeration and transport, and should simultaneously greatly reduce spoilage en route to points of consumption. Under these circumstances the water that might otherwise be applied to marginal irrigation in the hinterland is put to much higher valued use..

The overall energy supply picture for rapidly expanding urbanization is closely bound up with the water and transport systems. Hydro-electric power will be insignificant except on the flanks of the Himalayas and metropolises dependent upon the Mekong River. Virtually all new installations larger than 250,000 kw. will find nuclear fuel more economical hereafter, so that the thermal plants now under construction are likely to be relegated to ancillary status in a decade or two.

Almost all of urban transport will need to be converted to electrically operated systems as the city grows. Even if the fuel were available it seems likely that the space for parking and traffic flow could not be afforded, nor the smog problem evaded. Thus, there is no justification for the automobile, and even the bus and truck will be displaced within the fully developed city environs by electrically powered equipment. Light motorbikes would probably be the last to go.

Aircraft are different because they must carry their own fuel and must have the highest energy content per unit weight. Nuclear reactors are too heavy when shielded. Thus all aircraft, whether large size conventional designs, vertical takeoff and landing types, or Mach 3 supersonic liners, will use liquid carboniferous fuels. Light to medium transport in the hinterland has similar problems and must compete for the supply of such fuels. Marine transport is in

the same position. Fortunately the technology for the conversion of low grade coal, shale, and tar into suitable liquid fuels is being perfected rapidly and should be available in a mature form in the latter part of the 1970's if developing societies are willing to pay a somewhat higher price for liquid fuel in the future.

Another principle, one that produces the greatest economies in the cost of energy delivered as services to the consumer, has little effect on the per capita consumption. Multi-shift operation of all offices, production plants, and public facilities would increase the output per installed kilowatt of capacity by at least a factor of two. The savings derived from reduced capital investment could be reallocated to human resources development.

Increased dependence upon electrical trains, buses, and taxis greatly reduces the demand for iron and steel and for rubber, both of which make heavy demands upon the fossil fuel resources. Light metals are rapidly taking the place of both steel and stainless steel, and the common components of the increasingly popular light alloys (aluminum, magnesium, manganese, copper, nickel, chromium, beryllium) have electrometallurgical sources, therefore they could be manufactured in any city with a large nuclear power plant. The medium grade ores for these metals--the best that are left by the 1980's--are to be found in many countries in South Asia, so that scarcities do not seem to be a problem in this instance.

By now every natural medium of the tetrad, earth, air, fire, and water, has been assessed except the second. Air pollution is a most serious threat to the growth of cities already. However, the policies

introduced for other reasons have a significant alleviating effect upon air pollution. The banning of the automobile, truck, and bus in the higher density areas of the city was the most important contribution to this solution. The planting of perhaps 40% of the urban land with vegetables and fruits should help a great deal in preventing temperature buildup in the urban center.

Our resource-conserving urban design should then be able to operate at or above the minimum adequate standard of living for everyone and yet only require (a) about 20% of the water consumed per capita in Western Europe, (b) about 20-30% of the energy requirements in the same area, and (c) perhaps half or so of the higher-valued minerals consumption. Since rainfall in the smaller basins draining into the Bay of Bengal (see Table 3) is not particularly high (30-50 in. per year), about 40,000 square miles of watershed would be needed to supply a megalopolis of 100,000,000 persons who were settled over an area perhaps 4,000 square miles in extent. The upper portions of these watersheds would need specific reconstruction of land forms and vegetation so that the yield in dry years would be maximal.

Because we have very little information on the variability of rainfall it is still impossible to assess what would be the best strategies for meeting a failure of the monsoon. Very likely it would be some form of internal economizing combined with withdrawals from inventory in upper reservoirs, importation from Assam using tug boats and "sausage-casing" water containers("dracones"), as well as accelerated desalinization. The water is available, it is merely a matter of cost. The cost of living at the minimum adequate standard could increase

Table 3

CLIMATIC CONDITIONS IN THE VIZAG REGION, INDIA ¹²

1. TEMPERATURE

Highest annual mean daily temperature 39.4°C (highest ever recorded 44°C)

Lowest annual mean daily temperature 16.2°C

<u>Month</u>	<u>Mean Temperature</u>	<u>Humidity</u>
January	23.3	74%
May	30.4	72
August	28.8	80
November	25.7	66

2. AIR CURRENTS

Wind speed 4-9 km/hr mean monthly (bottom quartile for India)

Livability is "comfortable" with occasional cool and hot periods

3. HYDROGRAPHIC CONDITIONS

<u>Month</u>	<u>Rainfall (Monthly Mean)</u>	<u>Solar Radiation (Maximum)</u>	<u>Sky Clearance Factor</u>
January	10.9 mm	405 cal/cm ² /da	70.2%
May	50.8	600	35.2
August	131.1	590	15.8
November	118.6	400	42.2

Mean Annual Rainfall: 962.4 mm

Average Net Solar Load: 174 cal/cm²/da (1,100 mm evaporation/yr.)

Net Mean Evaporation Loss: 140 mm/yr

by as much as 10% in a catastrophic drought. The difference between this relatively minor adjustment and the famine conditions that would otherwise ensue is a measure of the capacity of the new approach of resource-conserving urbanization to meet the extreme variability of Nature.

II. ANOTHER MEGALOPOLIS ON THE BAY OF BENGAL

4. Migration, Modes of Movement, and Settlement

To test our model we chose a site on the Bay of Bengal destined to become a city with the dimensions of a megalopolis. It has good access to natural resources via world trade and to other productive centers. The land to be occupied is flat and relatively well drained. The weather is as favorable as will be found in India, so that people can work virtually all the time without being subjected to discomfort.

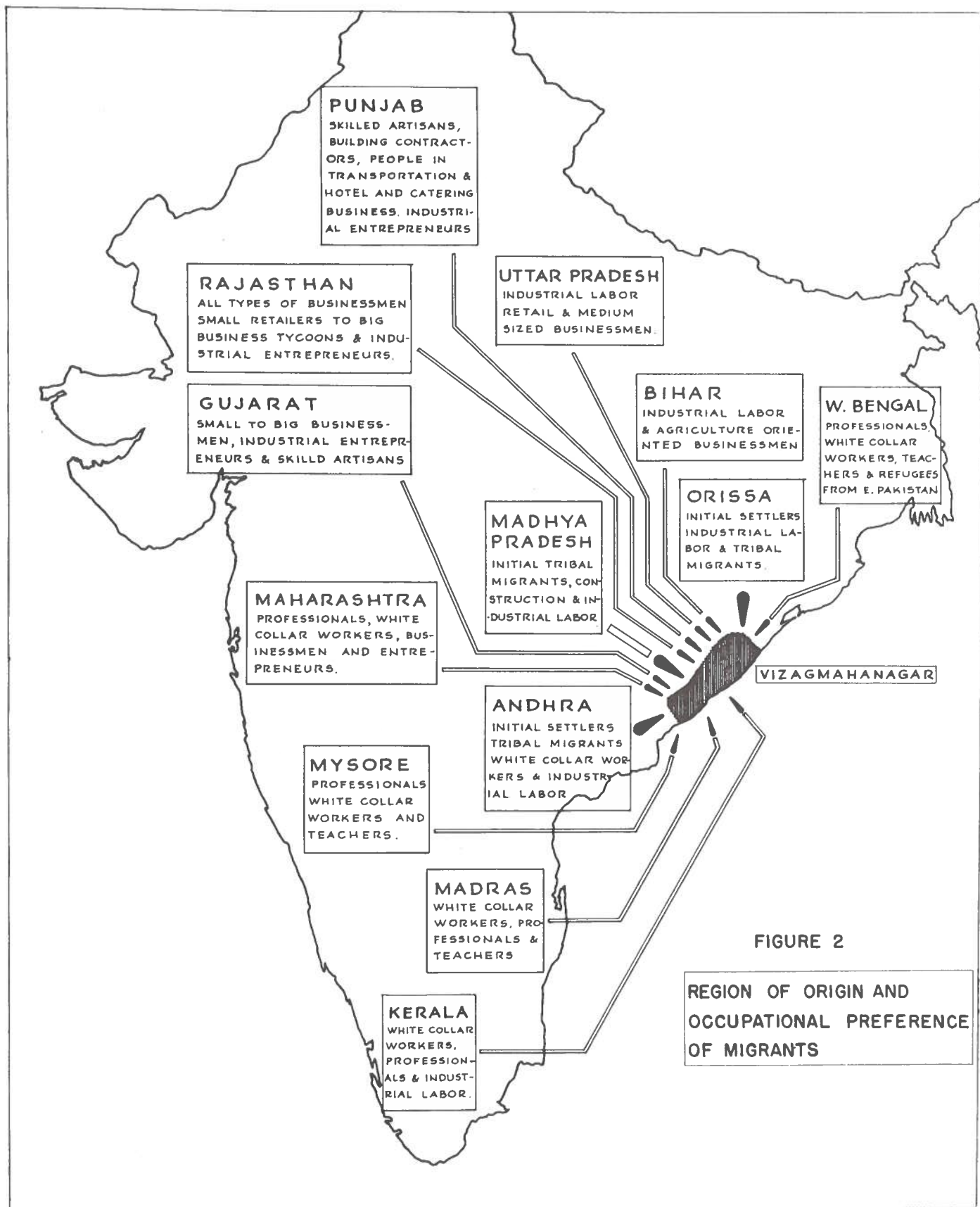
The concept of a megalopolis is still quite alien to Indian thinking. It is a Greek-derived term which has taken on a metaphysical connotation, but the meaning is changing due to the need felt by geographers for a term which denotes the constellation of urban centers that is progressively fusing and integrating. In India large scale urbanization will have to be planned, because the nation cannot long afford the uneconomic agglomeration that results from random "pushes" and "pulls" in the course of responding to overpopulation, so it is proper to coin a term for the planned form. Since the Greek megalo and the Sanskrit maha are derived from the same root, and the nearest equivalent to polis is nagar, the megalopolis at Vizag very naturally becomes Vizagmahanagar. This is in the Southern Indian tradition of polysyllabic place names. The outsider, however, would probably continue to call it Vizag.

Where might the people come from? How will they get to our city? The origins of the people who arrive, and the path they take in transit, will make a considerable difference in settlement pattern. Migration

experience in India is sufficient to show that the patterns conform quite closely to expectations based upon this migration data elsewhere in the world.¹³ Thus Hindu migration appears to fit sociological theory, and we are quite safe in applying the theory in projecting developments over the next decades. It is much safer than simple extrapolation of past trends.

Everett S. Lee has summarized the present state of migration theory.¹⁴ Briefly he finds that migration is increased (a) by the variety of environments in the target area, (b) by the economic opportunity present there, (c) by abnormal stresses in the area of origin, (d) among people whose familial bonds are loosening, such as the youth, (e) by diversity among people in the target area, (f) by reducing the cost of surmounting intervening obstacles, including distance, and (g) by the achievement of economic progress in the society as a whole. Each migration stream produces a counterstream. The net transfer per thousand trips will be greatest when the original move was made to escape deprivation or persecution, or when the obstacles to movement are greatest. Migration is a selective process in a population, so that both the hardest elements and the weakest are most likely to move, the former usually earlier than the latter.

The propensities to move in India over the next generation are summarized in Figure 2. These patterns are likely to dominate as long as the rural and small city population continues to grow, but will change markedly when the rural areas reorganize and decant all unneeded population into the cities. About the earliest this can begin to occur in India is the turn of the century. The effects are clearly



indicated in the growth model for Vizagmahanager. (Figure 1). The quality of the migrants is likely to be quite consistently poor as compared to those already living in cities but the later efflux will probably be a most backward lot, so that the institutions for acculturating rural immigrants must be well developed by that time and capable of very rapid expansion.

The principal immigrants in the first several decades should include Telegu speakers from Andhra Pradesh, Orija speakers from Orissa, and a member of miscellaneous tongues introduced by tribesmen from the Ghats (principally Kandh, Savara, Gond, and Oraon, but Konda-Dora, Konda-Reddy, Bogata, Bhottada, Binjhal, Koya, Poroja, and Jatpu tribes are likely to be strongly represented), since the number of tribesmen now living in Andhra state is estimated as being in the neighborhood of ten million. Indian industrialization up to the present time has drawn about half its workers from within the state and the remainder from the rest of India.¹⁵ There is every reason to believe that such a pattern will continue.

Thus, by the time population accretion reaches metropolitan dimensions (e.g., several million residents), the city must expect to operate its public sector with as many as five principal languages, maintain at least a dozen distinctly different language-based communities, adjust to the holiday and ritual requirements of several religious communities, and accommodate ten or more tribal settlements. Conditions are further complicated by the left-over compulsions of a broken-down caste system, which will have strong effects upon both spatial and social mobility. The city must be so organized that pluralism becomes an asset rather than a hindrance.

How might these contingents arrive? Most of the large construction projects, such as the development of the harbor and the heavy industry at Vizag, or the electrification of the mainline railroads, will bring in their own labor by rail and bus, but a large residue will be left behind looking for industrial work. Troubles at the borders, communal conflicts, and civil wars may be expected to route a stream of refugees to the scene by rail. The local agriculturalists will use any marketing vehicle available as well as bicycles. New diploma holders moving in with relatives already in town to seek some kind of corporation employment will be especially bicycle-oriented. Small entrepreneurs will come in with a lorry load of goods to trade. They might remain if business looked promising. Temporary influxes due to droughts will also leave major residues. The prospects then are for a steady flow of opportunity-seekers, modulated somewhat by the business cycle, and aperiodic floods of refugees.

The counterstream of immigration will develop road connections with the rest of India. Bus and lorry movements should increase hugely and cause tremendous congestion on the periphery of the urban centers. Growth of the cities would be thwarted if an urban transport system is not planned so as to channel and distribute the movement efficiently. If such an urban region as Vizagmahanager is to grow, highest priority must be given to the installation of a transport system that can develop step by step with the growth of population and economic activity.

A most promising solution is provided by ideas for mass transit which are currently under discussion. Electric railways that evolve into what is called a multi-modal system (e.g., cars drop off a train

while running and are collected at a limited number of stops on the return trip). The most significant economies in operating such a system are obtained from multi-shift organization of urban services. Once achieved, something like fifteen hours of peak operation should result and five more hours of extensive use should be planned for when the land served by a line is fully settled.¹⁶

By working backward and forward between assumptions about land use, settlement pattern, and transport system design an arrangement was found which appeared to be close to optimal for the growth model proposed here. The properties of the solution that fitted all the criteria are best summarized as a series of statements. Only the most surprising of these will be explained and defended with supporting arguments:

1. Optimum travel speed for commuter densities 20,000-30,000 per mile of line, using a value for time spent in travel equal to the minimum adequate standard (50¢ per hour at the internationally defined scale of values), and with a stopping time of 15 seconds at the station, was found to be 60-65 mph. Maximum speed, about 100 mph.

2. The compromise between the need for transport efficiency and the coherence of the two communities at each station set the ideal station separation at 1.5 miles and the separation of lines also at 1.5 miles. Then the typical urban village dimensions would be set at 2.4 x 1.2 km. and a population of 30-35,000 persons.

3. A double track line with speed transfer into local service, so that full train stops are made only periodically, permits a train to serve up to twenty stations from the center before the service

approaches line saturation. Express lines are to be provided only when connecting centers serve multi-millions of population (Table 4).

4. Freight movements move along the same line during the short off-peak period and can be greatly accelerated using containerization and piggy-back techniques. Most sidings and switches can be eliminated.¹⁷

5. Lines are most economically run at the surface but reduced below grade when entering the high density cosmopolitan core and therefore constitute a considerable barrier to community interaction except in the vicinity of the station.

6. Rolling stock would be self-propelled, automatic coupling, carrying 150 passengers per car. Possibly cars could be equipped to operate as trolley buses at the end of the line in the period before construction was completed.¹⁸

7. Local transport in areas with 50-150,000 persons/sq. mi. density would be kept primarily in the pedestrian mode, but assisted at the periphery of the 1.5 mile module by electric buses ("elephant trains"), bicycles, and tiny electric cabs.

8. Local transport in urban villages merits the provision of electric buses between stations on parallel commuter-lines. They can more than double the effective area for job-hunting open to any urban village.

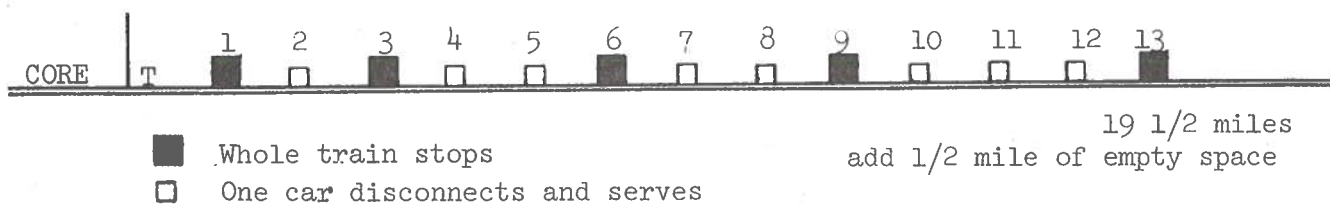
9. Commuter line movements in this design have almost constant cost regardless of the length of trip. If a 10% annual return on capital is to be obtained, a fare of 5¢ per round trip (0.20¢/seat-mile) would have to be charged.(Table 4).

10. Lines between metropolitan cores could apparently be handled with four tracks conveying up to 400,000 passengers per day per station

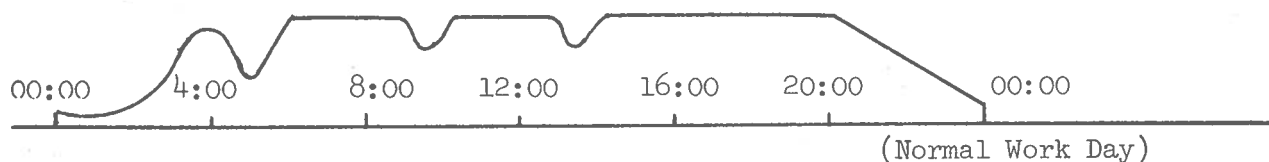
Table 4

COST ESTIMATES FOR TYPICAL COMMUTER LINE
IN VIZAGMAHANAGAR USING MULTI-MODALITY VEHICLES

1. STRUCTURE OF LINE DEMAND (other side of core is symmetrical)



2. STRUCTURE OF TIME DEMAND (with multi-shift offices and services)



3. OPERATING CHARACTERISTICS

Average speed - 60 mph.
Station population maximum - 70,000
Trip rate - 200/person/year
Headway at peak - 150 passengers/station/3 minutes
Track open to containerized freight - 2-5 hours/day

4. CAPITAL COSTS

Stations	@ \$ 500,000	\$ 6.5 millions (50 yr. life)
Track	@ \$1,000,000/mi	20.0 "
Yard, shops, etc.		2.0 "
Start-up expense		0.5 "
Self-powered vehicles	@ 200,000	28.0 (20 yr. life)

5. OPERATING EXPENSES (modified S.F. Bay Area Rapid Transit estimates)

Labor, power, etc. @ \$ 150,000/mi	\$ 3.0 millions
Amortization (50 year)	0.9
Rolling stock amortization (20 year)	1.4
Return on unamortized capital (10%)	4.0
For 182,000,000 round trips: Total	\$ 9.3 millions/year

6. COST PER ROUND TRIP < 5.1 ¢

at average speeds of 80-100 mph. Costs are likely to run 0.3-0.4¢ per seat-mile.

11. An international airport is likely to be warranted as the population reaches 2-5 million persons. A site can be found adjacent to a small estuary which promises to be convenient during the full growth period.

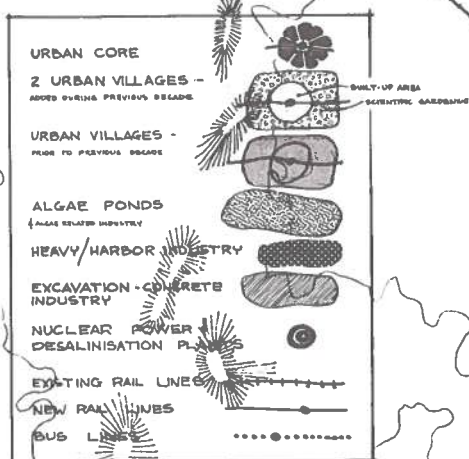
12. Helicopter and V/TOL or V/STOL networks are needed to connect the airport with all the metropolitan cores, and they with each other. Anticipated costs, however, are 2-8¢ per seat-mile, so the flows of passengers will be too small to affect the loads on surface transport.

The spatial implications of this transport system, the standard community module, and the growth model can now be fitted together into a settlement program. Starting from the two original foci, it is possible to grow the full city on a map. The results appear to be quite modest, being not nearly as spectacular as the numbers involved. (See consecutive maps of Vizagmahanager, 1980-2060, by Don Hunter, et al.)

In these maps land was allocated in such a way that the city would feed itself except for the staples (rice, wheat, sugar, pulses), and the shoreline was set aside for recreation (except for power plants, airport, and harbors that take up about one tenth of the total). Since emphasis was placed upon the growing urban village at the beginning, their cores were left white, surrounded by rapidly intensifying garden areas showing a vegetative tone. The transport system and the multi-shift organization of the centers was gradually improved up to the specifications set up in Table 4. The most surprising finding from this exercise in the application of land economics was the evolved form of the centers (whose total population grew faster than the rate for

Bay of Bengal

Vizagmahanager



1980

POPULATION : 1,200,000

8 HOUR PEAK TRAVEL PERIOD

TRANSPORTATION SYSTEM :

TRAINS - 15 CARS, 200 PEOPLE/CAR, OPERATING IN

5 CAR TRAINS @ 20 MIN. INTERVALS ON ORIGINAL RAILS

BUS - 20 BUSES, 70 PEOPLE/BUS

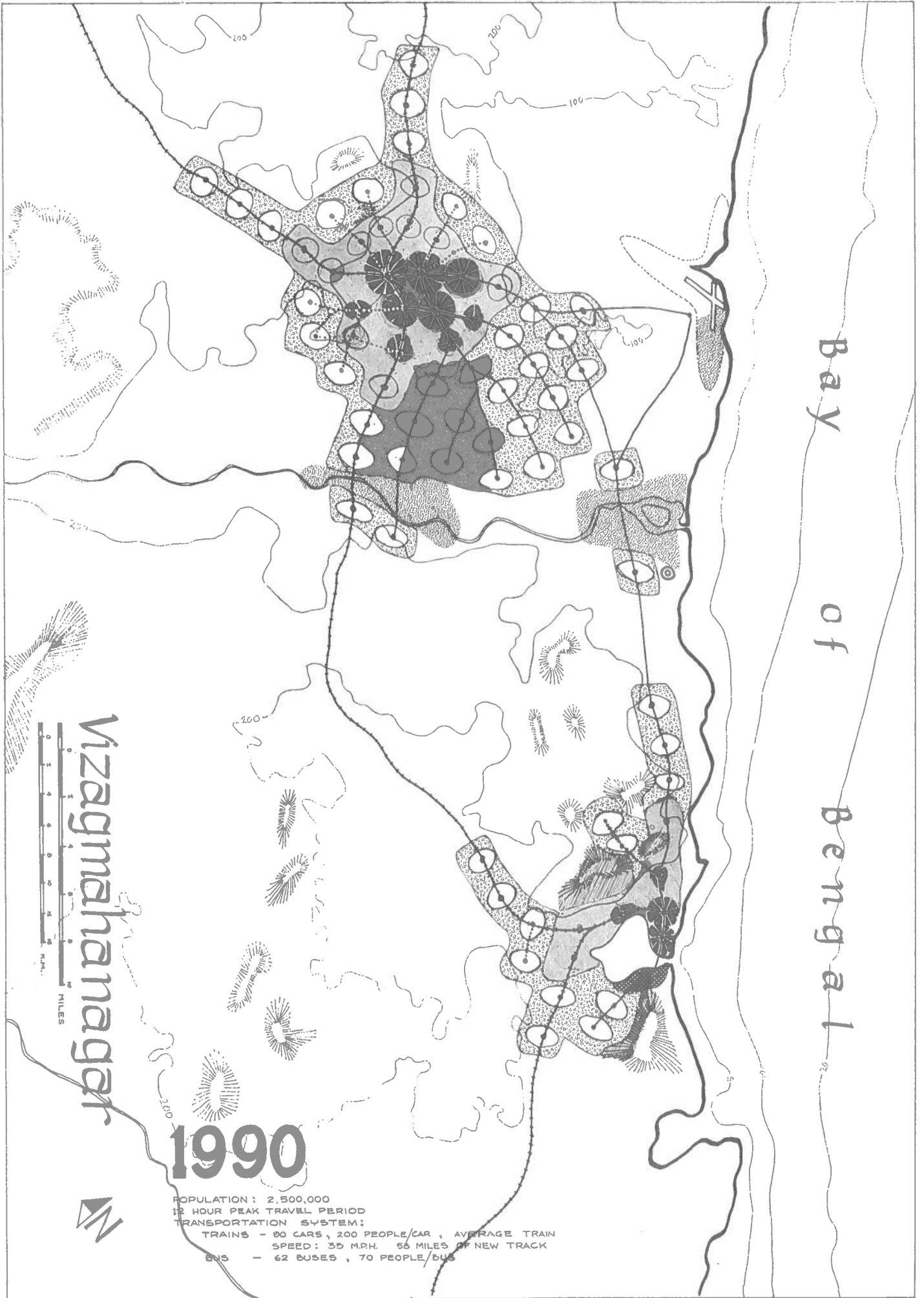
Bay of Bengal

Vizagmahanager

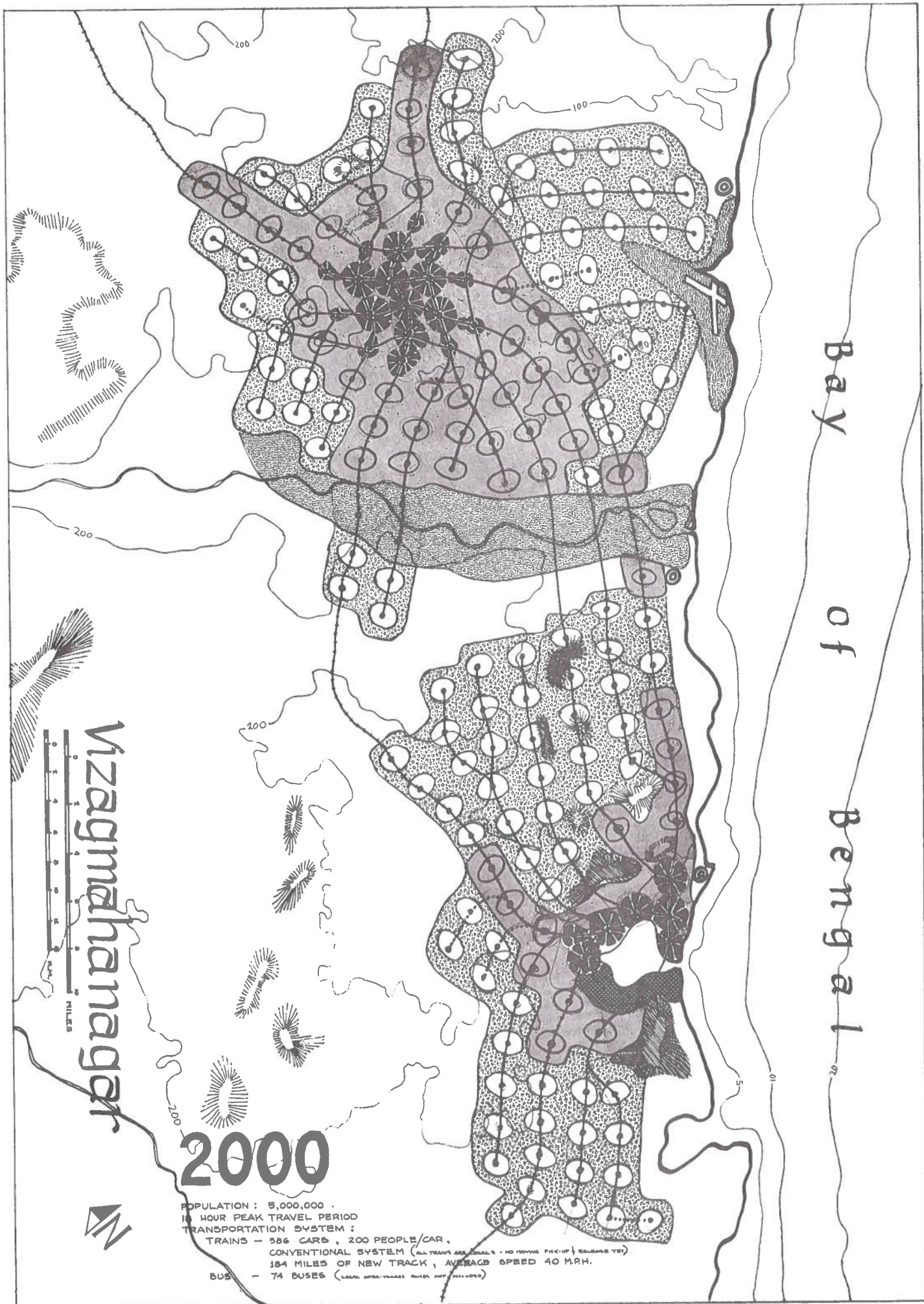


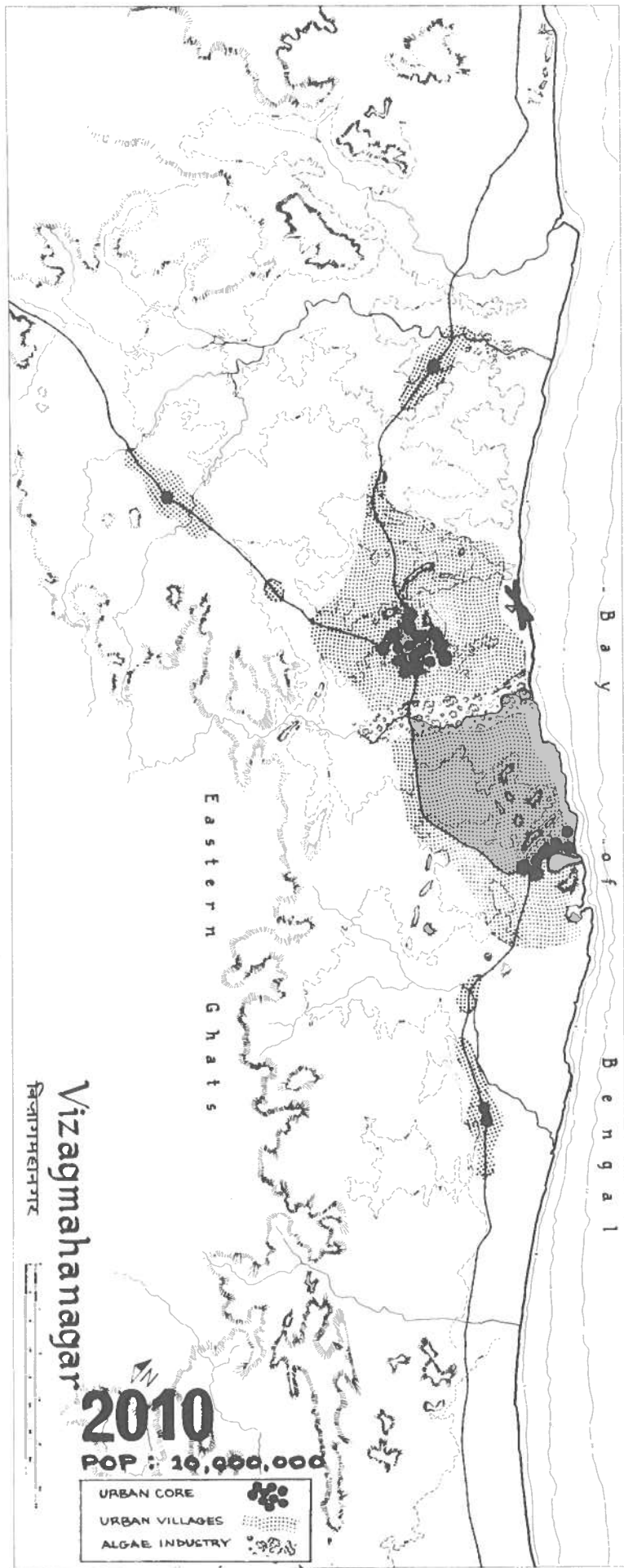
1990

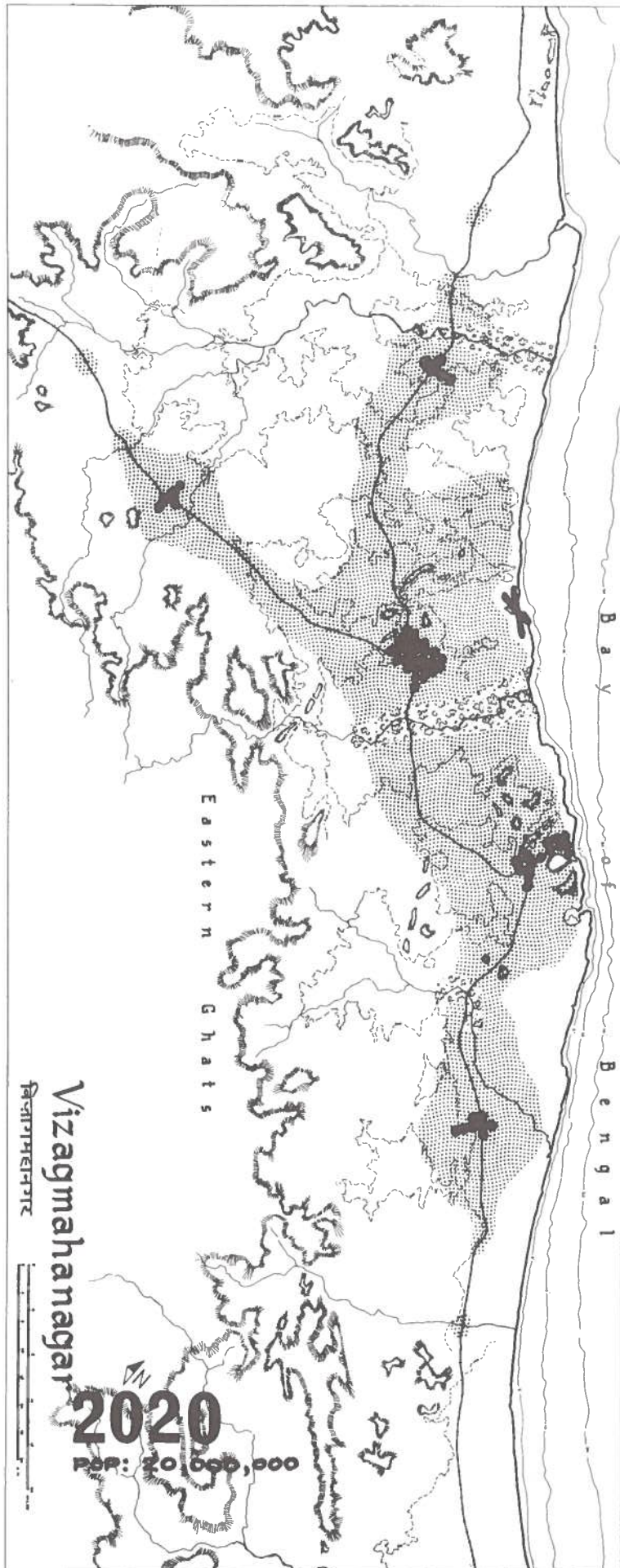
POPULATION: 2,500,000
12 HOUR PEAK TRAVEL PERIOD
TRANSPORTATION SYSTEM:
TRAINS - 80 CARS, 200 PEOPLE/CAR, AVERAGE TRAIN
SPEED: 35 M.P.H. 55 MILES OF NEW TRACK
BUS - 62 BUSES, 70 PEOPLE/BUS

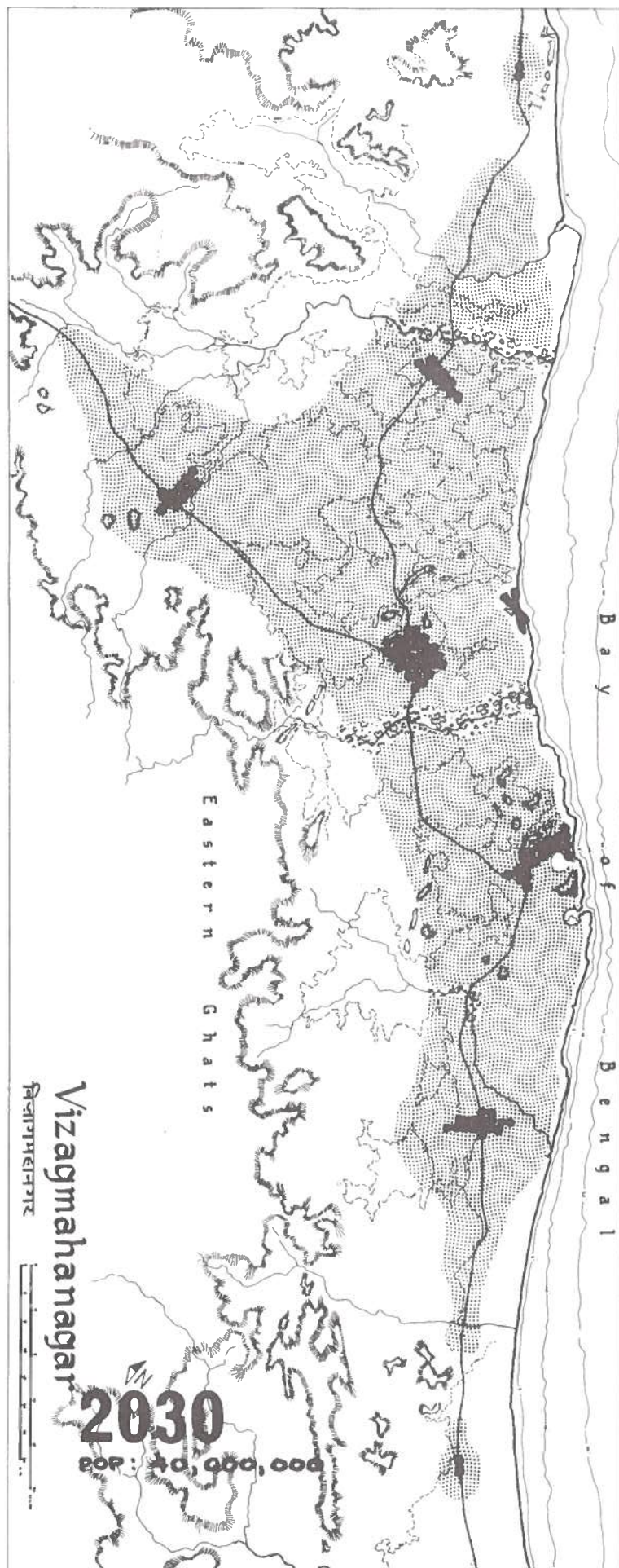


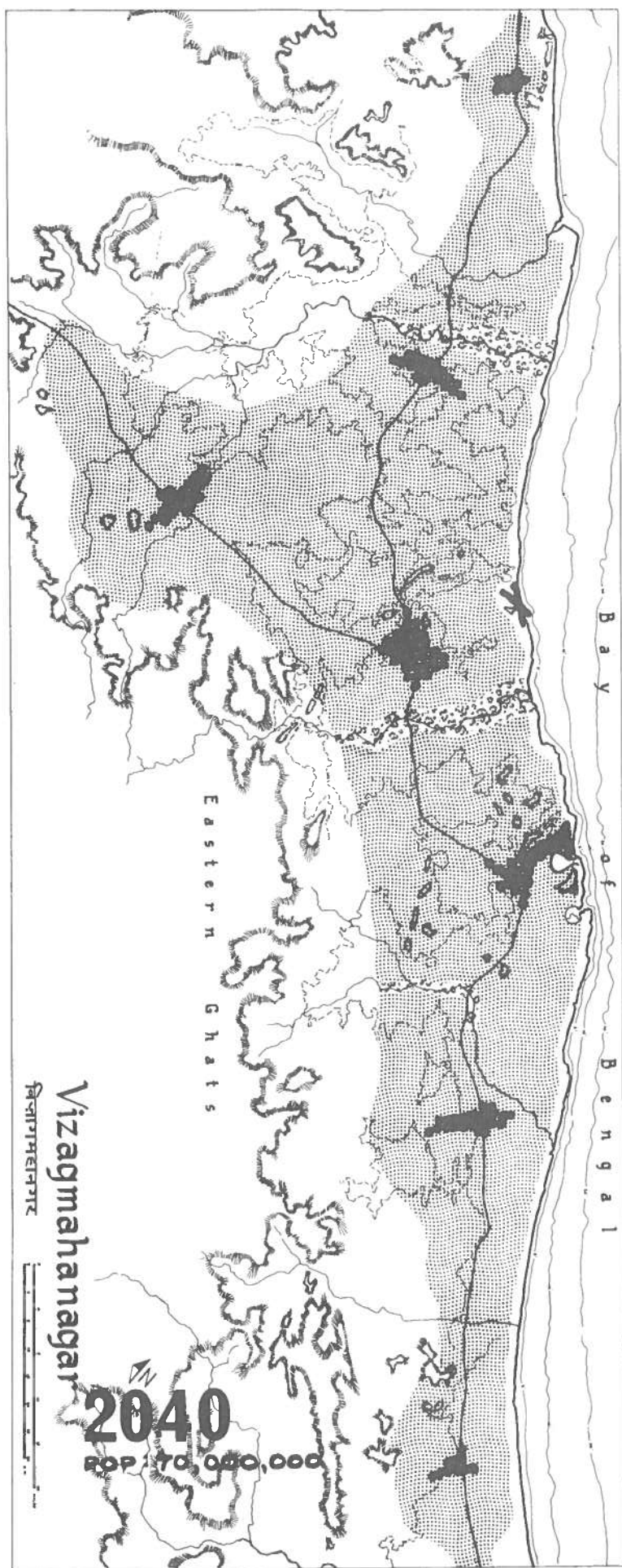
Bay of Bengal

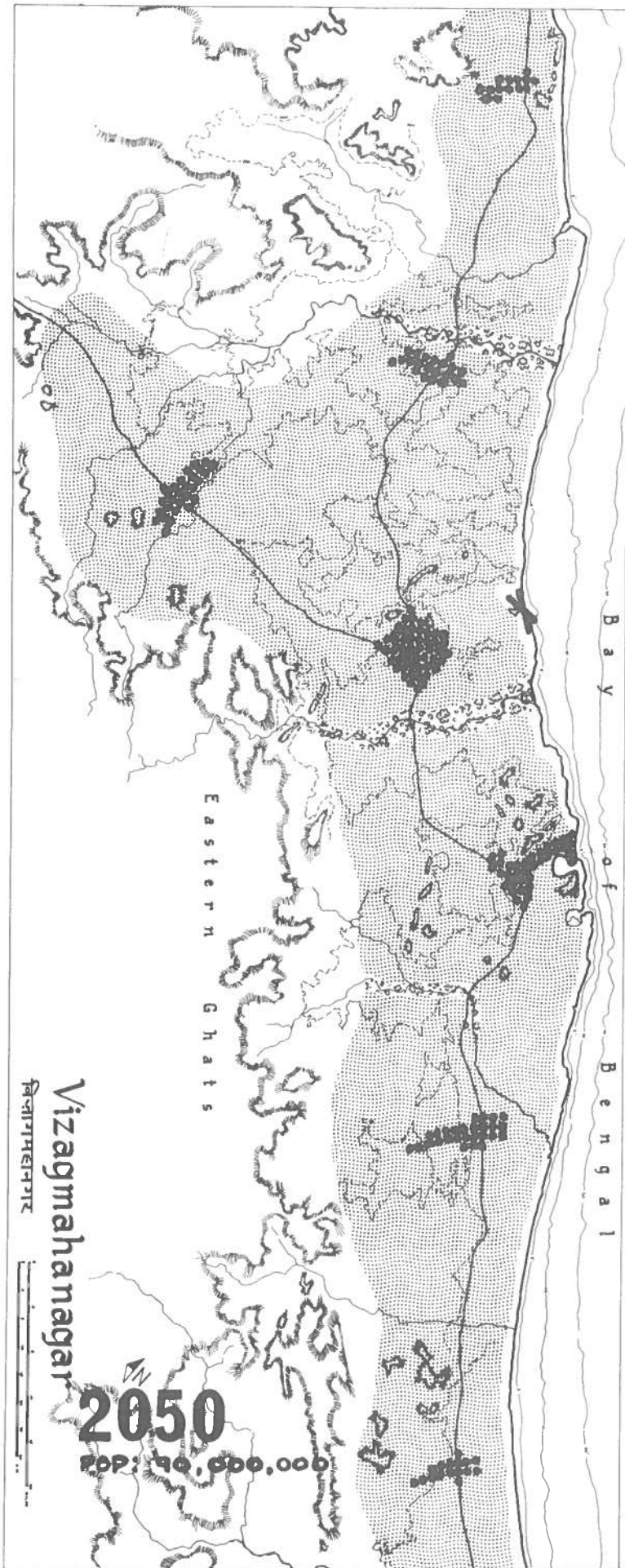










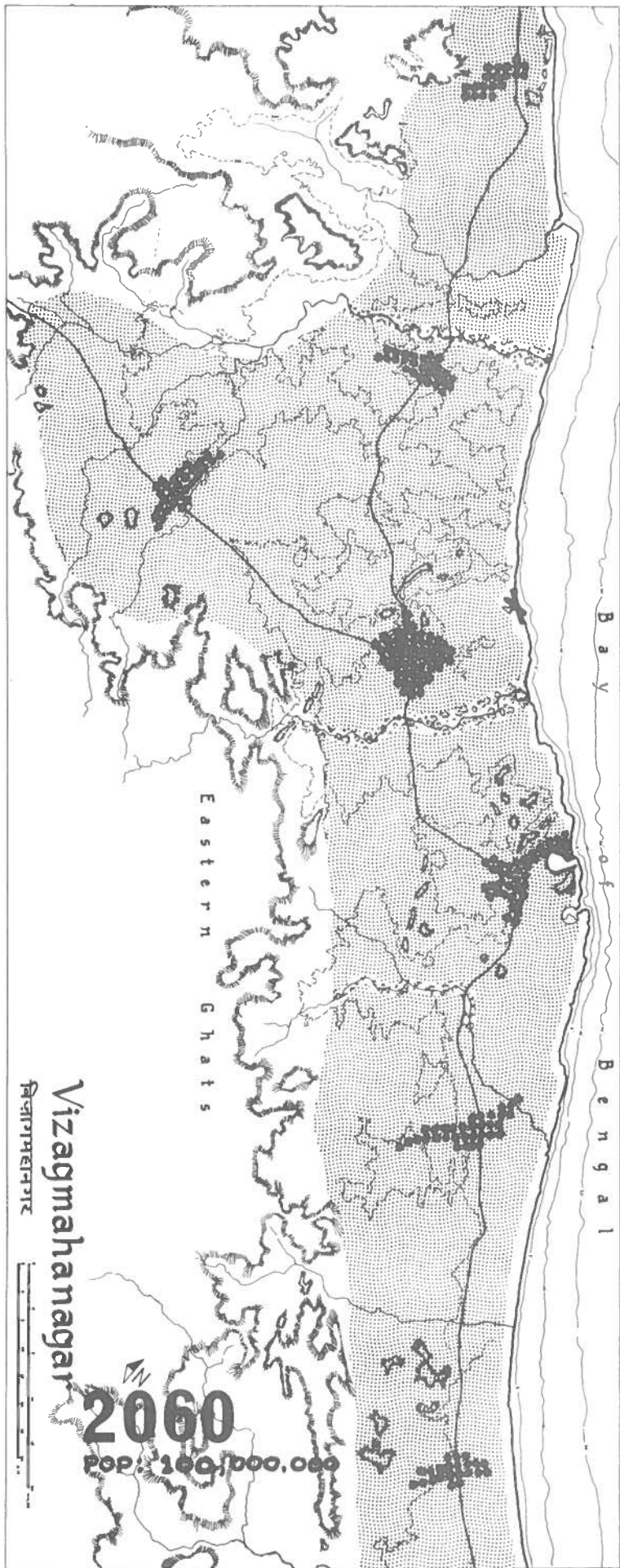


विनागमहानगर

Vizagmahanager

2050

POP: 40,000,000



whole megalopolis--doubling every seven years instead of ten). All sub-centers, except that evolving from Vizianagaram--became linear cities, despite the fact that all but one are inland. It is interesting also that transport economies--the other side of this coin is "congestion avoidance"--oriented the centers perpendicular to the mainstream. We suspect from operation of the model that the topography which forced Vizagmahanager to be a strip megalopolis is responsible for this outcome. The interactions are too complex to say this with assurance; another terrain will have to be tried.

5. Community Form and Organization for Acculturation

The ultimate megalopolis is conceived as possessing thousands of relatively autonomous communities, representing scores of sub-cultures, which are nevertheless only way stations on the road to a cosmopolitan urban culture that can compete with any in the world in the realm of ideas and imagery. Therefore, the "urban village" is designated as a locale for education, a place where the tasks of subsistence are met, but attention is continually drawn to the world of technology, of abstract thinking, and exciting new social roles that exist outside the community itself.

The "learning by doing" process for developing a new community is the most reasonable technique in a very poor country. India will not have the capital required for a formula that would provide housing for the immigrants when and where it was needed, as has occurred for the most part in Israel, for example. These migrants from rural areas must create their own facilities, and build up their own skills in reshaping the physical environment. The place of "planning" in this

framework is not far different from that a teacher who recognizes that his students are learning more from each other than from formal presentations. The greatest hazard is that community behavior and organization would consolidate at too low a level to produce an adequate level of living for its members plus a bit of surplus to assist others less fortunate. The special skill of "planner as pedagogue" is in presenting development tasks to the community in an order and a scale that would not be overwhelming. When the task is too great to be handled by self-organization, employing local contributions of capital and labor, a planning and development agency must be ready to intervene and find some means of assistance.

For example, land is almost never available to a new immigrant community in sufficient quantity and contiguity. In present practice the respective families fit into the city as best they can and later try to form a religious center or a club as a focus for the sub-culture. Therefore planners must have a land acquisition policy that may use eminent domain if necessary, but would encourage the assembly of land by other means in blocks large enough to accommodate a community. The difficulty with the legal procedures is that they proceed much too slowly to allow a metropolis to double its area in the course of a decade, and keep on re-doubling it in subsequent decades. Nor is the law able to cope with speculative booms in land that fragment and frustrate development. Planners are coming to recognize that these difficulties can be overcome by the profit motive, but the process must be institutionalized so that the outcomes are socially useful as well as individually profitable. No such institution has been

encountered in the documentation on India, but some variants upon what has been done elsewhere in the world (particularly Israel and Japan) appear from a distance to be feasible.

Once the boundaries of a proposed urban village have been surveyed a "land trust" corporation is automatically declared. Each present owner gets a share of the stock proportional to the amount of developable land he contributes. The land trust installs the aqueduct, storm sewers, and street alignments using local labor at going rates, thus many farmers gain extra income as workers. When the land is occupied the trust pays the original agriculturalist at a value halfway between agricultural land and urban land less the development costs. The land trust reassigns the land to immigrant plot holders in sizes of 80, 100, 120 and 200 m² on long term lease, according to recommendations from the panchayat or the new community government. Both government and lessors become the new stockholders. As the land is further developed, with gutters, sewers, paving, water supply, electricity, and street lamps installed, the value accrues to the community. As long as the land trust owes money to the state, the state will have a director on hand to review procedures. If the land is later converted to metropolitan core, again the profits can be distributed, this time among the old lessors and the new community members. Since the very first urban villages to be formed are most likely to benefit from the further transformation a generation or so later, much less risk is entailed in the acquisition of experience that would enable the land trusts to fill the desired function. The important feature about this procedure is that leases and contracts can have terms set so that urban development is not held back, and windfall profits are averaged out so that many people make a modest gain.

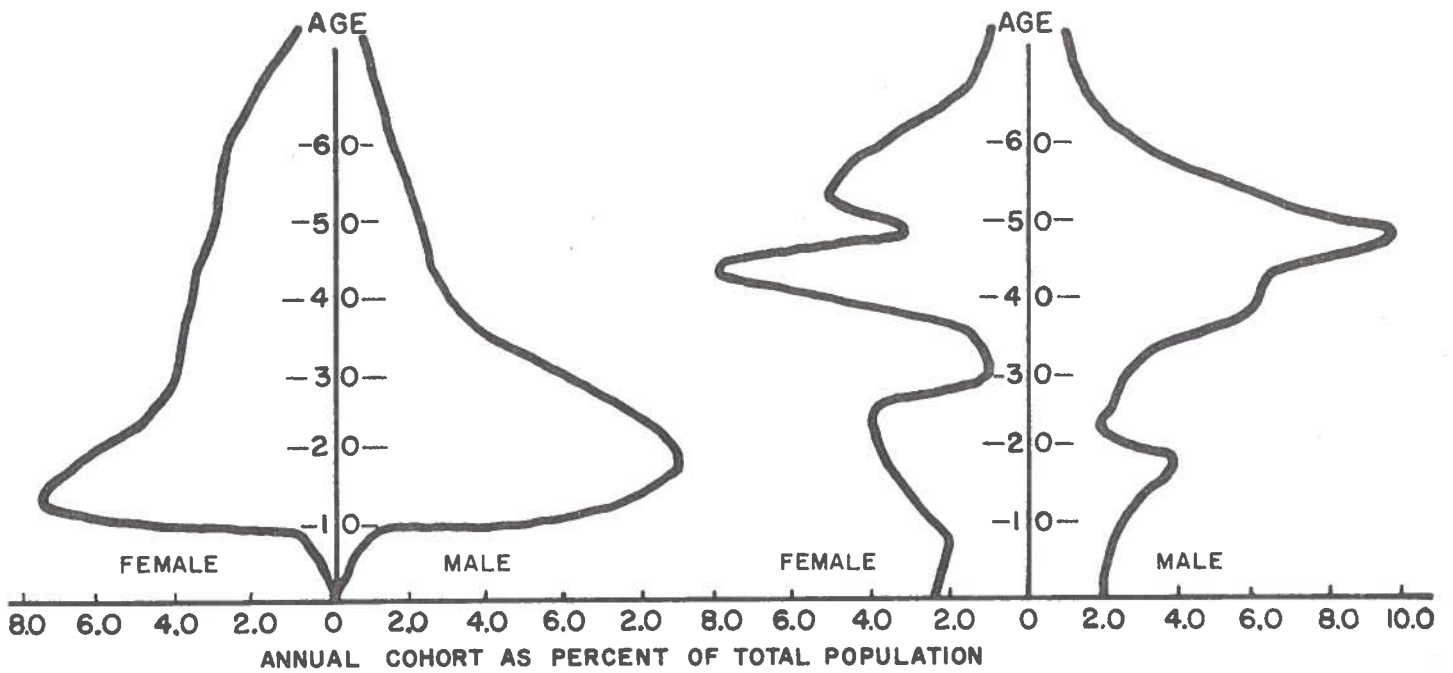
The "urban village" is subject to most of the trials inherent in "new town" development. One of the most serious of these is the abnormal age distribution in the community. When establishing the urban village as a waystation on the acculturation road we are, in fact, encouraging a rapid rate of outmigration to the metropolitan core which gives a greater fluidity to its population.

A numerical exploration of the implications of current migration patterns was carried out. The community was begun with a typical age-sex distribution for migrants (see Figure 3). In these projections the migration propensity from the urban village, either to the metropolitan core, to a newly founded urban village up the line, or to adjacent villages for marriages, was set at 70% of the males and females in each cohort that comes to maturity in the urban village. This proportion required modest rates of renewal from the hinterland, much of which could be accounted for by marriages and the regrouping of families. A second wave of immigration reduces the extreme age bias if undertaken after the twentieth year.

Use of land within the urban village (dimensions 1.5 x 0.75 miles ideally) is conditioned by the volume of various activities and by the character of the traffic. Production activities would be concentrated upon agriculture and light industries. Roughly half of the total area of community, the least accessible half, has been allocated to labor-intensive multi-crop agricultural production, much of it possibly utilizing economic approaches to hydroponic culture of vegetables. Light industry would be assigned some of the most accessible land, while commerce remains at the center where traffic density is the greatest. (Figure 4).

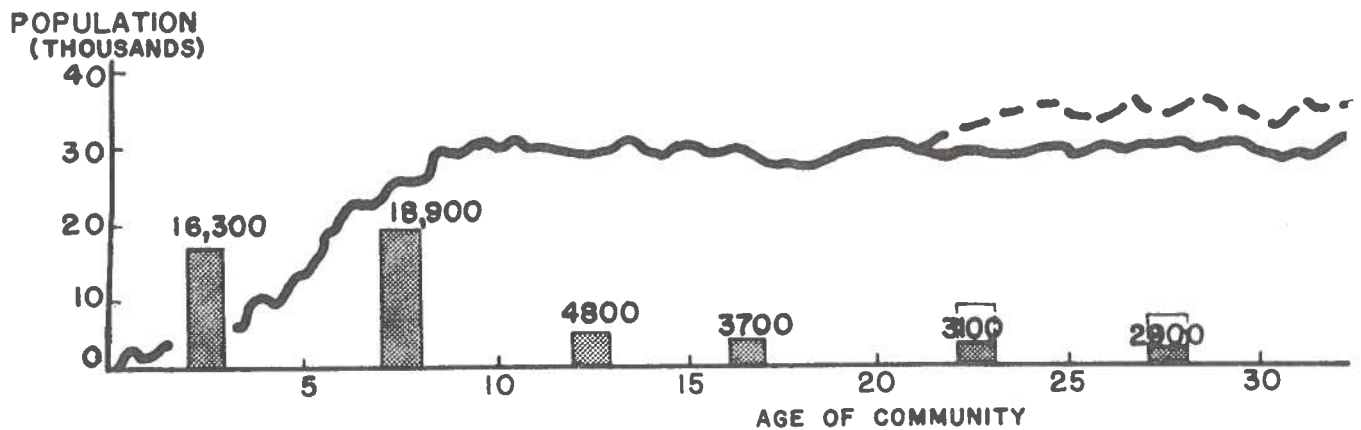
FIGURE 3

URBAN VILLAGE SETTLEMENT MODEL



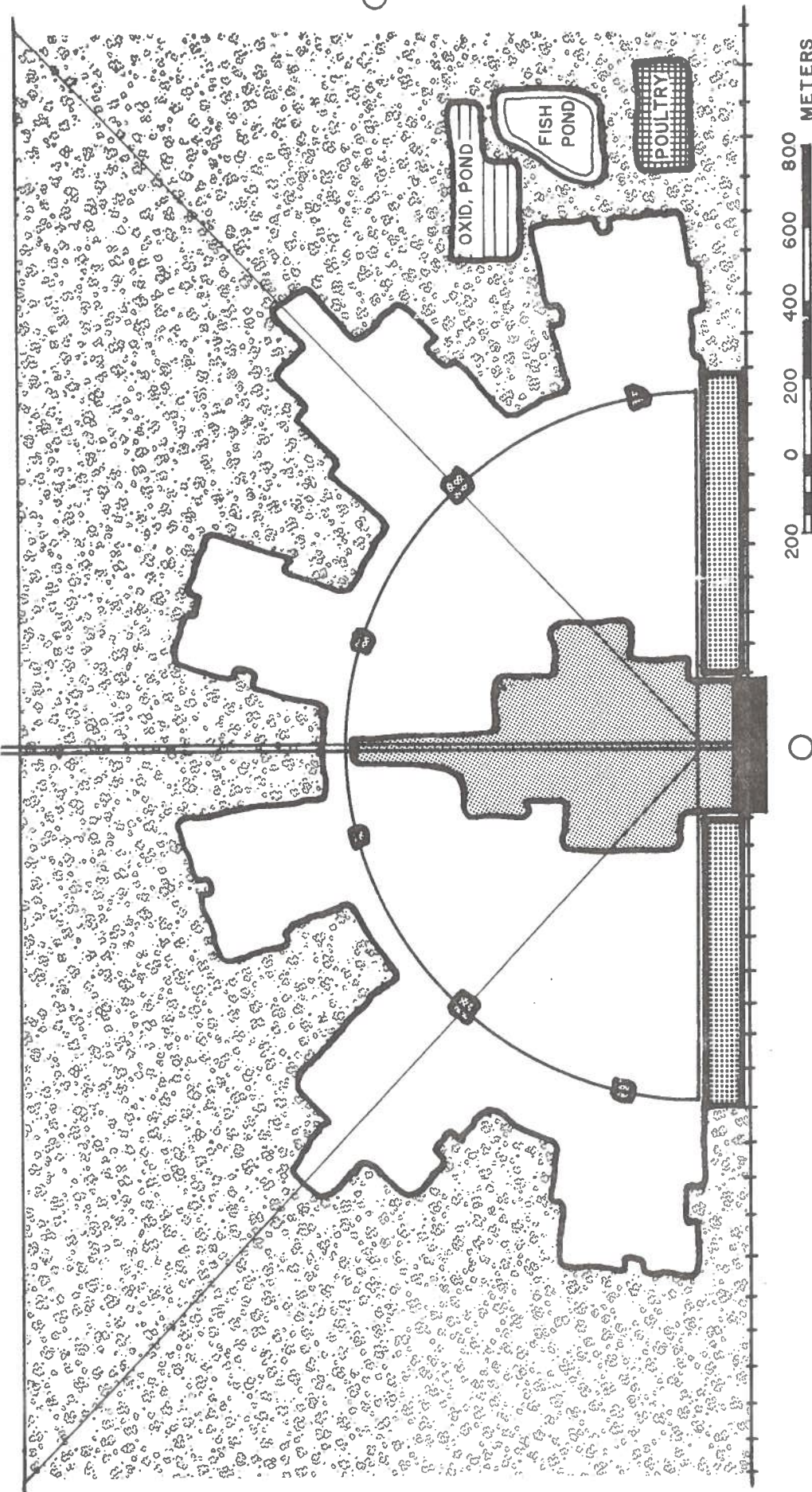
A AGE-SEX DISTRIBUTION OF
IMMIGRANT POPULATION: t

AGE-SEX DISTRIBUTION OF
COMMUNITY POPULATION: $t+30$ YR.



B IMMIGRANT REQUIREMENTS BY QUINQUENNIA

FIGURE 4



RESIDENTIAL

GARDENING

LIGHT INDUSTRY

COMMERCIAL

ADJACENT URBAN VILLAGES

ELECTRIC RAIL

"BROADWAY"

SECONDARY ROADS

CYCLE TRACTS

AN URBAN VILLAGE PROTOTYPE

POPULATION: 30-35 THOUSAND

METERS

Bicycle demand will be quite high. As the community approaches an adequate level of living, and human time is valued from \$0.30-1.00 per hour, bicycles add to productivity. Perhaps half the households will find them useful. Parcels up to 200 lbs., and infirm individuals can be moved about by tricycle. Loads up to a half ton can be moved by the motorized three-wheeled carts that are common in most developing countries. Occasional larger shipment lots would require the importation of an electric warehouse truck. A bus connecting back-to-back villages would become economic. But pedestrians should still predominate by far. Virtually any establishment in the community should be within twenty minutes walking distance for the pedestrian. Circulation patterns like the one impressed upon these urban villages draw people very naturally to the community center all hours of the day. Both regular and random social contacts are encouraged. Thus each person comes to know, and is known by, many others. Under such circumstances the building of small firms, social groups, and community institutions will be much easier than experienced at present.¹⁹

Most of the acculturative learning stems from experience acquired in creating new institutions. There are perhaps a thousand small units to be formed ranging from family firms to women's associations to sports clubs. There are scores of community-wide organizations to be initiated. Some guidance and encouragement is necessary, including occasional technical assistance from the outside, but more than 99% of the effort must be internal.

Very likely there will be numerous delegations from the respective communities, each of them focused upon a single problem. In this

manner a successful organizational innovation in one community can be transferred to others. To supervise this process of inter-community learning an agency must be created which follows the progress of urban villages in detail and can battle the other departments in the bureaucracy, if necessary, for scarce services and equipment.

6. The Upcoming Technological Revolution in Housing

Before the potentials of the urban village were reconsidered for this report, the foundation for the "learning by doing" emphasis was self-help housing. It had this position of precedence because housing was important, and building any dwellings made from traditional materials, such as rammed earth or brick, is an extremely arduous task. The period of construction extends over many months, often into a second year. Cooperation of several kinds is required. Some of it to handle the heavy weights and more to handle special features such as roofing and door frames. Therefore familiar types of social organization need to be re-established in the new environment between virtual strangers. In the "aided self-help" schemes scattered over the world administrators and planners are able to assist this organization process, introducing information, credit, and encouragement so as to have a better quality structure upon completion. Thus the house becomes a teaching facility, each part of it a reminder of associations formed during the construction process that can be exploited for some other purpose at a later date. An important part of the city has been decoded by the man who has built his own house; he is likely to keep on achieving after that, either in his work or in his neighborhood, usually both. This feeling of established competence is conveyed to the children, who move up to more complex tasks in the city.

A rule of thumb applied to the expected value of hard labor building one's home from adobe brick or concrete block is that a full day's work in Latin America is worth about 50¢.²⁰ This means that in India it may be only Rs. 1-2. The work is back-breaking and often deteriorates due to adverse weather. We sought to make it more productive and to reduce the lags inherent in founding a new community.

The most promising efforts are those based upon foam plastics, where the work of the Architectural Research Laboratory of the University of Michigan was the most advanced.²¹ Several of their proposed structures would fit conditions in tropical India, but the evaluations of these would be closely parallel, so only one was carried through in some detail. The net effect is to eliminate the back breaking features of housebuilding, reduce the time of construction by half or more, and increase the pace at which new levels of building sophistication are introduced.

Rigid polyurethane, sandwiched between paper or foil, appears to be the most generally acceptable structural material. A layer of resin formulation (contains prepolymer from toluene diisocyanate and glycerine or sugar, blowing agent, surfactant, catalyst, and fire retardant) is pressed between two strips of kraft paper and recoiled for shipment. After arrival on site this coil is passed through hot rolls for a given contact time, whereupon the resin expands to the desired thickness and sets, all within a few minutes. The rigid board can be cut with a saw, or trimmed with a knife, and the seams can be closed with the aid of glass tape and epoxy glue. It is lacquered and painted like wood inside and out. Tests show that the primary design problem is

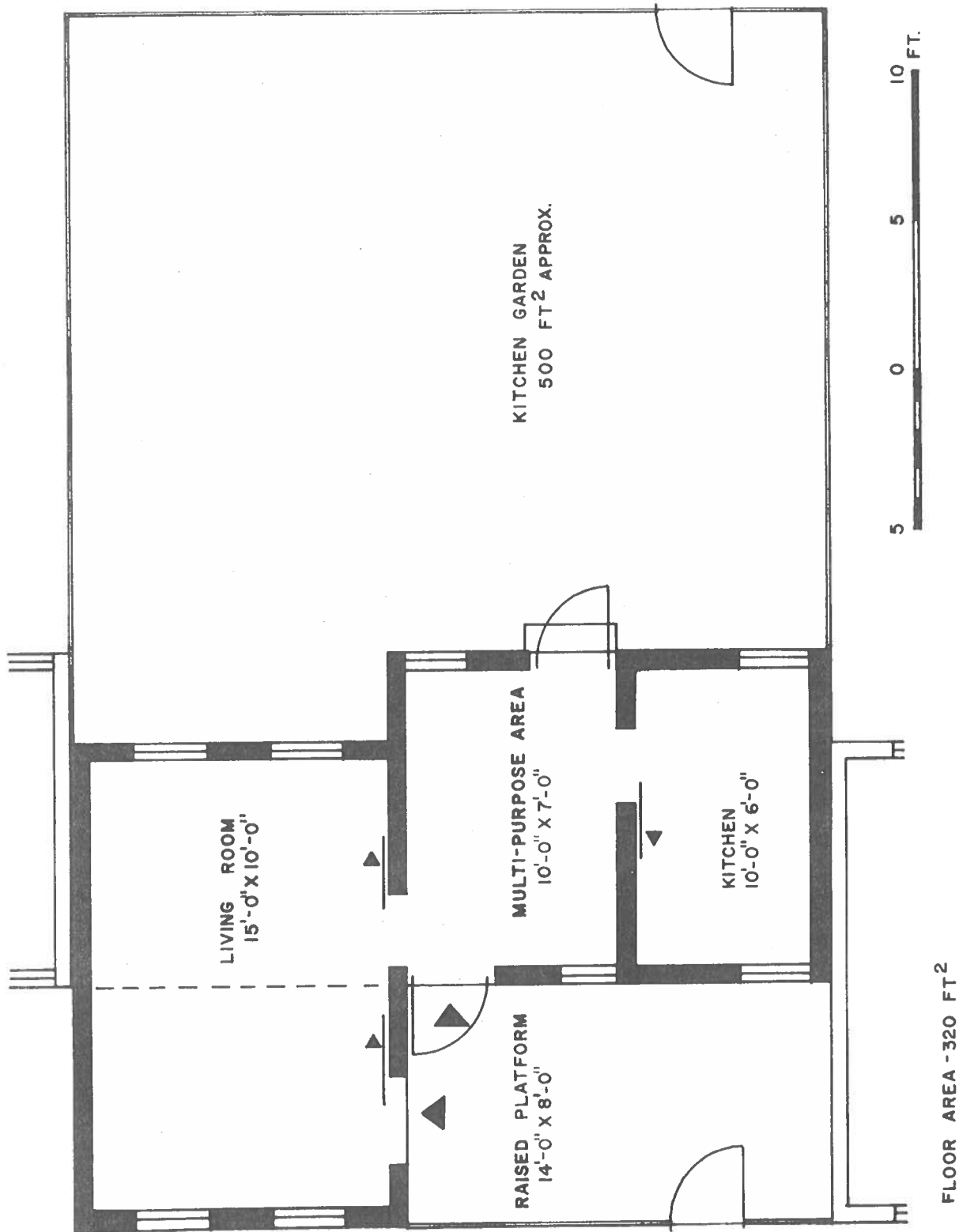
creep, which was found to be 50% greater than wood, but still readily manageable.

Arvind Garde has carried the possibilities through to a proposed design simple enough to be constructed by a family. (Figure 5). He used 1000 sq. ft. plots, very likely the most common of the 800-1200 sq. ft. sizes assumed in block and community designs elsewhere in this report. It is anticipated that perhaps a hundred man-hours of work is required to obtain satisfactory shelter. Several hundred hours would be needed later on for reinforcing and finishing the dwelling. The cost analysis Krishna Bhattacharya prepared is of interest:

(a) Flooring (tile or flexible pad of Polyurethane)	Rs. 125
(b) Walls (1440 sq. ft. @ Rs. 0.40/sq. ft.)	576
(c) Roof (340 sq. ft.)	136
(d) Glass reinforcing tape	100
(e) Surface coating (polyester resin)	375
(f) Doors and windows with metal edges	250
(g) Supervisory assistance	100
	Rs. 1,662
Expendable supplies and equipment	250
Contingency	200
Estimated Total Cost	Rs. 2,112

A comparable house built of brick with a four inch concrete slab roof was projected to cost Rs. 3750 with no allocation for assistance. Given the difference in cost and the even more remarkable difference in the effort required, it is hard to imagine many settlers choosing to build "traditionally" (this tradition is no more than forty years

FIGURE 5

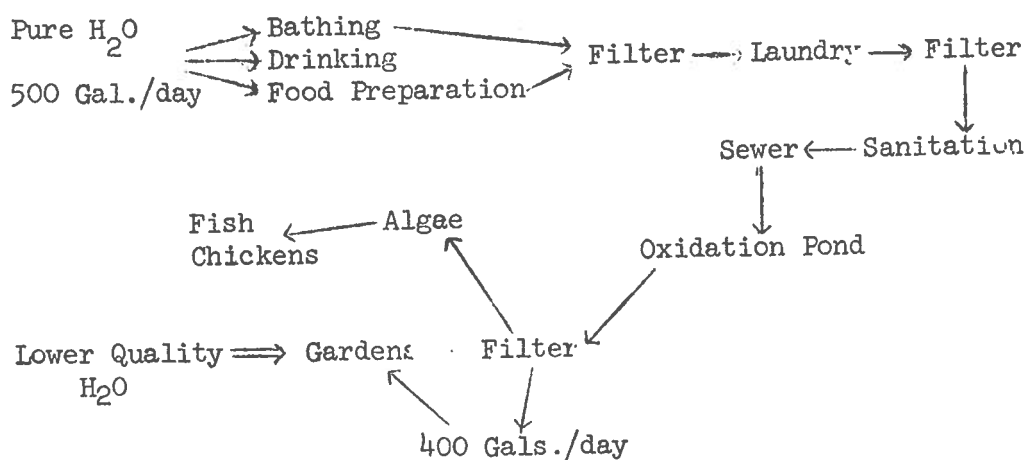


A SINGLE FAMILY DWELLING UNIT

old, but it has become thoroughly accepted). The traditional house does have the advantage that the roof can be used for sleeping in the very hot dry periods, but for Rs. 250 extra a reinforced roof could be produced for the polyurethane house. Objection was made by people living in poor countries that the foam sandwich walls could be breached too easily by thieves, but the designers in Ann Arbor pointed out that it is possible to put glass fibers in the polyester surface coating, followed by spraying the mix on the wall so that only a power saw would be able to cut through it.

Because a careful program of water conservation was planned, water was not piped to the individual houses. Residents could fill their cisterns from a nearby facility that improves upon the village "tank" and also capture runoff from the roof. Neither would they have an individual sewer connection to the house.

The water facility would be the most important unit in a central compound, no more than 30 m. away from the houses it serves. Water would be re-used several times prior to discharge with sewage. The program for water utilization and economy should work as follows:



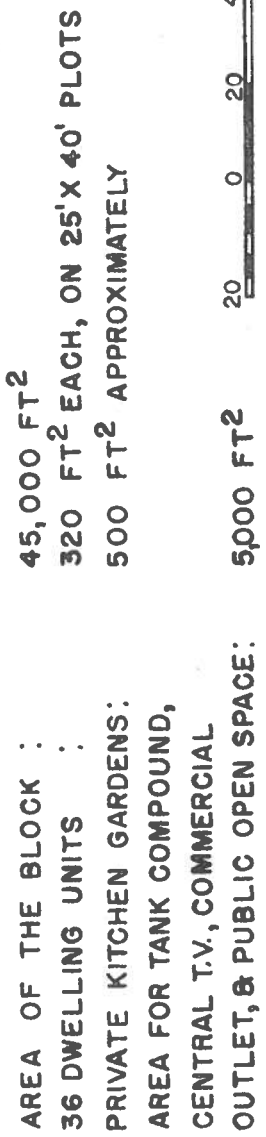
An example of a possible block of houses which combines thirty-six dwelling units into a coherent group is shown in Figure 6. A number of such arrangements can be imagined which are roughly as convenient as the one shown. It seems likely that most such combinations will have been tried already, but they must be experimented with continually as the technologies improve; therefore a considerable variety should exist in a single community.

The central facility of the block is not only the location of all water and sanitation facilities, it also introduces a welcome basis for socializing for the whole family. It is the obvious place to put the public television set (everyone brings his own mat) and it is the proper place to put a public telephone, a kiosk that sells convenience goods, and possibly a creche for infants. Due to the multi-shift character of much megalopolitan employment only about two-thirds of the families are likely to be able to attend mass meetings. Therefore the capacity when seated need not exceed a hundred persons when the need for meetings arise. The court areas adjacent are set aside for play and for circulation.

Ten of the above neighborhoods would comprise a residential sector that cluster around a sub-market or small bazaar. This size could also support an elementary school of economic size. Police would be on call at all times. Regular bus service to two rail stations would be available.

Some of the public structures would undoubtedly be assembled from traditional materials. This would establish their permanency and status. However most commercial firms would most likely opt for the most economical structures, and therefore utilize polyurethane board

FIGURE 6



SCHEME FOR A RESIDENTIAL BLOCK

or its successors, sometimes in two story structures. The advantage is that the foam sandwich structure can be disconnected from its foundation (a course of concrete blocks or five inch brick footing) and carried away by hand. A standard house is expected to weigh only 70 kg. and a two-story commercial structure no more than 150 kg. An area within the community could be redeveloped and completely rebuilt within a week without bringing in any heavy duty equipment! The structures, for the most part could be refurbished and re-used.

The outcome is a community with such astonishing flexibility that it calls for a totally new outlook. There are more decisions to be made in a community that is financed at the lowest feasible level. These decisions require more participation, more organization, a larger number of social roles, and more to learn on the part of the members. A period of extensive testing and neighborhood development is in order before a "program of instruction" can be prepared.

7. The Growth of Cosmopolitan Centers

The engine that powers the development that creates the wealth that builds the megalopolis is located in its largest centers, the metropolitan cores. Here will be found a subtle sort of social system, most difficult to describe explicitly. The corresponding portions of Tokyo, Sao Paulo, and Hong Kong, each of them a most remarkable developmental metropolis with a unique style, provides some indication of what the core should be like.

In this environment the constantly regrouping business organizations attempt to take advantage of new opportunities opening up almost anywhere in the world. Often the basis for a new project is the discovery

of some local talent or source of expertise that can be fitted to a known market, or vice versa. The efficient metropolitan core makes possible the mobilization of human resources and the discovery of the highest bidder.

Since human resources are the only kind of resource potentials India has in abundance, and thus offer its only hope for development, very careful attention must be given to the planning of the cores. Managers in them will be daily scrutinizing events scattered about in scores of places around the world, rather than primarily in a hinterland--as befits a "regional city"--so the atmosphere is of necessity cosmopolitan. This is an environment within which a foreign sojourner could fit without feeling ill at ease, and Hindus could savor some of the features of overseas life styles.

The most significant feature of the metropolitan core is its large volume of varied forms of communication. Whether printed on paper, audio-visual, face-to-face, telephoned, or on tape, the message intensity will be far greater than in the rest of the city. The design of the center hinges upon the means available for keeping these various forms of communication from interfering with each other at specific points in space and time. The human capacity to maintain a high rate of message processing, when the information must be interpreted and acted upon in some way, is provided particularly by higher education. A person must acquire knowledge before he gains the chance to have his messages transmitted over modern media.

The high value placed upon education in contemporary India, together with the increasing weight placed upon technical subjects and economics,

is a proper beginning.²² However, India appears to lack, thus far, the tradition of mobilizing this trained talent into organizations with initiative. The national form of business enterprise in India, as with Latins, Greeks, and Chinese, is familistic and slow to be public-spirited. Socialist forms of organization are public-spirited but not sufficiently entrepreneurial and often too traditional in ideology to be well managed. The tradition of responsible management seems to be found preeminently in the top grades of the civil service, but even there not universally. The leadership that can fit together these rather extraordinary potentials (i.e. for a country with such extreme poverty as is exhibited by India) has not yet moved into any positions where it can be identified.

Again the formulae for growth found by the Japanese, more in Tokyo than in Osaka, are instructive. They organized their research and development personnel (including marketing) so that the "Antenna" (persons travelling for business reasons overseas) could transmit useful prospects in detail. Foreign technology was licensed and, in the more complicated instances, consortiums were formed with international firms.²³ In the most important cases a cosmopolitan form of management evolved that created worldwide markets for labor-intensive Japanese manufactures.

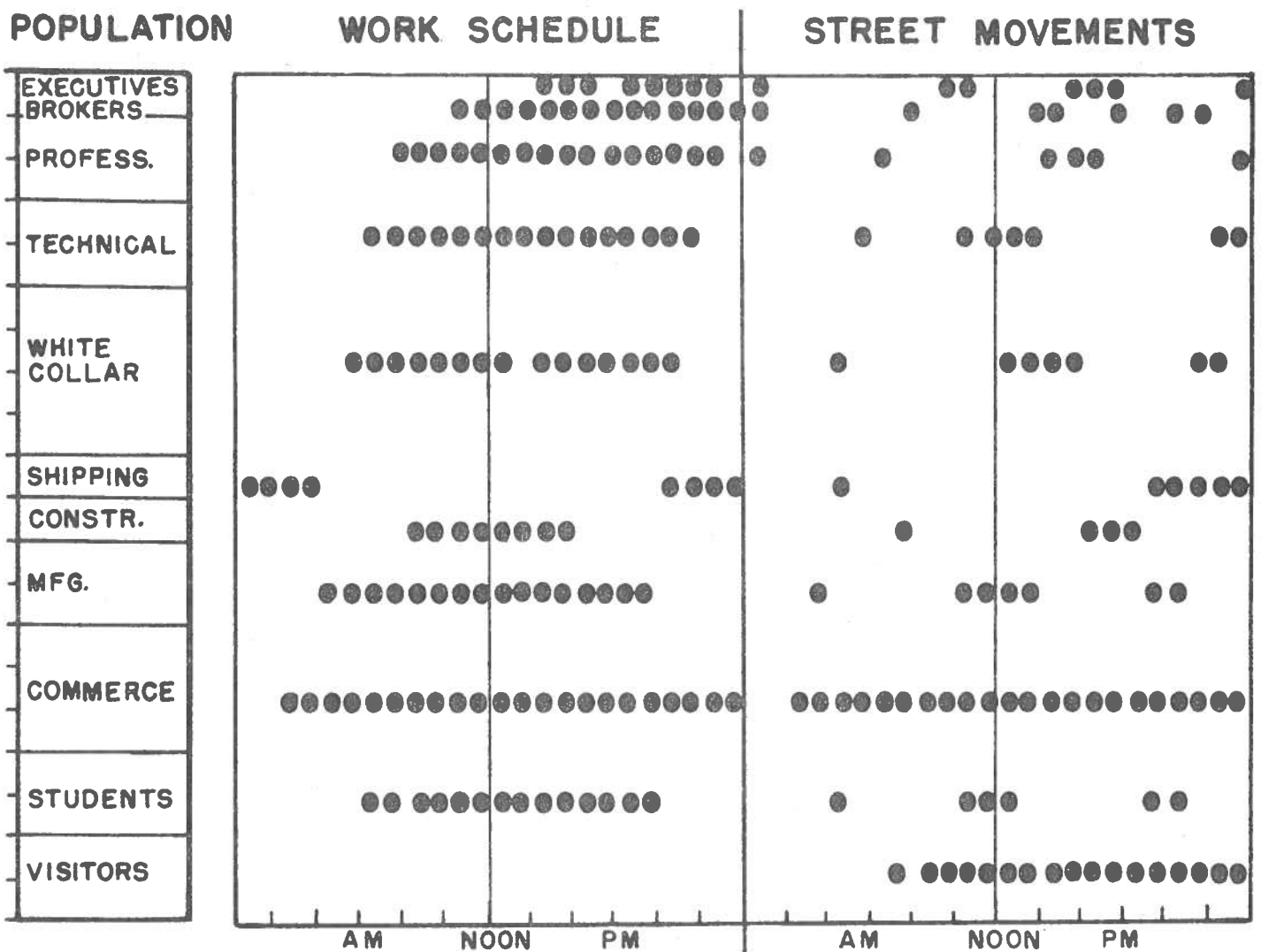
It must be assumed that India will synthesize a similar formula for identifying opportunities elsewhere in the world and for joining with the rapidly expanding complement of international firms to use Indian labor for the production of the desired goods and services. This is the only path to prosperity without the largess provided by rich natural resources.

An important element of such a formula is that the product is unpredictable. Thus, no one in or out of Hong Kong as few as a dozen years ago would have predicted the remarkable capability in plastics fabrication now coming into being there or the success of the new advanced electronics plants which are directed towards converting color television in America to solid state circuitry. Therefore, the metropolitan core must be ready for almost anything. An organization must be able to subdivide a contract, distribute sub-contracts to the urban villages or to other installations in India, assemble the components and sub-assemblies into the final product, maintain scheduling and quality control, and ship by the contracted date. It must have the ability to expand and shrink very rapidly, according to its commitments. An industry that finds a formula for success on the world market should have an opportunity to expand its manpower by a factor of five or more within a year or two without needing to change the neighborhood within which it does business. A city that allows such fluidity has a competitive advantage that is hard to beat.

One means of obtaining "quick reaction time" in a city is to build a multi-shift organization.(Fig. 7). Then the decision making reacts to what happens elsewhere in the world and gets implemented within hours. This capability will be increasingly advantageous as pattern and style of product are assigned a greater part of the overall value. The differential will become more apparent after international business adjusts to the services provided by communications satellites, with their capacities for transmitting unprecedented quantities of information. The Mach 3 level supersonic aircraft enables various kinds of sensitive relations to be negotiated on short notice.

FIGURE 7

AROUND THE CLOCK IN A MULTISHIFT METROPOLITAN CENTER



POPULATION CALIBRATED IN 5 % UNITS

Thus far executives and top managers have responded to the speedup in the pace of communication and organizational operations by working more overtime. The load has become particularly severe when the company spreads itself over several time zones. In the future, our personal forecast tells us, new means for the division of labor in this society must be found. Financial districts can no longer close up tightly at six in the evening. Stores and plazas will be bustling day and night, but the people on the streets will vary markedly, most noticeably according to social status. Decision makers in the office blocks will be on the way to work at times virtually identical with those of their counterparts in Western Europe. The 5-6 hour time differential, judging by the sun, brings them to the office later in the day, at the same time their organizations keep step with the West.

Planners are more familiar with procedures for the allocation of land to various specialized activities. Scores of plans for the reconstruction of C.B.D.'s in advanced countries have been published. However, none of them faces congestion problems approaching those encountered in a megalopolis of the magnitude concerned with here. Only the abolition of the automobile makes the problems tractable.

The core envisaged here is still only the germ of an idea. Its magnitudes check out at the slide rule level, but it requires a dynamic programming simulation to determine whether it can handle the unusual stresses caused by holidays and political events. The following characteristics seem to produce the needed adaptability.

1. Urbanized population choosing to live in the core will need to expand by about 10% per year in order to keep up with the overall growth

programmed earlier. Both residential floor space and modern work space must be added to current stocks at least that rapidly.

2. Construction times need to be reduced by at least half over those experienced in Western countries, a prospect that seems feasible in the light of multi-shift operations and the proposals for congestion control.

3. Clogging of transport can be minimized by forbidding multiple intersections. Thus an electric beltway can handle the flows from an inter-center high speed railway to the commuter lines.

4. The old city would be redeveloped on a bi-level basis, with the lowest serving warehousing and the upper carrying pedestrians, bicyclists and micro-cabs.

5. About 50,000 square feet of floor space per acre would be sufficient to provide dwellings, storage, employment, and shopping for 100,000 persons/sq. mile gross density at the minimum adequate standard of living. A mixture of some elevator buildings and mostly two to three floor structures should leave more than 50% of the pedestrian level as open space for parks and circulation.

6. A growing core could be made up of 2.25 square mile modules served by a central station, and differentiated into a number of specialized sectors (e.g. a toy manufacturer's quarter, a diamond grinding area, an ornamental gold community, an optometrist's supply center, etc.), each of them served by electric bus but providing many dwellings close to work.

7. The most rapidly growing sector should be directed toward a new module that could be converted into core if the demand were great enough

to pay the expense of conversion. The mobile portions of the specialty would move and stimulate a mix of services calculated to give it a competitive advantage. (Fig. 8).

8. The skins of buildings, the utility lines, and surface routes should all be designed for shifting about at low cost without disturbing traffic.

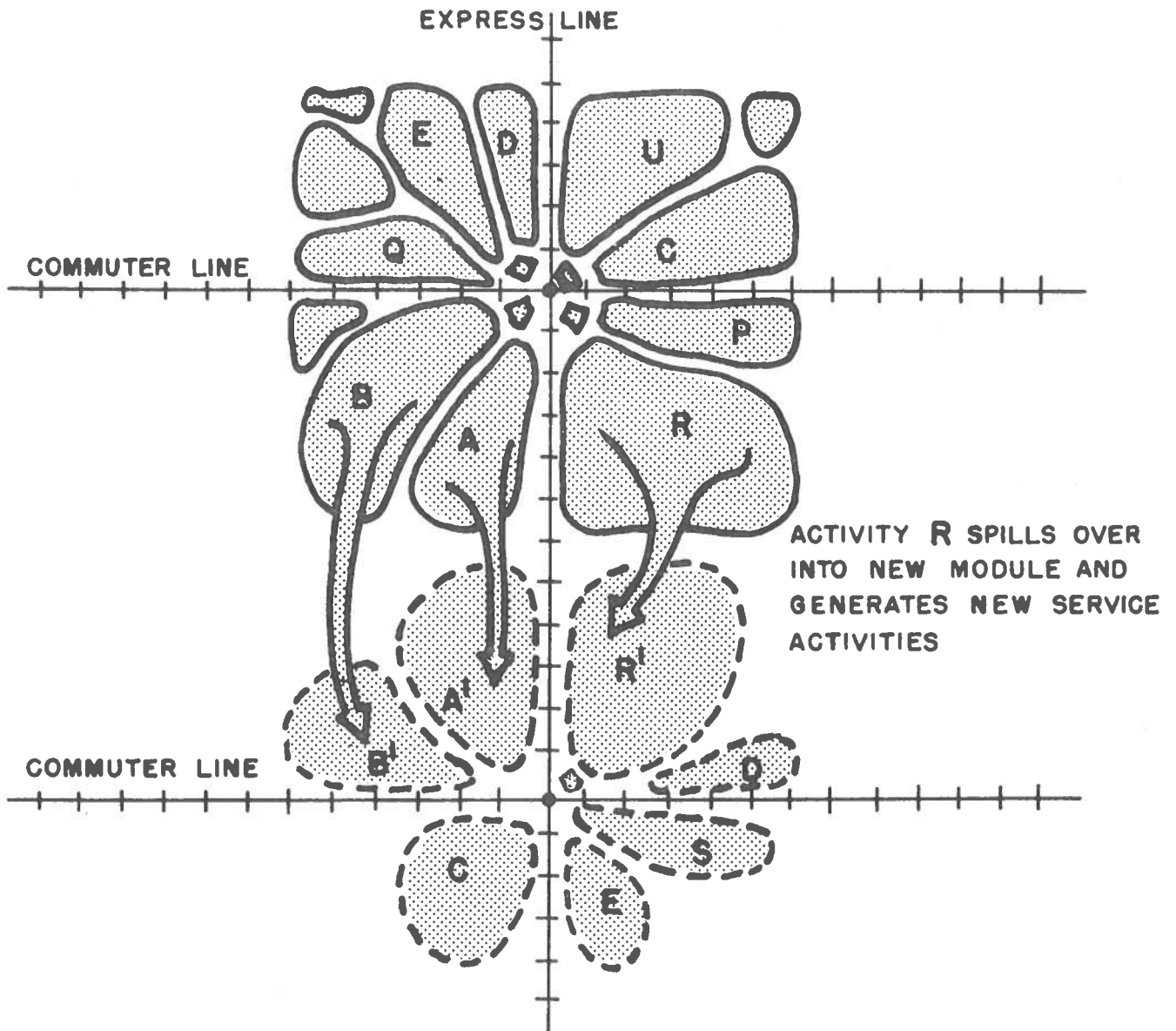
9. The utilities grids can be reduced to water, sewage, and storm sewers, electric power, and wave guide tubing (for telephone, television, and computer connections). They are readily distributed immediately below the top level and supported by the same structures.

10. Special public institutions, such as museums, libraries, gardens, and hotels should be grouped, so as to emphasize a cosmopolitan function (e.g. Chinese, Arab, mass media, medical, etc.).

None of these points highlights the most serious threat to the cosmopolitan core of a megalopolis. Even in the most puritanical societies the leadership nurses an itch for conspicuous consumption. Often it is done not for personal vainglory, but in the name of a venerated institution. Burdened with a history of maharajahs and of empire, India is especially vulnerable. Metropolitan cores are the sites most often selected because there conspicuity is maximal. All through this prescription for design the principles were to save water, energy, urban space, capital, and anything else that was scarce and substitute with communications, imagery, and personal services. Therefore, the proposals for constructing a center have not assigned the normal prerogatives of a man of importance to the chief executives; neither a car, nor a grand house, nor

FIGURE 8

AN EXPANDABLE METROPOLITAN CENTER



A, B, C, ... AREAS DEVOTED TO SPECIALIZED URBAN SERVICES

P, Q, R, ... AREAS OF NATIONAL OR INTERNATIONAL INTEREST

large scale partying have been allowed for. Uniforms, aides, bodyguards, servants, and first class transportation, and anything else purely symbolic would be reasonably conservation-oriented, not skyscrapers or Cadillacs. Grandiosity in cities and monumentalism in public works are a drain on resources and a bane upon development.

8. Evaluation of the Conservation Techniques

Resource-conserving arguments have been used at many points in the foregoing urban systems synthesis when choosing between alternative technologies. Now it is possible to stand back and appraise the total system, identifying the conservation policies that would work best.

The term "conservation" has unfortunately become respectable in affluent societies, and therefore has been attributed a number of meanings in conflict with each other. For example, the most important political connotation requires that natural environments be preserved as they are or restored to some earlier condition closer to the ideal; that is the kind of conservation one writes his Congressman about. "Multiple-use" is a management concept that is paid much lip service, but now engages in frequent skirmishes with the political sentiments. "Cost-benefit ratios" for the selection of the best resource use projects are greeted as mere rationalizations of entrenched bureaucracies. These viewpoints are not applicable in India, and should be challenged when introduced by exchange students and publications. The political content of conservation can be most pernicious, so we shall abjure it.

A developing country has dedicated itself to growth in several directions at once. Therefore, the resources that are available must be used

so as to stimulate social change, political stabilization, economic expansion, etc. These criteria almost always necessitate a major physical change in the natural environments--the direct opposite of preservation. Resource policy must be aimed at efficient exploitation (no longer a respectable word), enabling the system as a whole to rise to a higher level of function where extra capabilities allow it to tap other resources not previously accessible.

These issues arose quite clearly in water conservation, where it seemed likely that mountainside thickets and narrow valleys in the Ghats would need to be transformed into grasslands and covered reservoirs to supply Vizagmahanager. Water scarcities are expected to be the strongest single force pressing rural India into the migration routes to the cities. The crises come in the exceptional years when mean rainfall data becomes irrelevant. Then the success of an urbanization policy rests very heavily upon the water economy it has been able to install.

Water conservation begins at the urban village. There it was proposed that the water facilities would be centralized into block-serving units. They can then be watched and tended as a public function. In times of adequate supply this attention means only that sanitation is held to a respectable standard and the equipment is kept in repair. Individual households might draw upon their own cistern for many uses, but when the monsoon fails they become completely dependent upon the public supply. Each block is assigned at least one parttime attendant, and he should be supervised by a water controller. At \$1.00 per thousand gallons (25¢/ton), consumption in a block (150 persons) results in a collective bill of \$100 per month.

Water re-use is determined by what is done with the effluent from the oxidation pond where wastes are to be treated. Under normal conditions the flow, including some rain water, would average 600,000-700,000 gallons/day, or less than 20% of the flow from a similar population in the U.S. Sewage in India is expected to be three times as concentrated. The ideal design uses three ponds, the first being fairly deep (ten feet) and anaerobic, so that it may smell slightly, the second is about a third that depth and aerobic, with the sludge from it being pumped back to the first, and the third, still shallower, produces a dense culture of algae with maximum efficiency in the fixing of sunlight.²⁴ The optimum size, together with fishpond, would run 10-20A. A poultry battery would be operated adjacent to this facility. About one pound of fish, varied with chicken or eggs, could be produced per household per day from the algal!

This is an operation that is almost totally automatic in the United States but enough is being learned about the microbiological processes to suggest that a labor-intensive approach, partly because it can play an intelligent game against the weather, could increase productivity per unit area significantly, as well as reduce first cost. (The \$1,000,000 for a 26A concrete facility in Concord, California, might be reduced to a \$300,000 formed earth and plastic design in India.) The yield of edible food is extraordinarily high (at least 4 tons dry weight per acre-foot of water lost to evaporation), so this plant would be maintained at full capacity during a drought. The normal output of water suited for gardening would be 600-700 acre-feet/year, enough perhaps for 100-150A.

The majority of the area allocated to gardening would require extra irrigation-quality water, ordinarily about 1000 acre-feet. The source is importation from a reservoir further up the watershed or, in an extreme emergency, pumped up from the shoreline.

Hydroponic gardens offer the closest control of evaporation. They have become commercial only in the past half decade, the earlier well-publicized ventures foundering upon the same shoals that stop most new agricultural enterprises--marketing problems, plant diseases, insufficient capital, and unsuitable plant breeds. California's first commercial plant opened up in 1966 in Fremont, adjacent to the Weibel Winery. The technical development that enabled various small firms to break into the market (mainly for out-of-season demand) at this time is an economical sterilization of the gravel to prevent spread of plant viruses.

For India a less highly capitalized design would be desired. The following description summarizes present expectations regarding an economic approach: Thirty foot troughs are formed in the earth (two feet wide and a little less deep, V-shaped bottom) and lined with polypropylene film. They are filled with washed, crushed rock, centimeter size. Most crops are transplanted from seed beds similar in design, but shallower and using sand. Fertilizer solution is delivered each time the wilting of the leaves indicates that it would be useful (two to five times per day). Plants are supported by twine and overhead frames. Partial shade from the midday sun is often necessary. Humidity is controlled to remain at 70-80% around the plants. When the harvest is past the peak, the plants are pulled out, the gravel sterilized, and new plants set so that the next crop can be growing in the morning. From four to

ten crops per year can be grown in this fashion, and a yield of 100 tons of vegetables per acre per year should be routine. One acre provides three to six full-time jobs, once the "best practice" procedures have been established. If wages were paid at the rate of Rs. 2 per hour, and capital earns a return of 10% per year, vegetables and fruits could be produced at 3-10¢ per pound. Even potatoes will sell well at those prices!

When water is expensive growers will turn to crops that have low transpiration rates per unit of photosynthesis. Most root crops do well under these circumstances.

The inhabitants of the metropolitan centers must be good customers of the urban villages, but much more of their food will be processed and preserved. Algae ponds at the rate of 1-2 A per 1000 persons can provide most of the protein sources, from ice cream to fish paste. Rice, flour, and sugar, plus condiments of all kinds, would be brought in from the agricultural regions.

In the centers energy conservation becomes the chief criterion of design. It is very closely intertwined with the conservation of human time and economizing upon capital investment. The principal saving was made in the area of transport by banishing the internal combustion engine to the hinterland of the megalopolis. Electricity delivers power to exactly the point where it is needed. The heating up effect in the urban center is greatly reduced as compared to existing cities, if the waste heat of power generation is kept to the shoreline. In the city itself comfort is provided primarily by fans and by airscoops incorporated in the buildings. Air conditioning would be restricted to sites

which are otherwise limited in their possibilities for exchanging the air, or to facilities where extremely precise work needs to be done. The use of long avenues in line with the winds prevailing at the time of highest humidity appears to be imperative. Paying attention to comfort does not seem to help directly in making a city more energetic and developmental, but it does make it possible to bring people from the rest of the world to collaborate with residents, which can be extremely productive over the long run in generating new sources of income. Also, there are fewer days in the year when irritation with the heat causes a flurry of errors within organizations that could have expensive repercussions.

One aspect of energy conservation that has not been appraised is the effect widespread use of the plastic foam sandwich board has in the area of manufacturing. This is an industry to be carried on in an industrial estate adjacent to a metropolitan center, probably that of Vishakhapatnam itself. The dimensions of the operation are instructive:

Demand:	800,000 dwelling units/yr. by 2000 A.D.
	3,000,000 " " " " 2030
Capacity Required:	60,000,000 lbs/yr. resin by 2000 A.D.
(For Construction Industry):	300,000,000 " " " " 2030
Materials Produced:	Polyurethane, polyesters, acrylonitrile-butadiene-styrene (ABS), epoxy, polyvinyl, polypropylene
Raw Materials:	Petrochemicals = propylene, styrene, butadiene, toluene, phthalic anhydride, acetylene
	Heavy Chemicals = nitric acid, chlorine, sulfuric acid, hydrochloric acid
	Natural products = drying oils, sugar

Value in resin form:	15-50¢/lb, average about 25¢/lb. \$15,000,000/yr. in 2000 A.D. \$75,000,000/yr. in 2030
Capital Investment:	\$30,000,000 in 2000 A.D. 110,000,000 in 2030
Jobs in Manufacturing:	About 1000 at the first date 3000 by 2030 A.D.
Transport Needs:	About 1% of competitive products
Area Requirements:	Mfg. 300 - 1000 A Storage 100 - 500 A About 5-10% of competitive products

The great significance of such economizing in the shell of the dwelling is that the hills need not be denuded to supply the demand for poles. The number of carloadings of building materials is reduced to a triviality, as is coastal barging. Cement and lime remain modest industries, and their demand for coal forestalled. The quarries, kilns, and yards, always eyesores and dust producers, are left out of the allocations of scarce urban space. The amount of material needed for a megalopolis of 100,000,000 people with the new technology is no greater than the mass now employed for a metropolis of 5-10,000,000 persons. And the capital cost for plant and equipment for the production of resin is no more than that required for a middle-sized steel mill. However, capital savings elsewhere are so great, they should pay for the resin production plants several times.

It is not worthwhile at this stage to attempt detailed assessments of capital requirements for a megalopolis like Vizagnahanagar. They can only be undertaken in India. But even in India they will be faulty because the design as presented is already known to be obsolete in part. Still more economical solutions are in the making as a

consequence of developments in marine technology, but their impact upon Indian cities is still extraordinarily difficult to judge. In any case that rapidly accumulating body of knowledge is applicable at an earlier date to other, more crowded, areas than India. Besides, the Chinese culture is faced with a still more difficult future than that of India, since it presses closer to the resource limits for sustaining human life and is more subject to variations in weather. It must be expected then, that sometime around the year 2000 A.D., following a lead set by Japanese and Chinese, a part of Vizagmahanagar will establish itself in the Bay of Bengal, and the aquatic immigrants, primarily fishermen and marine workers, would flock to it. However, the seashore area could also become a recreation area for the educated classes, a respite from the throngs in the metropolitan centers.

At this point we shift to a consideration of what another great civilization can do for urban life at an adequate standard of living within the constraints set by the supply of natural resources.

III. MARINE SURFACES: A NEW URBAN MEDIUM

9. Overspill on the Sea

One of the universal laws of planning states: As income rises, people insist upon buying more physical space. Some of the added income will be spent upon tripmaking and public entertainments, which need the space to "decongest", but quite a bit more will often go into extra living space. One important reason is that, once artifacts have been purchased with increased income, more room is needed in the home.

Space is seldom a commodity in its own right--it is usually introduced into a schedule of expenditures as a rent charge in an overhead item. The effective demand for space, combined public and private, is quite inelastic for the very poor; the index of elasticity shifts to a region around unity for those who are poor only in a relative sense, while for incomes above adequacy elasticity may move in any direction, depending upon the life style preferred. Such nonlinearities pose complex problems for those city planners forced to use statutes, rather than the market, to allocate space. Whatever space standards are set, important components of the population will be displeased.

A developmental metropolis--one that creates new wealth at a rate that increases 10% per year or more--finds itself in a peculiarly difficult situation as a consequence. The demand for extra urban space may increase from 5-15% per year, depending mostly upon the size and character of the attendant population growth. People living in the city can only get the space they want by rebuilding skyward or by going out to the fringe. In each instance the functions of many neighborhoods will change swiftly,

so that buildings that remain solid and presentable are made obsolete in scale and design within seven to fifteen years. Compare this with the useful life of the structure, say forty to eighty years! Almost every occasion for the redevelopment of an urban neighborhood turns out to be slow and time-consuming, so the pressure to move out is enhanced further. Out in the suburbs land comes in the most convenient-sized parcels. The principal trade-off takes the form of time spent commuting from point to point.

The quick, brief explanation for overspill recounted here hinges upon the development pace that is maintained. The limited supply of dwelling space in the inner city is repeatedly trimmed back in favor of roads and public institutions (mainly schools and hospitals), all of which need greater capacity. Extra private living space is bought up by those who can now afford it. Thus, despite a new crop of high rise structures, an important fraction of the population (almost equal, perhaps, to the rate of income growth) is squeezed out. Out of these pressures for space the schemes for suburban tracts and new towns are spawned.

How much urban space is equivalent (i.e., in equilibrium with) to living at subsistence? In ancient and medieval cities the ordinary people were impelled to live as close together as was humanly possible because bands of brigands or pirates forced them to huddle within the walls. The average floor space available was 30-40 square feet per person. In modern Asiatic cities that exchange population freely with the countryside the new housing for the poor settles down to the same densities, regardless of the original standards for the allocation of living space to families. Children and aged dependents are traded around until a

"packing ratio" of eight cubic meters of enclosed space is reached as a bottom limit for a population average. Being realists, the authorities in Hong Kong have decided to proceed with 36 square feet of floor space per capita as the standard for low income public housing.

Hong Kong is a developmental metropolis conforming to the specifications stated above. A third or more of its population has been raised significantly above subsistence already and many more are expected to follow. The next threshold is that of adequacy. How much space is required for full participation in urban society? In Science and Economic Development it is stated that 60 square feet of well-organized space is sufficient; if subsistence level apartments are redone, probably two would be required for the adequacy standards. Therefore, if Hong Kong continues to find ways to prosper it must expect to decant half of its population into outlying settlements.

Hong Kong faces prodigious urban physical development problems. Water supply is a major constraint, since it must be imported in large part from Communist China. Sea water distribution systems are already used for the disposition of wastes. Steep slopes make construction excessively costly. The island-peninsula conformation of the coastline adjacent to Hong Kong causes strong tidal variations and roundabout road building, so that transport charges must be high. It does not seem at all likely that the city can meet the demand by proceeding with traditional approaches. Thus it is logical that Hong Kong be among the first of the metropolises of the world to explore the settlement of the seas.

The shores of Hong Kong are already world renowned for the size of the population living afloat. The sampan colony has been a response to

urban overcrowding that has existed for a long time in Cantonese China. Accumulation of pollution would normally halt such settlements elsewhere in the world, but the great tidal variations experienced daily in these bays carry the wastes out to sea, diluting them to tolerable levels in the process.

Residents of the present "floating villages" are ethnically distinct, 90% are estimated to be Tanka and the remainder Haklo. No other regional Chinese groupings or ethnic minorities represented in Hong Kong have felt that residence on the water was acceptable. All verbal reports received from residents of Hong Kong agree that even a modernized sampan would not be regarded as attractive by any rent-paying element of the population.

Economic and cultural feasibility dictates therefore that any use of marine surfaces that is planned must (a) cater to a middle class whose earnings definitely put them into the market for private living space, and (b) borrow a modern leisure-oriented technology from Japan and the United States that appeals to educated adults. The search for housing types, then, is to be conducted among non-Chinese sources, but adaptations must be made to the sizable middle income market, presently at the \$2000-3500 annual earnings level. If this stratum can be dispersed into marine developments, the remainder of the population should be able to profit somewhat from the "trickle down" effect in the housing market. Population pressures would be relieved.

What are the best possibilities open to the middle income, educated class at present? Apartments have been going up adjacent to the urban core with kitchen, bedroom, living room compressed into about 200 square feet of living space. The average resident family size is 3.5 persons.

Rents run \$ HK 200-350 per month--the higher levels include a balcony as an extra.

These urban Chinese are clubby people. The tong of the surname is still a most important basis for getting together. Trade associations and professional groups are strong. The tea party becomes the vehicle for Ma Jong games. Eating out is a social occasion that often facilitates the transaction of business. They have learned to live according to English law and the Gregorian calendar, and are treated by Western medicine, but have retained Chinese family-oriented gregariousness. A balance between Confucius and Calvin has been contrived, aided by an injection of Epicurus.²⁵

One important political relationship cannot be ignored. The lease on the territory runs out in 1997. As that date approaches there is increasing reluctance to invest in real estate except under conditions of very quick returns on capital. Much of the wealth must be kept in the form of gold so that it can be transported quickly. If some financier can show that floating assets can be as transportable as gold, he might start a boom in floating residences, not dissimilar to many other booms Hong Kong has experienced over the past two decades.

Accessibility to the present centers of commerce is likely to be a governing factor in the location of new middle income floating settlements. Freedom from the direct force of the easterly gales and the surface swells created by them will be essential. Although Hong Kong's weather is usually good, typhoons may develop in the May-November season. Their severity suggests that the residential aquatic areas need the natural protection of the hills and in many instances also will require the

construction of breakwaters. Tides are variable around Hong Kong, but in general houseboats and barges would need to be in ten feet of water or more to avoid being stranded on some occasions in wet mud or on jutting rocks. The sites obtained from a scrutiny of maps, climatological and tidal information are:

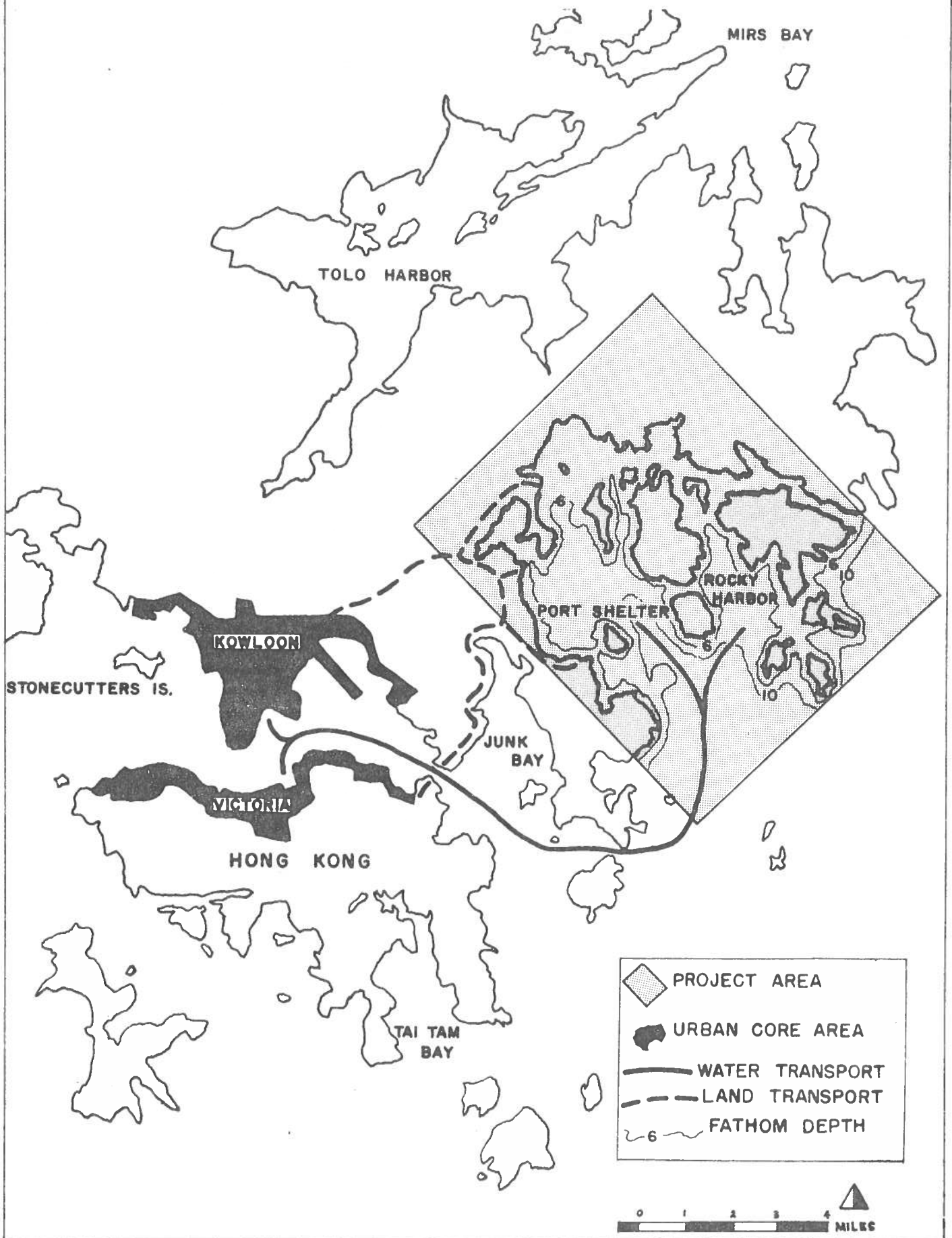
	<u>Distance from Victoria Harbour</u>	<u>Probable Area</u>
Aberdeen Harbour	6-8 miles	0.5 sq. mi.
Deep Bay	31-37	20.0
Deep Water Bay	10-11	1.0
Junk Bay	4-7*	4.0
Lamma Island (Sukka Wan)	6-7	1.0
Lantau Island (Cheung Chau)	10-11	1.5
Lantau Island (Tung Chung Wan)	16-17	2.0
Port Shelter-Rocky Harbour	8-15*	11.0
Stanley Bay	12-15	2.0
Stonecutter's Island	2	0.3
Tai Tam Bay	11-16	5.0
Tolo Harbour	8-14*	9.5
Tsuen Wan	6-7*	2.5

* amphibious route

total about 60 sq. mi.

We chose to look into Port Shelter-Rocky Harbor possibility in more depth than the others because it provided a scale of operations as large as any that could be easily conceived in the Hong Kong area and could well be among the first to be undertaken (see map, Hong Kong Shoreline Development-A). It was assumed that the first neighborhood scale

HONG KONG SHORELINE DEVELOPMENT - A

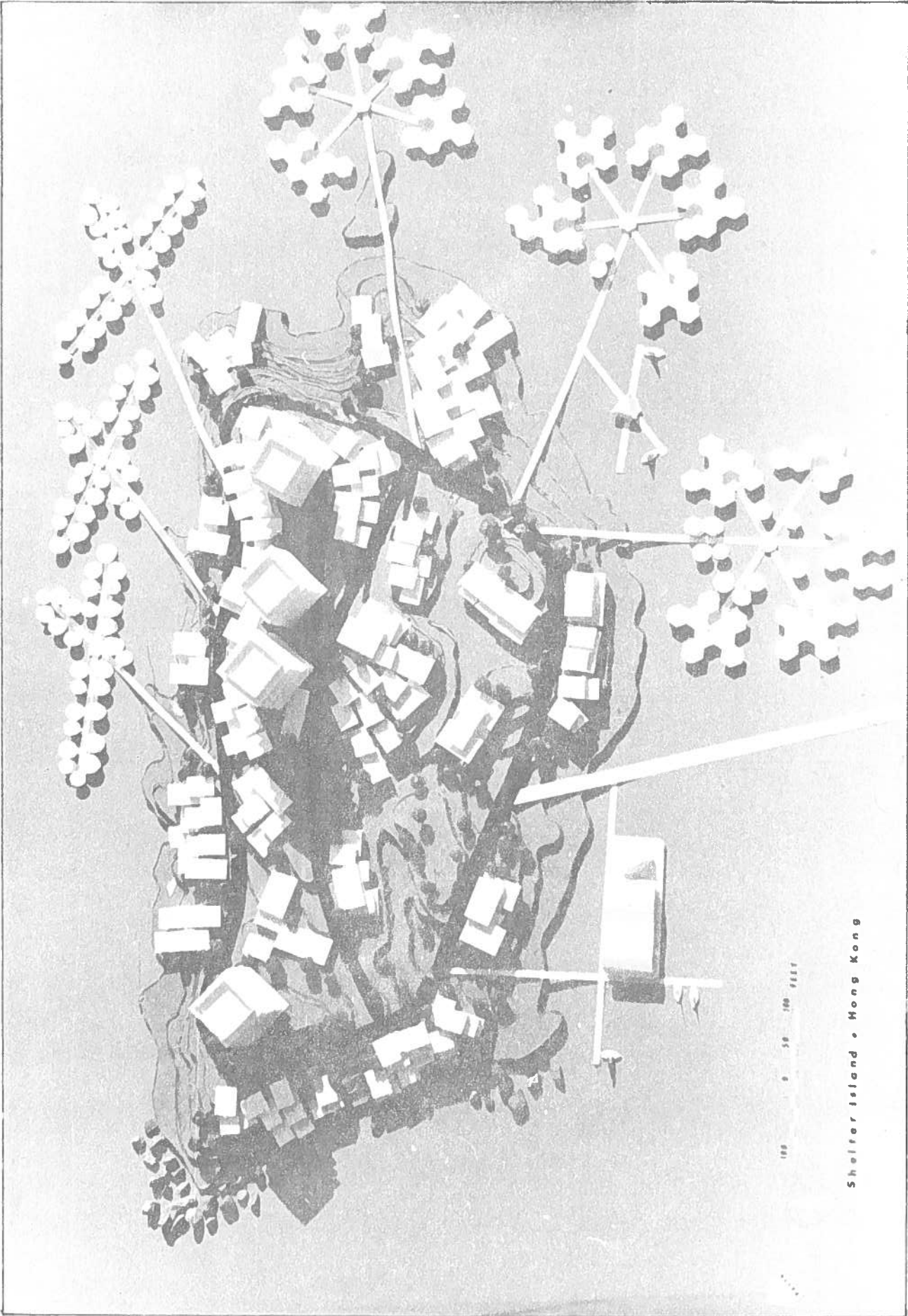


settlements might be undertaken in the harbor of Stonecutter's Island and in Aberdeen Harbour; perhaps Junk Bay may be released from ship-breaking by then. Full satellite communities probably could be constructed first in the 3700 acres of Port Shelter Harbor. Later extensions could be made into Inner Port Shelter, 1200 A., and Rocky Harbour, 2100A.

The questions regarding ownership rights to the marine surface within the three mile limit are not raised here. It has been assumed that this will have to be settled by the Crown in this colony, but that access to the marine acres will be dominated by possession of the shoreline properties. Only an integrated development, achievable by cooperation between the civil authorities and local entrepreneurs, would be profitable. A speculative, somewhat romantic possibility based upon the existing shoreline and low density use was modeled by Yan-ho Tse for his B. Arch. thesis (Fig. 9). The contours do not show up in proper proportion in the photograph.

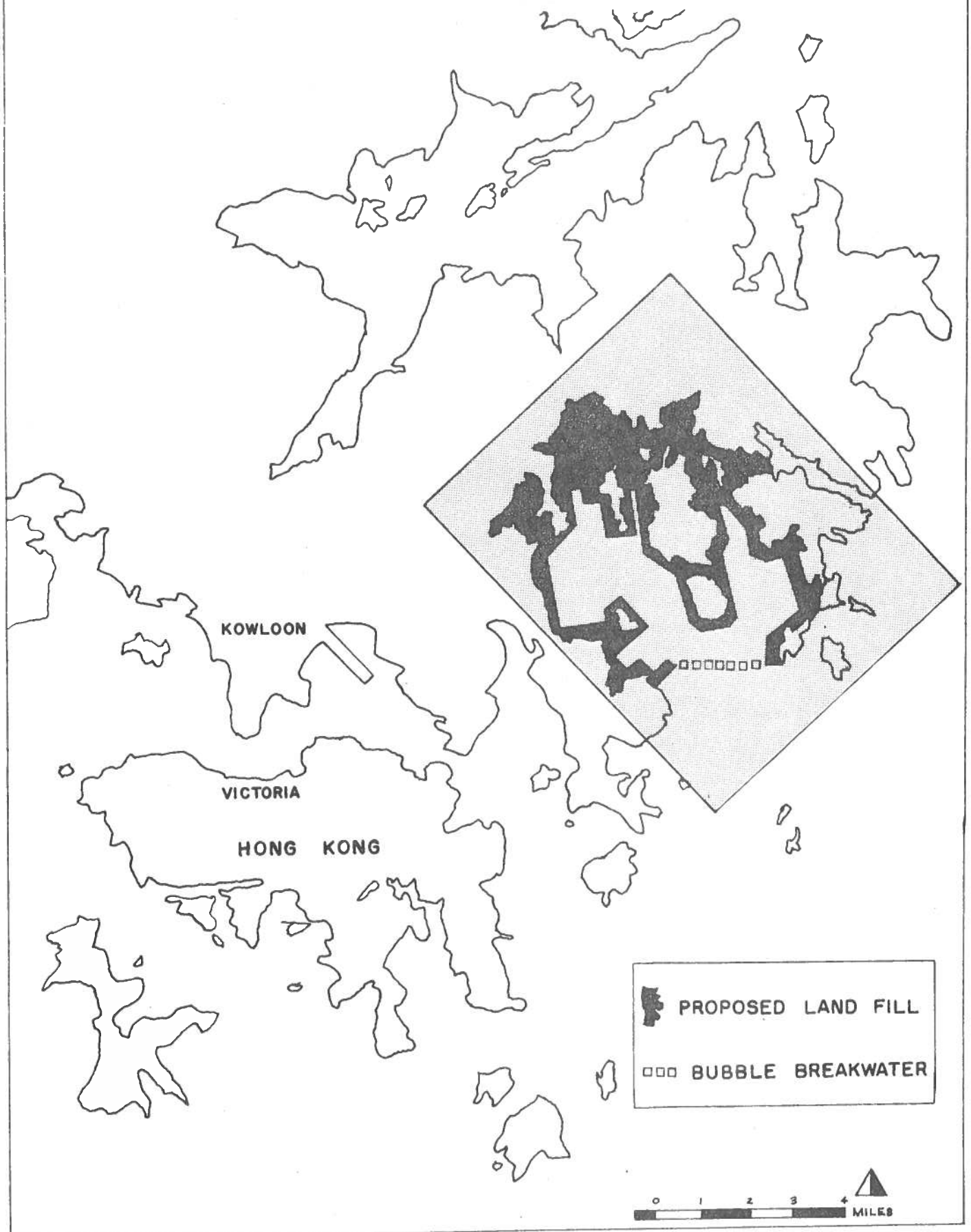
A more thorough analysis of the potentialities of the site was produced by Alvin Bonnet (see map, Hong Kong Shoreline Development-B). He assumes that large scale earthmoving schemes, more advanced than those used for the airport at Kowloon, will fill in the shallower portions of the bays. This reclaimed land would be used for housing and industry. The urban uses of that land, and the services it could render, would greatly enhance the value of the water surface. It therefore pays to consider carefully how to use the surface intensively. Only then, for example, might it be worthwhile creating a "bubble breakwater" which expends tens of thousands of horsepower in rough weather reducing the force of the waves. A storm usually causes a reduction in the

FIGURE 9



SUBURBAN DEVELOPMENT OF SHORELINE AREAS

HONG KONG SHORELINE DEVELOPMENT-B



industrial use of power, so the breakwater would only have to pay extra fuel costs, perhaps about a third of the normal industrial price for electrical energy.

10. Suburban Development of Marine Surfaces

One of the first considerations in planning residential use of aquatic surfaces is that of density of settlement. How far apart should the respective units be? By what rules should they be spaced? None of the procedures for subdividing land is likely to be appropriate because water possesses strikingly different accessibility characteristics. Thus any determination is required to start with fundamental principles. Reasonable approaches to the allocation of surface for moored static vessels of minimum dimensions corresponding to the single family dwelling can then be deduced. Larger tracts may be regarded as multiples of some basic plot dimensions.

At present the sampans of Hong Kong are arrayed in a protected channel side by side. Some are tied up to quays, docks, and breakwaters. We must assume that these traditional vessels will have accumulated to the point that all sufficiently protected havens have been filled to overflowing. This means that only the less protected, but more scenic, bays and small harbors remain open to settlement. For such areas more seaworthy craft are needed, because the most hazardous phenomena are the typhoons blowing mainly from the south and east. The principal nomination for an "unsinkable" design for the hull of a houseboat are a discus shape (a slice off a spheroid) and a torus. The proposals are based upon theory, but they have been tested as models in ripple tanks and in full

scale prototypes.²⁶ Vessel size should be small, however, as compared to the separation between waves during a swell, otherwise the craft could sustain severe stresses. Protection from weather is expected to remain important; during a bad year in Hong Kong as much as 5-10 days of residence afloat may need to be foregone. People could assemble in public buildings as long as the storm was severe since the warnings can come in time for evacuation in the future with weather satellites aloft.²⁷

In the Buoy Technology Supplement (1964) the hull dimensions tested were diameters of 20 and 40 feet. If a dwelling unit were to be attached directly over the discus or torus, even the "hole in the doughnut" being decked over, it is possible to estimate the amount of living space provided. Allowing the full $6m^2$ per capita for the MASL (cf. Meier, Science and Economic Development) the hull sizes can be calculated:

<u>Persons in Household</u>	<u>Hull Diameter*</u>
4	6.8m
5	7.4
6	8.0
7	8.5
8	9.0

*Assumes 60 cm. exterior deck on each side of a cylindrical or domed cabin.

Such calculations show that the standard berth (equivalent to the standard lot in a plotted subdivision) should accept nine meter circular outline hulls. Outsize hulls can be installed, but only when adjacent to craft correspondingly smaller than the nine meter standard. This measure is handy in English units, being 30 feet for practical purposes. The standard rectangular outline houseboat for eight persons would

measure 9 x 6 m. If it occupied a 9 x 9 berth a third of the area could be reserved for private small boats.

Utilities supply and transport modes also determine the spacing of urban structures. Cost functions associated with the respective technologies of distribution are sensitive to the separations between dwellings. Similarly the means by which leasehold rights are obtained, the mode of financing, and the structure of the real estate market will influence settlement patterns. Before a definite proposal can be put together some reasonable assumptions on each of these points needs to be stated.

Electricity. Metropolitan power grids can be used to supply shoreline developments and the offshore clusters. Delivered cost to grouped houseboats should not exceed 5¢/kwh over the long run. Boats in deeper water may not use electricity; the best substitute being bottled propane.

Apartment complexes in very deep water would most likely find a propane-feed fuel cell most advantageous. Units of 100-200 kw ought to be available in another decade that produce electric power in small quantities at competitive costs. Light industry of many types could be sustained but islands offer a more stable base.

Fresh Water. Since sea water can be used for many purposes, the amount of fresh water used will be much less than on land. Let us allow about 20 liters per day per capita--two large pails full. Light industry will often require quite a bit more. A tug pulling a dracone, a plastic tube, could deliver water regularly and take away waste at the same time. The water can be obtained from small reservoirs that catch run-off which would otherwise be lost to the sea. Close to shore fresh water may be collected at a public fountain and carried by hand.

Cooking Fuel. Liquid fuels are even more economical at sea than on land because they are readily transported and stored. They are virtually required for surface transportation, so they will always be in stock close at hand. Of course, wherever electricity is available, hot plates would probably be preferred. Deliveries could be made by tender or when purchasing food.

Waste Disposal. The human waste, including food preparation losses and spoilage, should not be dumped into the bay but collected by tender. It would be removed to a location where an oxidation pond was in operation, where the wastes would be ground up and digested by bacteria followed by algae formation. The algal crop would make excellent carp food. (The carp would be sold back to the settlers at premium prices.) Surface litter would have to be removed by anaquatic version of street cleaners; they would use nets instead of brooms.

Telephone. Many homes may well dispense with the private telephone. This income level finds a pay telephone at a kiosk a sufficient convenience. However, at least one out of ten households is likely to contain a worker who is "on call" for emergency service. Radio telephones are already available at reasonable cost, but are subject to jamming by solar eruptions and interference by stray radiation. In the long run it seems quite possible that a laser beam may become most economical. Standard maritime signals, using lights, flags, and gestures offer partial substitutes.

Television. By the latter part of the next decade it is expected that receivers will be 100% solid state components. This means that power requirements will be trivial (a small battery should last weeks

or months), but that antenna are important. Signals tend to be reflected by the waves and cause interference that must be screened out by the shape of the antenna. It is possible that this equipment may be merged with the demand for radio.

The simplest and best means of accommodating houseboats is to construct a marina with service piers and berths. Normally several small, local breakwaters would be built to extend minor promontories and add protection to the inshore sites. The channels need to be maintained so that light vessels may go regularly out to sea, but the proportion of the total navigating any given day remains small. Thus houseboats will be mixed with some seagoing craft, the opportunity to go to sea being one of the principal attractions of houseboat living. The rectangular houseboat, floated on catamarans or bamboo, will occupy the most protected berths, while those with discus and torus hulls will take up more exposed locations, and barges of various designs might be found almost anywhere.

The most serious problem is that of cost of construction of shoreline facilities. It cannot readily be estimated at a distance. We should not consider any development that costs more per dwelling unit for piers, service lines, dock facilities, and shoreline road than would have been spent in an outlying suburb (say 30-50% of the cost of the dwelling unit). Thus many marina-type proposals may fail due to the physical limitations of the site. This is a situation with which Hong Kong, Tokyo, and most other port cities are already familiar. The alternative to a floating community is the development of steep-slope land or the reclamation of tideland.

Maintenance problems are extremely serious at sea. The breakwaters and the piers will have an unpredictable effect upon tidal currents. Sandy portions of the beaches may be shifted about, and silt often accumulates inside the marina. Dense patches of weeds may grow up from the silt, particularly if nitrogenous and phosphatic wastes are incompletely collected. The weeds hinder navigation and reduce opportunities for recreation. Fortunately, maintenance costs on hulls of houseboats can be reduced to a low level using the new plastic materials, so that the accumulation of barnacles and bottom growth should be trivial.

Piers are often limited in length by advancing depth of water. Otherwise, however, a distance of 400 m. will normally require 8-10 minutes to walk; it represents a practical limit for the separation from public transport for the social classes producing income equal to or greater than the minimum adequate standard of living. Piers that are 500-600 m. in length need to be equipped with a platform near the end that contains convenience shopping, fish markets and perhaps even an elementary school. (We are told that Hong Kong already has three clinics on houseboats at "floating village" sites.) Thus the effect of landbound services upon the pattern of settlement becomes negligible about a third of a mile beyond the beach. In that strip the settlers are likely to be amphibious. Outside of this zone the modes of movement are fully aquatic.

The channels between such piers must allow for a multiplicity of movements occurring relatively independent of each other. Service tenders may need to make trips once or twice a week to all houseboats and commercial units. Visits may account for several trips by water each week per dwelling unit. Houseboats may change berths with about

the same frequency that people change apartments, say once every two to three years. A liberal allowance for the channel would be 15 m. The net density then becomes 50 units per hectare (about twenty per acre). If all the berths were to be filled the population density would approach that of the newest high density public housing in places other than Hong Kong and Singapore.

In deeper water, and at a distance from shore, houseboats are likely to cluster. The focus will be some kind of floating platform similar to those patented for oil well drilling under those conditions but with relaxed specifications for drift due to wind and currents. Utilities can be brought up in a cable from a trench in the bay to this platform. Houseboats would be tied to the platform in a manner similar to a pier. Utilities connections will therefore differ very little from arrangements that have evolved in mobile home courts except that sewage and organic wastes would not be transmitted.

The cheapest platform appears to be a torus about the same diameter as the houseboats themselves--9 meters. The various lattices are evaluated as follows as supplied by straight line trenches:

	<u>Gross Area/du.</u>	<u>Length of Trench/du.</u>	<u>Area of Platform/du.</u>
Triplets	280 sq. m.	10.5 m.	1.05 sq. m.
Quadruplets	197	5.6	3.1
Sextets	144	6.0	11.0
Octets	220	5.8	21.0

The cost of platform area is cheap, and may be viewed as a minor addition to living space, while length of trench could be expensive. Thus the sextet grouping produces more units at a given accessibility to share costs for the trench (where unit costs are on a plateau) and has more than minimum platform space.

The cluster of six consumes a hexagon of surface about 18 m. on a side. These hexagons can be fitted together by an underwater framework that depends upon utilities trenches about 25-26 m. separation. Five or six parallel trenches yield a very interesting supercluster containing perhaps 300 dwelling units, each of which is readily serviced by tender boat without disturbing the neighbors. Several such super clusters may be served by a floating center that provides education, municipal services, and shopping. The principal unknown in this instance is the durability of underwater space frame. Would the joints stand up to the internal stresses and corrosion over a long enough period to be amortized?

Bothersome, unanswerable questions like this led Alvin Bonnet to design a triangular underwater frame from concrete which could be assembled on site. It distributed utilities to three free platform buoys which could accommodate a total of eighteen houseboats (Fig. 10). This arrangement could certainly be made to work. Six of these would constitute a large hexagon about 40 m. on a side, and the net density at capacity would be 75 dwelling units to the acre. Concentration potentials like this caused us to look carefully again at the design of the dwelling unit itself and the privacy that could be built into it.

The outcome of this thinking resulted in a "flattened pumpkin" shape, from which a 150° slice was cut out for windows and entranceway. (Fig. 11). The material that seems to be optimal is a pigmented ABS resin that can be formed in a low pressure press so that a foam core is covered by a tough, hard "hide." (The formed shells in lots of 1000 or more might run about \$1.00/kg. in the 1970's.) The main deck is used for living, and in Hong Kong is anticipated to be stuffed with heavy furnishings that are

FIGURE 10

SCHEMATIC HOUSEBARGE ARRANGEMENT

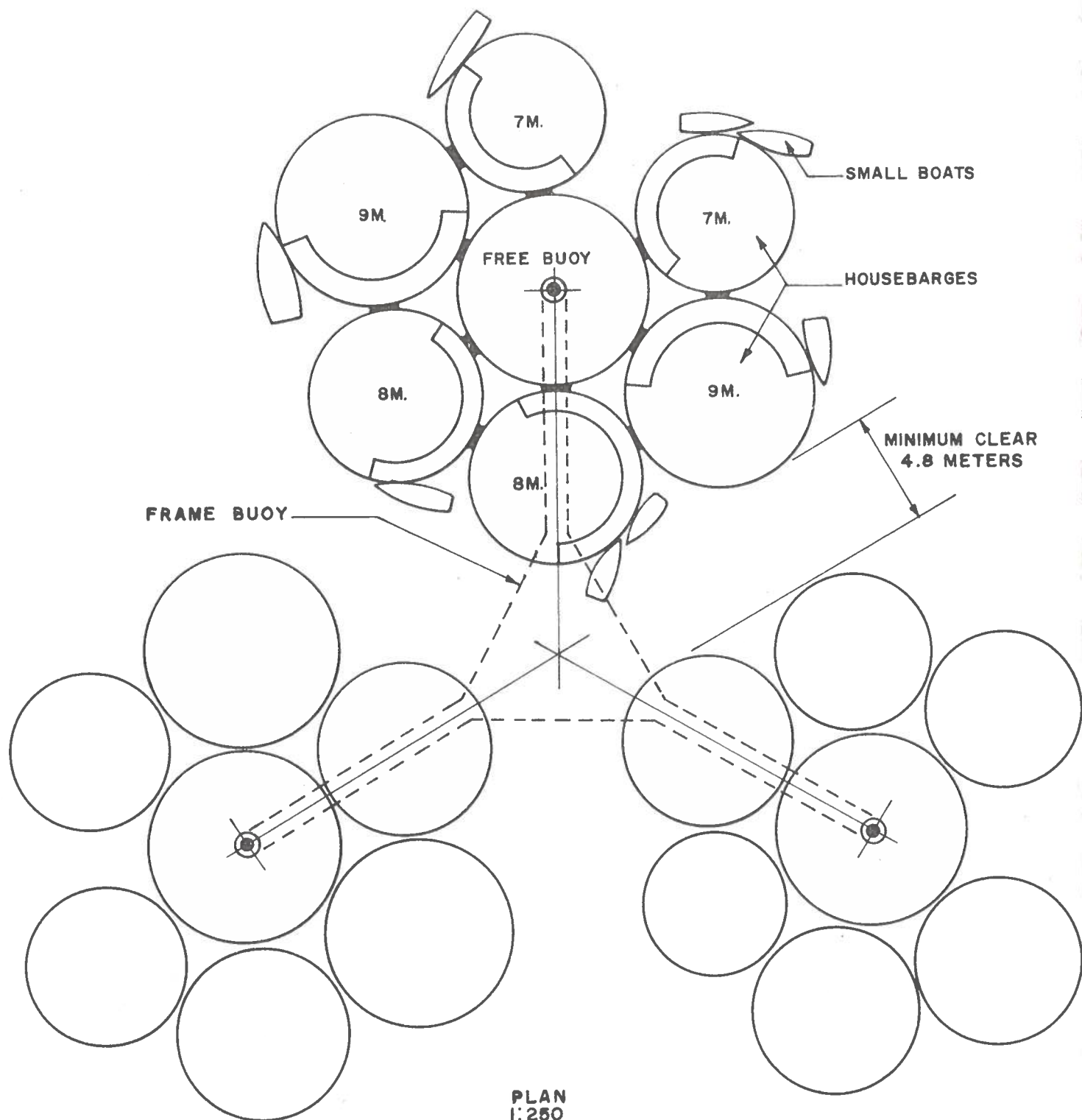
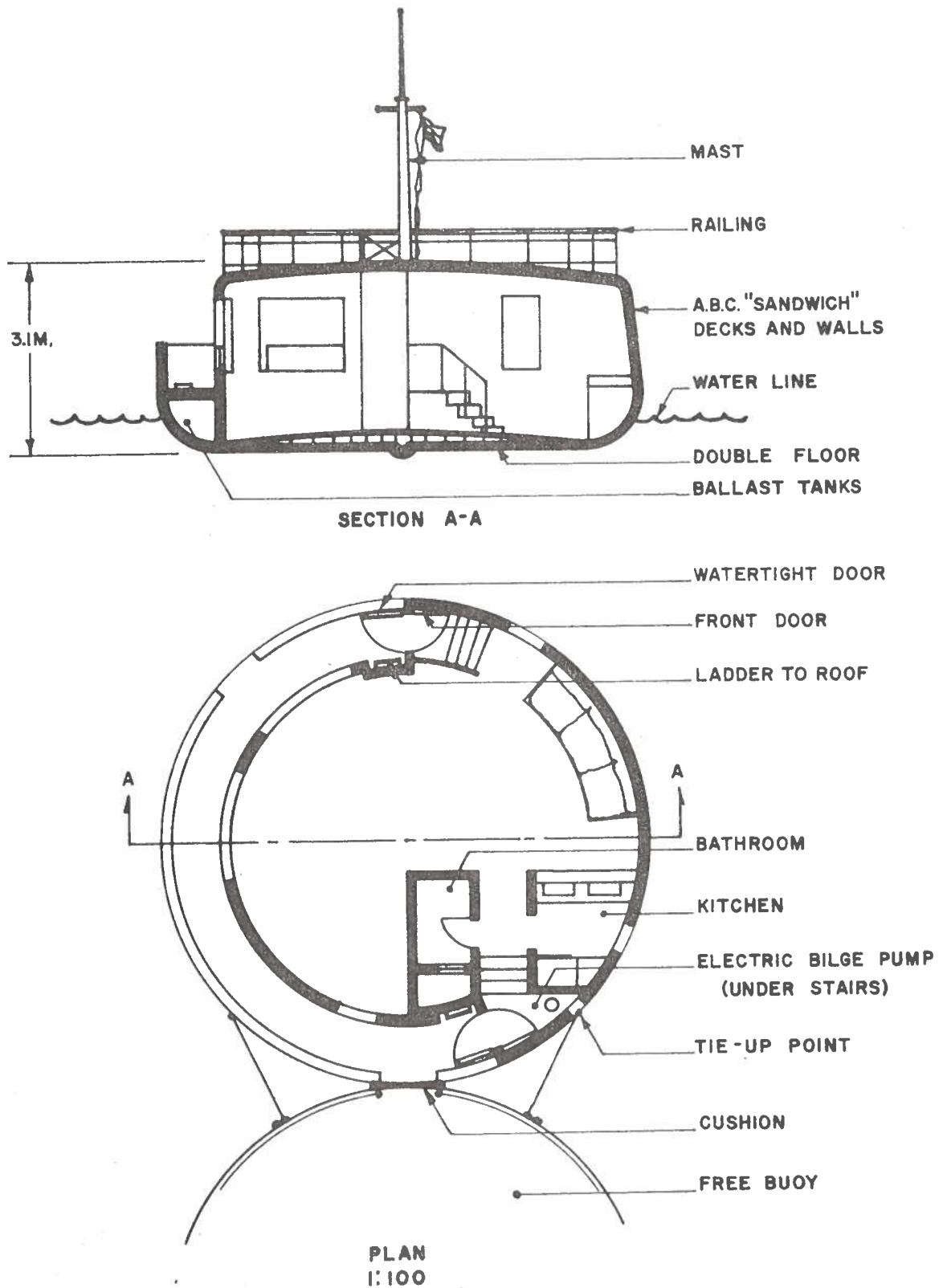


FIGURE 11

EIGHT-METER HOUSEBARGE



associated with the status and prosperity of the residents. The allocation of the space and the introduction of curtain walls is left open. The provision of ballast tanks in each quadrant allows the placement of heavy pieces where desired, because the level can be restored by balancing with water. The upper deck can be used for outdoor living; very likely some shade arrangement would be desired that is not susceptible to destruction by the elements (not shown in figure). The windows and entranceways can open up to the free buoy platform and to a small boat without being immediately in the direct view of neighbors. It would appear to have everything the middle class would want.

The cost comes out to be quite low. For an 8 m. diameter size, which will house adequately up to six persons, the amount of formed resin amounts to about 650 kg. (allowing for one inch thickness sheets in most places). Most of the expenditure must go for the standard bath-kitchen units and for miscellaneous marine equipment. Probably the overall cost would drop to less than \$3000 in lots of a thousand or more and still leave the kind of profit margins needed in Hong Kong. The rent of the berth is expected to equilibrate with the value of land on shore, but the cost of developing the surface in this fashion can almost certainly be held to less than \$1000 apiece. Thus the rent paying ability of the middle income group (\$40-90/mo.) can probably be met. The water surfaces can be subdivided and auctioned off, with the prospect of values being created that may reach \$100,000 per developed acre.

The gregariousness of the Chinese has already been mentioned. Noodle shops, tea shops, cinemas, and gambling houses must therefore be close to home. The attractiveness of houseboat living will depend heavily upon the distribution system installed for the floating urbanism.

Many interesting possibilities exist for laying out an aquatic shopping center. Of these I like two especially. One of them, the Netus Ocean Platform, would use a series of spar buoys tied together in such a fashion that motion in the superstructure resting on the links is reduced to a quarter or less than that found in a small boat (Buoy Technology, 1964, p. 158).

A hexagon with one side partly open is the natural form that such a structure takes in order to obtain maximum economies. Shoppers would tie up their dories and skiffs inside the hexagon and would then walk around between shops at a considerable height (up to 3 m.) above the water surface. The other would be a platform with floating walkways to handle the "parking." Such a platform could have "legs" which rested upon the bottom and an adjustable height. An hexagonal form would be quite natural, but not absolutely necessary. With the advent of a storm, when shoppers stay away for the most part, the walkways could be folded inwards in a manner resembling the bloom of a pond lily or a morning glory. Damage to walkways would thus be minimized.

Other exciting potentials exist in the development of "broadwalks" and "strands" at the land-water interface. The success of any floating suburban community will depend heavily upon the amount of fun incorporated in these strips.

11. Aquatic New Towns

The planning literature is replete with schemes for new towns and their evaluation. The theme has been a favorite of social historians beginning with the colonies of the Greek city-states and continuing to

the utopian communities of the nineteenth and early twentieth century. Hundreds of new towns have been launched, many of them substantially completed according to original plan. An analysis of the marine-oriented features of new town settlement, especially any deductions regarding the place of the sea in civic design, would require a major digression. It can be dispensed with because the past thinking has little relevance in treating the possibilities now at hand. Suffice it to say that, outside of some literary speculations of persons like Jonathan Swift, Jules Verne, and Arthur C. Clarke, aquatic satellite cities have not been proposed. The sea remains to this day a wilderness that has not been tamed sufficiently to support human life except in transit.

The natural resources of marine areas are much too thin and too homogeneous to support the kind of urbanization stimulated by mines, forests, or rich soils. Careful comparisons show that even the best marine regions produce less value per unit area than grasslands,²⁸ while "cow country" on land has never been able to support real cities. A significant factor explaining the non-settlement of the seas is that the costs of transport per linear mile are much less than on land. This means that marine resources are best exploited by parties or camps which return to a protected base after each expedition. The improving productivity of labor for those working the seas for a livelihood will reduce the numbers employed still further. Therefore, the demand for new housing generated by increased production of commodities from marine resources is trivial. This means that aquatic cities, if they ever should be founded, will have a raison d 'etre depending upon political or spatial relationships with established entities rather than hinterland development.

The economic base for a large, relatively independent floating settlement is most difficult to supply in any detail due to lack of precedents. Off the American coast it might well be dedicated to tourism, a marine Las Vegas or Mackinac Island, or to science as a "la Jolla afloat". In Europe it could be a petrochemical entrepôt standing over the heart of the North Sea oil and gas fields. Outside of Hong Kong it seems likely that special entrepôt functions, not convenient to either Kowloon or Macao next door, might find an aquatic satellite center a useful base of operations. If this is the case much of the work will be in offices, taking advantage, perhaps of the advanced business intelligence potentials offered by communications satellites and micro-wave relays. Light manufacturing could serve as a source of employment for a segment of the population not suited to arbitrage activities. Tourism should be sufficient to support a high proportion of the labor force in the services.

It is realistic to hypothesize, therefore, that the finance required for an aquatic city near Hong Kong will come from local investment banks and commercial families with strong, specialized commitments overseas. The time would be in the 1980's, some years after suburbs on the sea have begun to develop. The settlers would be white collar, educated up to secondary school or junior college level for the most part, but the construction labor may well come from the ranks of the seamen who work out of Hong Kong. The Tanka sampan dwellers now in the harbors could be induced to supply a number of service workers. Almost all jobs need to be modern and productive. The location would be in international waters outside of the three-mile limit, or whatever new boundary will be set by international convention. The chief hazard remains weather, since very

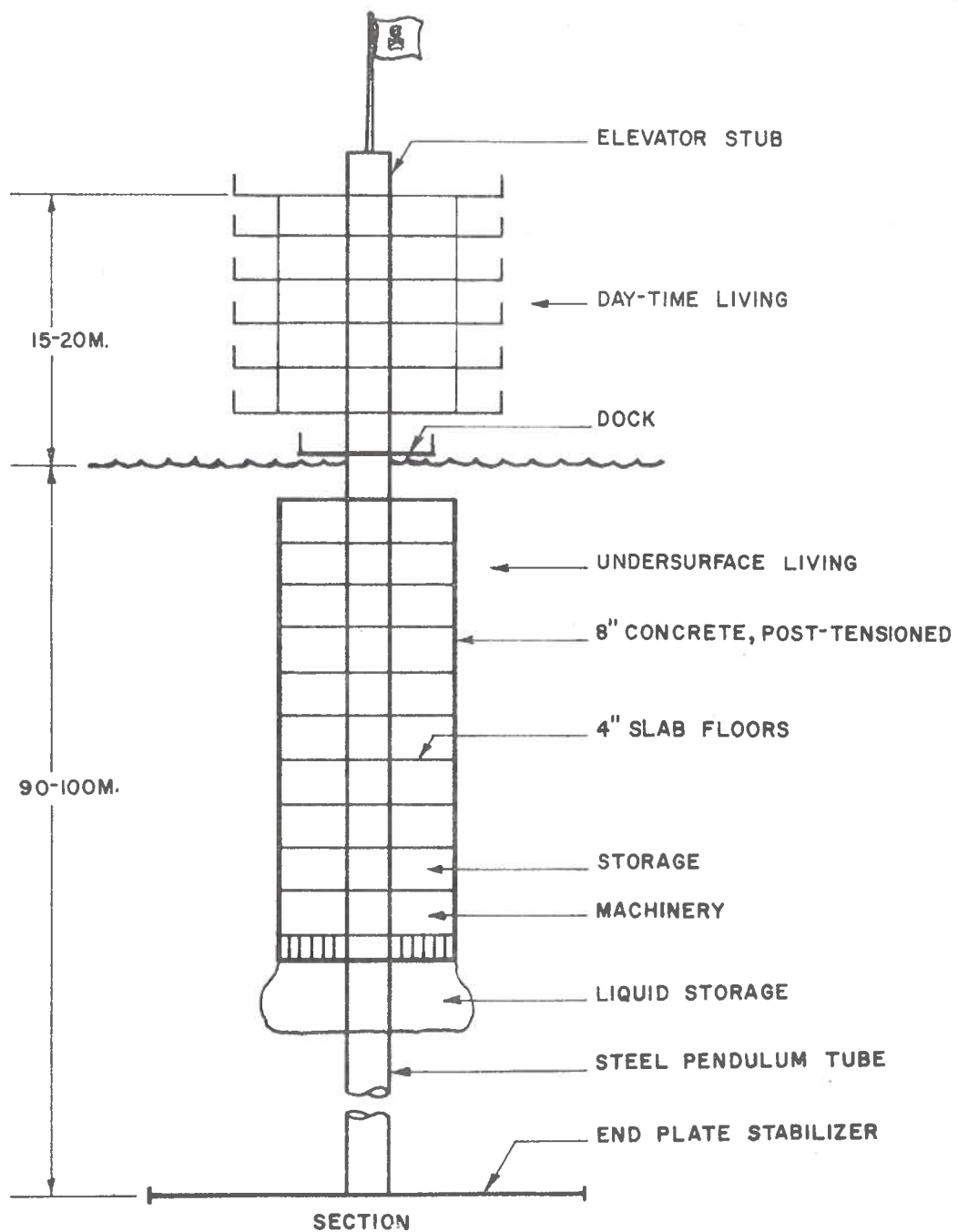
little protection is offered by the land of the Colony itself.²⁹ Insurance rates for sea-going craft run ten times higher than equivalent coverage for land-based structure.

The basic residential unit, one that has been shown to be stable in the worst storms at sea, is a spar buoy. The essential dimensions for minimizing response to wave motion are 300 feet draft and about 50 feet jutting above the surface. The diameter is not important for stability, except at the water line where it should be minimal, but it will have an effect upon the prevalence of leaks. An estimate of a feasible diameter, when reinforced by decks eight feet apart, was 35 feet. The inside diameter then becomes ten meters. Used strictly as an apartment structure, up to 190 persons could be housed at levels of adequacy (Fig. 12). If reinforced concrete (expanded clay aggregate) were to be the material of choice, walls of 8 inches and floors of 4 inches appear to be required. An important feature of a design like this is that it could be constructed at sea by slip-forming and post-tensioning. This construction technique would eliminate the expensive launching step and at sea the cost of raising the wet concrete to the point of pouring would not be encountered.

According to present methods of cost estimation this structure could be assembled for \$12-14/sq. foot. The completely equipped apartment unit with elevator, air conditioning, fuel and water stores, and safety equipment might run to \$25-30/sq. foot. Thus a suite for four persons is expected to cost \$6000-7000, which is out of range for most Hong Kong middle incomes today, but may be broadly acceptable if development continues into the 1980's. It should be assumed that at the start the cost of water surface rights will be negligible whereas the cost of

FIGURE 12

MARINE APARTMENT UNIT



land suited to apartment living would still be rising due to a demand for living space on the part of the population where the enlarged cohorts already born will be entering the housing market.

These spar buoys must be moored to the bottom of the sea in order to keep them from moving with the currents. The methods are now well understood and not too expensive. They must also be kept from bumping into each other. The most economical "bumper" that could be imagined to date is an inflated torus, perhaps fifty feet in diameter that could also be used as a fair weather walkway between apartment structures.

Architects will note immediately that these engineering-based specifications for stability and minimum cost have almost converged upon Kiyonori Kikutake's conception of Marine City, originally published in Japan as part of Metabolism (1960)³⁰. All the other imaginative proposals dealing with the occupation of Tokyo Bay, including that of Kenzo Tange, could not be considered seriously because the costs, as far as they could be estimated, were several times too high. Kikutake was designing around the potentials of the slip-forming approach to the construction of apartments, so the likeness is not accidental.

Marine engineers object, however, to the large number of windows he has opening out into the bay below the surface ("How will you keep them clean". If they get fouled, why have a "porthole" at all? Besides, virtually all the leaks would begin at those joints!). A superior solution for the Japanese culture would be to incorporate a telescope or peephole with covered lens in the concrete wall which permits a resident to watch wildlife. Micro-size marine gardens can be designed and put into place at the focus with the assistance of a skin diver. They

should provide continuous variety for the occupants. It is rare that the wilderness can meet the city with so little disturbance to either ecotype.

Kikutake also showed a large circular slab, floated on a number of spheres, which served as an urban center for his cylindrical apartment units. Since then the problem has been given searching structural study, although most of the results remain within the "most confidential" files of marine architects and shipbuilding firms due to intense competition at present in making bids for off-shore oil drilling rights. A favored solution, investigated by one of our group, Jeff Stubbs, requires the mass production of hollow 20-foot cubes of concrete which are post-tensioned to each other by cables up to 240 feet in length.³¹ Similar cubes were being constructed for oil-drilling platforms by Permanente in Oakland. The overall size of the disk able to cope with a full typhoon was estimated to have a minimum diameter of 1200 feet, thus, it required about 1000 cubes and left about 100 holes at scattered points. The cost estimate was \$25 per square foot, so that a stable sea platform suited for service as a new town center would cost \$10,000,000 at a minimum.

This concrete "raft" should float about four feet above the surface of a quiet sea. When heavy seas are running a seawall would be needed to keep the breakers from sweeping across. An eight foot wall should be sufficient to beat back the worst of the storms, but it would also greatly affect the appearance of the C.B.D. in the eyes of those approaching by ferry or launch since they must head for slots in the wall that can be closed to meet the brunt of a storm. If the raft is to be expanded by adding new cubes to the fringe, the sea wall, too, would be moved out.

Architects are tempted, under circumstances like this, to propose a high tower in the center of the slab for the hotel and prestige offices. It would undoubtedly make a spectacular impression on a quiet sea, and an interesting one during a swell. The high cost of surface reinforces the argument that intensive use of a kind like this is required. However, at sea a major additional cost comes into play--wind force must be counter-acted by anchors and mooring cables, very likely assisted in an emergency by tugs or onsite power plants. Perhaps all the skyscraper that could be afforded is the absolutely essential microwave relay and radar tower.

A most promising approach to full utilization of the dry surface would be the superimposition of an expansible megastructure. Various buildings would be suspended from it. Of these the most necessary would be factories, offices, power plant department stores, hotels, schools, restaurants, theaters, hospitals and sports arenas. A center at sea probably cannot be operated on a multi-shift basis as was needed for India, so the central spaces cannot be utilized as intensively.³²

The services for the independent settlement do not need a separate review. Those that differ from land-based communities were treated in the suburban example earlier and reported to be not only technically feasible but reasonably economic. Food production via floating hydroponic gardens ought to be attempted because the cost of obtaining supplies from the mainland will be high. The educational system would probably attempt to propagate a new and distinct sub-culture, so that one of Athelstan Spilhaus' "sea-grant colleges" would be highly appropriate.

The overall population to be served by a minimum size center is in the neighborhood of 10,000 persons. This figure allows for a much greater than normal tourist industry. One of the principal industries would undoubtedly be the manufacture of facilities and structures for the new town and its successors. Eventually, after the size exceeds 25,000 persons or thereabouts, an aquatic new town would split off the dust-producing industrial unit. An air view would thereafter give an impression of sun, moon, and constellation rather tightly huddled together to hold down daily transport costs. Then it would fit rather nicely into the stereotype for a new town.

IV. NEW INQUIRIES

12. Special Problems of Growth and Organization

In these two exercises in urban systems synthesis we had set out to discover new futures for cities in densely populated places of the world. The outcome was to be more desirable than those obtained by extrapolating present trends and policies. We made an effort to meet rather rigorous tests of engineering feasibility, economic practicality, and institutional precedents. The result is a design for urban organization that in plan, at least, appears to be as desirable as the better cities today. As always with plans, however, it is the suitability for implementation that counts in the long run. What kinds of studies ought to be undertaken as soon as possible that would improve the chances of carrying out such plans for development and amelioration?

A discussion of the miscellaneous set of serious problems that remain must be organized in some manner that is readily comprehended by readers from various disciplines. In each instance some thoughts about the nature of an adequate solution will be provided, but with the full realization that the best solution is likely to come from an altogether unexpected quarter where the problem was formulated more productively. The order of the arguments will flow from the smallest scale to the largest, micro to macro, personal to mass, or from the individual to the aggregate.

A. Acceleration of the Acculturation of Individuals. Being urban is a state of mind; it is the ordered memory of many experiences which establishes a set of expectations about urban events. Raw experience,

interpreted by tribal or village judgments, sees the city only as a bewildering jungle. The immigrant's contacts with the urban environment need to be explained by friends, the gaps filled in with vicarious experience from reading, and the resulting assessments expressed in word and sketch for possible correction. Thus a time and place for personal study is required. This need is not known or understood by newcomers, so their self-help houses are not built to accommodate it.

A carrel is a booth designed for study. Currently a number of efforts have been undertaken to design a multi-purpose carrel for libraries and dormitories. The costs seem to fall in the range of \$2000-5000 apiece when mass-produced. What might it be like if it cost a hundredth of that amount?

I imagine a shaded lamp on a cord, a hard, flat surface and an elastic net to hold papers and books, drawing equipment, slide projector (?), and abacus. The board would be very light, metal-edged, and equipped with screw-on legs that produce a steady surface. The "student" is seated with crossed legs on a sweat-absorbing mat, or is on his knees to draw or brush a sketch. The light cord is on a pulley, so that the whole assembly (sans mat) may be raised to the ceiling out of the way of children. It is equipped with a space ring to hold up mosquito netting. Somehow the images of respectfulness, devotion to duty, and hard work should be imparted to the equipment by the designer.

B. Initiation of Pre-School Children into the Community. The astonishing popularity of Operation Head Start in the United States indicated a major unrealized demand for assistance in the socialization of children among the poor. Every new settlement in the city must expect

to be deluged with children in the first decade of its existence--even if family size is controlled--when it is organized to meet only the most fundamental needs of its members. It therefore ought to have available a branch of a metropolitan nursery school system that comes in and trains local teachers. It also needs a prefabricated nursery school, with toys, furniture, and teaching materials, an item that is not yet available even in the United States.

C. Previews of the Operation of Urban Institutions. Both children and adults are mystified by the difference between outward, conventional morals and the actual behavioral norms of the individuals in complex organizations, and therefore never learn to participate effectively. The games brought from the village don't prepare them for the fast competition of the city. Therefore, a new set of games, each representing a major institution and the strategies available to roles in it, needs to be invented. A "life" game, for example, would rehearse the key decision points in career development in that society. A business game should illuminate the requirements for survival of a firm. An election game would suggest useful strategies in politics. The athletics should emphasize useful body coordination (e.g. swimming and diving), and team organizing skills. The gambling should encourage the learning of more advanced principles in probability and statistics.³³

D. Intensive Food Production Techniques. World food research is dominated by agricultural thinking, which resists emotionally any major deviation from soil-based field crops and the husbandry of species that have been domesticated for thousands of years. Somehow the food processing and marketing industries must be encouraged to experiment with new

products in the urban markets. The foods should be manufactured by methods and from materials that get closest to the photosynthesis step. Synthetic rice studies need to be expanded. The developmental and behavioral research on fish, leading to the domestication of more species, are important. The problems of installing hydroponics gardens, stabilization ponds, and algal production from synthetic fertilizers, must be looked into from every point of view. Milk substitutes, breakfast foods, nutritional soups, fine-grained sausages, and ice cream could all be transformed into major dietary components by direct transfer of technology. In some instances a fund of knowledge exists which could lead to the economical mass distribution of a traditional food. How can the conservative sentiments in high quarters be evaded, so that necessary developmental investigations can be advanced? Perhaps only by inviting in the international corporations with experience in related cultures.

E. The Maintenance of Public Order. A major threat to densely populated cities are the riots and disturbances that appear to boil up with little warning. The subject has been reviewed at length in another paper.³⁴ In it I proposed a heavy emphasis upon expanding the range of social communications by the use of mass media, the production of bi-linguals, speeding up the reaction time of police and emergency aid personnel, the generation of productive social roles, the promotion of body contact sports, and possible use of drugs, all of which are suggested by a systematic review of the current behavioral literature.

A number of other inter-related questions cannot be framed so explicitly. They revolve around the new capabilities for institution

building introduced or diffused by space science which have yet to be injected into the organization of cities. Both of the principal foregoing projections of urbanism for the future already contained implicitly a level of performance of physical tasks higher than is to be found anywhere in cities today and only considered feasible because it has been accomplished publicly by space agencies. One such capability is the breakdown of a gigantic task, as immense as megalopolis construction, into a program of negotiable pieces and readjusting that program as it is implemented. (Although major military projects were already being organized in this fashion before the first Sputnik went up, the contribution of space science has been to bring out into the open vastly improved error control techniques for man-machine systems.)

The new organizational capability starts with data acquisition and organization. What minimum set of items does a regional government need to know about its people, its land, its structures, and its rolling equipment? Which of the flows, both internal and import-export, should it monitor? Growth imposes an extra set of needs, since some approximation of balance must be maintained. How is the data acquisition to be expedited with advanced information technology?

Most administrators react to such questions by commenting that these concepts are too advanced for the poorer developing countries. Yet in a test conducted by the U.S. Air Force on sophisticated weapons production it was shown that Japan already could handle virtually all of the organizational techniques in the middle 1960's.³⁵ Only the production of advanced instrumentation needed to be imported from the outside. Something like fifteen years may be needed to design prototypes for an

all-electric urban core and transit system, but at least enough precedents exist to make it look feasible. The electrical industry in India is in a position where it can absorb and elaborate the advanced work elsewhere in the world, but reports indicate that data processing has yet to reach that state.

These are judgements that require personal contact to confirm. It is possible that other routes to advanced organization exist in the East that do not get reported often. That much has already been revealed by the experiments on transfer of technology in Japan. If so, how are these other approaches to be modeled, so that they can be learned and applied in public institutions?

FOOTNOTES

1. R. L. Meier, Regional Development Studies IV: Proposals for Human Resource Development in the Detroit Area (November, 1964); V: Megalopolis Formation in the Midwest (December, 1965), Campus Publishers, Ann Arbor, Michigan. (The earlier items in the list were produced in a mimeographed bound form, and are no longer in stock.)
2. Source: Commercial Atlas and Marketing Guide, (Chicago: Rand McNally, 1965), 95th ed. "The metropolitan area includes a central city, neighboring communities linked to it by continuous built-up areas, and more distant communities if the bulk of their population is supported by commuters to the central city."
3. Principal factors included when arriving at this estimate are (a) natural rate of growth due to the excess of births over deaths, (b) attractions for immigrants as compared to other centers, (c) the population density in the service area of the metropolis that provides most of the immigrants, and (d) the ability of metropolitan economy to support migrants.
4. R. L. Meier, "The Social Consequences of Scientific Discovery," American Journal of Physics 25, 1957, 602-13; "Systems and Principles of Metropolitan Planning," Centennial Review 3, 1959, 79-94; "The Future Structure of Cities," Transportation Design Considerations, Publication 841, National Academy of Sciences--National Research Council, Washington, 1961, pp. 120-37.
5. Olaf Helmer, "Institute for the Study of the Future: A Prospectus," UCLA, December, 1965.
6. Richard L. Meier and Richard D. Duke, "Gaming Simulation for Urban Planning," Journal of the American Institute of Planners 32, 1966, pp. 3-18.
7. R. L. Meier, "Relations of Technology to the Design of Very Large Cities," in Roy Turner, ed., India's Urban Future, (Berkeley: University of California Press, 1962), pp. 299-323.
8. R. L. Meier, Developmental Planning, New York: McGraw-Hill, 1965, Chapter 1.
9. Ibid., Chapters 3 and 4.
10. Source: R. L. Meier, Developmental Planning, 1965, pp. 15-16.
11. A reactor producing 12 kw/capita/mo. (cf. the Minimum Adequate Standard of Living in R. L. Meier, Science and Economic Development, (Cambridge: MIT, 1966), Second ed., pp. 169-70) with 25% thermal efficiency and triple effect distillation yields only 2% of the community water needs of the population. To manufacture all this water by electrodialysis or freezing technologies from sea water, the power requirements per capita would treble.

12. Source: Central Building Research Institute, Climatological and Solar Data for India, Roovkee, 1959.
13. Donald J. Bogue and K. C. Zachariah, "Urbanization and Migration in India, " in Roy Turner, ed., India's Urban Future, Berkeley, University of California Press, 1962, pp. 27-54.
14. Everett S. Lee, "A Theory of Migration," Demography 3, 1966, pp. 47-57.
15. B. R. Misra, Socio-Economic Survey of Jamshedpur-City, Patna: Patna University Press, 1959; N. K. Rose, "Calcutta: A Premature Metropolis," Scientific American, September, 1965.
16. Thus far only one line in the world seems to have reached this level of utilization. The Yaroslavl line to Mystischi runs 22-23 trains per hour during peaks and fifteen per hour for the remainder of a 22½ hour day. Peter Hall, The World Cities, New York: World University, 1966, p. 175.
17. Two policies, the use of light expanded materials of construction where possible, and the raising of garden produce close to market, together reduce freight to a quarter of what is normally anticipated. Nuclear fuels and local transport electrification also contribute significantly.
18. Compare with Tokyo subways, which carry 300 per car at peak periods and are limited to steel tracks. The intention here is to postpone heavy investments in track and stations (@ \$2,000,000/mile) until justified by traffic.
19. The efficient arrangement sometimes gives one a pause. For example, we cannot find enough jobs for our community to meet demand. We know that Japanese cities have full employment, but many of these jobs are created by the inefficient land use and circulation system. What new services, beyond those available in Japanese working class areas, can be installed?
20. Private communication from Professor Aaron Horwitz, emeritus of the Haifa Institute of Technology, Israel, former United Nations consultant.
21. Stephen C. A. Paraskevopoulos et al., Structural Potential of Foam Plastics for Housing in Underdeveloped Areas, Research Report for A. I. D., Ann Arbor, November, 1965.
22. Tokyo, it should be noted, has already a higher level of education, measured in years of instruction, than any European metropolis. Its primary handicap, most of the instruction being in a language not generally used in international operations, has been inhibiting: Cf. Herbert Passin, Society and Education in Japan, New York: Columbia Teachers College, 1965.

23. D. L. Spencer and A. Woroniak, "The Feasibility of Developing Transfer of Technology Functions," mimeo, Howard University, Washington, D. C., May, 1966. (Scheduled for publication in Kyklos).
24. William J. Oswald, "Light Conversion Efficiency of Algae Grown in Sewage," Transactions American Society of Civil Engineers 128, III, 1963, pp. 47-83; G. R. Marais and V. A. Shaw, "A Rational Theory for the Design of Sewage Stabilization Ponds in Central and South Africa," Civil Engineer in South Africa 3, 1961, pp. 1-23.
25. I owe this expressive simile to Lawrence Moss.
26. S. T. Uyeda, "Buoy Configuration Resulting from Model Tests and Computer Study," Buoy Technology Supplement, Transactions of the 1964 Buoy Technology Symposium, Washington, 1964, pp. 31-42.
27. R. L. Meier, in W. R. Derrick Sewell, ed. "Urbanization and the New Weather Technology," Human Dimensions of Weather Modification, Chicago, Department of Geography, 1966, pp. 261-78.
28. In the American economy, fish are harvested with lower returns per acre than any other resource except the "lamb and mutton" crop. Leonard Zabler, "A New Areal Measure of Food Production Efficiency," Geographical Review 51, 1961, p. 564.
29. The Royal Observatory in Hong Kong has been conducting fundamental studies on typhoon formation and tracking. The best information comes from the infra-red scanners of the Nimbus weather satellite. David Fishlock, New Scientist 30, June 2, 1966, p. 595.
30. A clear representation in context is given in "The Future of Urban Environment," Progressive Architecture 45, October, 1964, p. 168.
31. These cubes have 18" thick bases, tapered sides, and an 8" lid. The latter is glued on with epoxy. Excess buoyancy available for structures was 343 lb./sq.ft.
32. The conscientious designer will be disturbed by the presence of all that empty space in the hollow cubes. Surely it can be converted into a surface-saving asset! To develop channels through the sides of the cubes, however, will demand more concrete and they would complicate the structure. Some of the space might be used for storage, if special machinery and containerization were to be developed.
33. I have argued this point at greater length for the general case in an as yet unpublished paper, "Transmitting Concepts of Social Organization with Simulations," December, 1965. Both James S. Coleman and Clark Abt are conducting advanced work in this field, much of it applicable in principle to developing areas.

34. R. L. Meier, "Policies for Urban Settlement Intended to Minimize Losses from Conflict and Violence," Center for Planning and Development Research, University of California, Berkeley, May, 1966, 37 pp. Earlier considerations of this general theme were taken up in my monograph, A Communications Theory of Urban Growth, (1962) and in Ray Turner, ed. India's Urban Future, Berkeley, University of California Press, 1962.
35. Daniel Spencer, "An External Military Presence, Technological Transfer, and Structural Change," Kyklos 18, 1965, pp. 451-474.