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A Stable Urban Ecosystem

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A Stable Urban Ecosystem

The future evolution of a stable ecosystem in a densely populated society is described.

Richard L. Meier

One of the essential properties of the stable human habitat of the future is that it have urban characteristics. Ambitious people from the countryside and from many towns stream into cities in search of employment and education. Despite conditions that are often deplorable, the enterprising poor remain attracted by urban environments, to which, in most cases, the propertied classes have already migrated. Cities are also dumping grounds for surplus people—those who could not be supported because of drought, flood, insurgency, and other stresses in the hinterland. A counterstream made up of winners, retirees, and misfits returns some to their places of origin; many aspects of urban culture diffuse back with them.

However, the cities we know, the kind that have provided the physical matrix for the flowering of civilizations, are doomed. The resources needed to maintain them will not be available in sufficient amounts in the future (*1*, *2*). To survive, cities must be conserving of resources—a characteristic that has not yet evolved among the pacemaking conurbations of Europe, America, or Japan, or among their followers elsewhere.

Technologies that will conserve large amounts of scarce energy already exist for producing materials, for building, and for transport (*3*). There are proposals for conserving large amounts of water without detracting from sanitation. Furthermore, it is now possible to design built environments that would easily accommodate the populations anticipated, although not necessarily in the most preferred locales.

Several promising economizing approaches can be found somewhere in the densely populated, low income societies that now exist. These efforts are little known and understood because they are scattered and are rarely integrated into an advertised development program. The underlying ideas diffuse slowly because direct communication between these peoples is minimal. Although not all needed innovations are already at hand, enough have achieved sophistication to point the way (*4*).

Because pressures to accommodate extra people in cities are greatest in the Third World, it is there that both resources and capital will remain most scarce. Population growth is still very strong, and therefore one of the functions of new urban institutions must be to transmit life styles and modes of family formation conducive to replacement alone ("zero population growth"). Third World urbanization must soon install very different technologies, settlement patterns, and organizations. If these urban systems fail to achieve much higher efficiencies in the use of natural resources for the support of people, unprecedented numbers of them (mostly rural, unexpectedly) will succumb to starvation, pestilence, violence, and other disorders (*5*).

Because prototypes of the desired outcome do not exist, it appears necessary to construct an economic image of human settlement at steady state. The appropriate model would start from a set of circumstances typical of less developed regions, and socio-technical changes would be induced once proper instructions had been dicovered. However, this approach starts with a necessarily incomplete concept (the "representative" prototype region) and ends with another, still less adequate, image (the steady-state urban ecosystem); at best, the model remains hypothetical (*6*).

Planning theorists offer, as an alternative, computer simulations of specific regions; the demands for data become increasingly extensive as progress is made. However, large-scale models of

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this type often have collapsed when used in planning for Western metropolitan areas, and as a result we have lost confidence in them.

Projections of the "Limits to Growth" type are unduly inhibiting because they emphasize the diminishing stock of exhaustible resources without introducing the potentials opened up by accelerated use of the inexhaustible (but pollutable) electromagnetic spectrum resource supporting all telecommunications. Marginal costs for the provision of energy, including food, have been rising, and are expected to do so even more; but costs of communication, computing, and control systems are declining at even more rapid rates. Moreover, the volume of scientific findings now working their way through the R & D pipeline suggests that the trend toward reduced unit costs will continue for more than a generation (*7*). The search for new and relevant technologies depends on the substitution of knowledge or information for material inputs such as energy, water, and soils suitable for staple food production.

The standard definitions of ecosystem, whether biological or social, are not applicable. They must be revised to include all "species" of "actors"—not just interdependent plants, animals, and humans constrained by a variable physical envelope—since populations of machines, vehicles, and automata are becoming potent actors. A future community will be urban if it maintains a dense, viable association of all these kinds of participants, even if it does not closely resemble contemporary Western cities. Ecological principles still apply as strictly as ever, but standard expressions, such as density, will need further specifications in order to convey meaning.

The best method for illuminating the significance of Third World innovations seems to lie in an adaptation of the old-fashioned case study. Its starting point is observable conditions in a difficult instance in the real world; the indicators of these conditions have trends that are known to some degree. Long-lasting features of that environment, such as climate, population dimensions, and legal traditions, can be used for guiding the choice of innovations to be encouraged. This raises the question of selecting a reasonably representative, readily understandable instance.

Certain urbanizing regions should not be chosen because the variability in climate, particularly susceptibility to droughts, allows them to overshoot their carrying capacity for immigrants. Places like Peking, Mexico City, Delhi, Santiago, Bogotá, Sian, Ahmedabad, and Bangalore are likely to have their expansion abruptly halted by the severity of local climatic cycles. Each of these represents a special case.

Urban settlements on coastal plains or deltas—Shanghai, Calcutta, Jakarta, Cairo, Bangkok, Manila, Karachi, Saigon, Tientsin, Canton, Madras, Dacca, Surabaya, Phnom Penh, and Mukden—have truly "problematic" futures. Their size must eventually exceed the 20 plus million that live and work in metropolitan Tokyo, at present the largest agglomeration in the world. Many more growth centers will feel similar pressures but are less likely to expand to the same dimensions—Havana, Algiers, Casablanca, Rangoon, Lagos, Accra, Hanoi, Travancore—because there is less population pressure from the hinterland. The necessity of coping with large numbers of people in the moist tropics distinguishes the largest class of urbanizing regions.

From this set I have chosen the cities of Java—Jakarta, Surabaya, and the smaller centers in between—as an advantageous prototype. If a path to some form of steady state can be shown possible for Java, a similar path probably exists for other cities. Java is more open to investigators than parts of China or India; the quality of its data, although still very poor, is rapidly improving, thereby enabling early discovery of faults in proposed relationships (*8–10*).

The theory and technique for bringing the populations of growing urban regions up to adequate levels of living have been described (*11*). Supplementary observations were obtained on recent visits to 35 Asian metropolises (of which five were in Java).

Designs for Limiting Population Growth

We have yet to see a regional plan that gives highest priority to the limitation of fertility and has mobilized all institutional resources and experience at hand to achieve that end by propagating a low-fertility social order. In poor societies this means new social roles for women; it also requires improved maternal and child health care along with dependable contraceptive supplies. When faced with the overall economic and demographic dimensions of this problem for Indonesia, Jones (*12*) was impelled to propose that new resource-conserving megalopolitan life-styles be a foundation for the planning.

According to international comparisons Indonesia has one of the more successful population control programs (*13*). Family planning constitutes the principal effort at the moment, but encouragement is also being given to increasing the average age at marriage, to the entry by females into the organized labor force, to social insurance incentives that substitute for the children that have been regarded as the sole support in old age, and, in a small degree, to the termination of unwanted pregnancies. Nevertheless, the estimated number of births prevented for the fiscal year 1974–75 was only 300,000, about a tenth of the total required for a stable population (*14*).

The management models for providing family planning services suggest that new means are needed to attract more of the individuals in the fertile age group; more appropriate incentives must be invented. When dealing with the very poor, for example, this may mean providing transportation to the clinic, as well as snacks for those children who accompany their mothers.

Indonesia's Second Five Year Plan (1974–79) is extraordinarily ambitious. It proposes to reach a stage where 35 to 40 percent of the excess fertility is eliminated. Several reorganizations of the program, made on the basis of what is learned from health education efforts in the field, are required. Somehow many projects must escape from the monopolistic control of the medical profession, which appears to be too timid to undertake redefinition of public etiquette. Most doctors cannot imagine their profession openly hawking birth control pills and allowing free abortions. However, some flamboyant promotion of family planning, perhaps associated with a women's rights movement that is backed by some elements in the health infrastructure, is appropriate (*15*). Attempts to reach the goals of the Second Plan must produce some lively content for the communications media of the metropolis, which until now have been stifled by religious and political clamps. Practitioners of folk medicine, who are now being encouraged with considerable success to disseminate information and materials on family planning, are likely to be conservative on women's rights issues. Experience—with appropriate publicity (different from that suitable for Java)—is being accumulated in Korea, where well over half of the excess fertility has been eliminated over the past 15 years.

Availability of factory work provides an opportunity to postpone marriage; however, dormitories for single women are often needed at industrial estates. Current experience in Malaysia, where modern export industries produce micro-

electronics, electrical equipment, small machinery, knitted goods, and fabricated plastics, is worth watching closely. The management must be willing to make these plants efficient—multinational firms in Malaysia have discovered a pool of talent among Indians, Pakistanis, and Iranians recently trained in North American engineering and business schools. Most of these managers have not regarded population limitation as part of the public service expected of them, but a few have and the remainder seem to be open-minded. Most are likely to cooperate fully in the provision of information, incentives, and education. Delay of marriage and acceptance of family planning measures by the work force are expected to reduce labor turnover—usually the most serious management problem encountered by a modern industry in a developing country.

The normal process of diffusion of modern ideas, such as birth control, to the countryside is greatly hindered because Jakarta has been officially closed to immigration—an internal passport (kartu penduduk) is needed for extended residence in the metropolis. Closing a metropolis in this manner is often advocated by educated people in the Third World, and approved by their counterparts in Western countries. Metropolises like Moscow, Warsaw, Peking, and Shanghai are already "closed" for one reason or another. However, over the long run, such closures have consequences not only for the general acceptance of family planning but for other developmental activities as well. In each case illegal residence has become very significant, and people without proper identity cards cannot avail themselves of public services unless the dispensers of the services are easily corrupted. Thus, if the police are efficient, illegal immigrants cannot allow themselves to be registered.

In Jakarta, the influx of rural people has a strong seasonal trend; during the peak period psychological warfare is waged between Governor Ali Sadikin and the unregistered immigrants. Police round up thousands of underemployed men, mostly pedicab operators and street vendors, and transport them out of town. Almost all of them drift back again, but meanwhile they have comprehended that they are emphatically not wanted. The method worked out by Seoul (Korea), a metropolis of the same size that has been closed to squatters since 1970, offers a more successful model. There the contribution of the metropolis to the demographic transition is not noticeably impeded.

Seoul's technique best fits a rapidly industrializing region; it is a dozen years ahead of Jakarta in that respect. In the Korean capital, police stopped squatter settlement within the walled city and its immediate environs. New settlers were assigned plots in rolling hills on the periphery where they could build an "instant city." Direct, inexpensive bus connections with the principal market place were provided. All new factories for the Seoul region were expected to locate in adjacent industrial estates unless they fitted into preexisting plans. Direct transfer of this set of policies to Jakarta is not feasible because its available land is salt marsh or paddy and therefore is not immediately suitable for building; therefore, some local innovations are needed.

Given these observations, we can consider the prospects of achieving a demographically stable society. It is evident that pronatalist beliefs and ideologies are not very strong in Javanese society, so that the present program of population limitation meets no entrenched opposition. Some subgroups, such as immigrants from the adjacent island of Madura, seem to be resistant to the appeals to use contraceptive services, but they are not influential. Moreover, about 80 percent of the women coming into the fertile age bracket in the next decade will be literate, so that a greater proportion of women will have direct access to messages in the printed media. Nevertheless, nearby Singapore (a pacemaker in population control in Asia) found that a residual 15 to 20 percent of the population was responsible for 40 to 45 percent of the fertility, most of it excess (*16*). Therefore Java should anticipate at least one more oversize generation before the two-child family becomes the norm.

Backlash is a problem to be considered. Once local leaders become fully convinced of the need to institute family planning, they begin to explore strong measures that often border on coercion. Such impulses should be repressed because they lead to reaction that deters the cooperation of families. The area around Dacca in Bangladesh needs family planning even more desperately than Java does, but visits to clinics are concealed or not made because of feelings remaining from the "hard sell" emphasized before 1971 when the government was Pakistani. Next door in Calcutta, where the campaign was once insistent but not so extreme, self-help programs in most slum communities could not have been stimulated had family planning been part of the initial package of services to be delivered as state aid. Although it is often advocated by foreigners, the "hard sell" approach is resisted by local leaders who must live out their lives in the local society and pay the price for mistakes. Use of authority can cause short-term gains, but it prevents acceptance of contraception and produces distrust toward all modernizing government services—an attitude that induces many apparently intractable welfare situations.

Prospects for achieving a stable population in Java have been improving over the past few years. Presumably because of strong government efforts, tradition-minded East Java reports 32 percent adoption of family planning as of 1975, an amount significantly greater than Jakarta's 21 percent. The ambitious plans for population limitation laid out in 1973 appeared to be fulfilled at the 79 to 110 percent level during the first 2 years (*17*). Implications for future population size, calculated on the basis of two semi-official projections that appeared in 1975, are shown in Fig. 1. Accompanying estimates of future urbanization seem to be wishfully low in comparison to hopes for economic improvement; hence I have incorporated my own. Java should expect roughly a tenfold increase in urban settlement within three generations if the intermediate Iskandar-Sumitro estimates prove adequate. Crowding is less of a problem for Java than for some other places in the world because the overspill can be distributed to urban settlements on the surface of the sea. The greatest challenge lies in the establishment of designs for urban environments that function well while enforcing low use of water, energy, capital, and high technical skills. The alternatives appear to be catastrophic, particularly for children soon to be born.

Resource-Conserving Settlements

The best understood threat to the conservation of energy and space comes from the popularity of the automobile and the life-styles that depend on it. Indonesia is not immediately concerned about the supply of petroleum, although its supply will be exhausted early in the 21st century. The planners are worried most about the intrusion of the automobile on living space and circulation networks (that is, about congestion). Java now has fewer automotive vehicles than other portions of Asia (except China) and a much smaller proportion of the population lives in affluent Western style, although very strong pressures exist in the society to evolve along a path similar to that taken by Bangkok and Manila. Promoters of a Makati (the landscaped, air-conditioned, auto-oriented

Manila suburb with its own financial district—a kilometer strip of high-rise office buildings) would find many enthusiastic customers in Java, but that pent-up demand should be resisted. Fortunately this threat to the future is intuitively apprehended; the offical position is to restrict private automotive imports, thus allowing Jakarta time to plan for its future traffic.

Equally threatening to the conservation of space and water is the increasing acceptance of Western-type home furnishings and the popularity of the American bathroom. This threat is not as innocuous as it seems. Beds, divans, tables, chairs, appliances, and television consoles require considerable amounts of floor space, along with a proportionate amount of garden and frontage. Heavy investment in stormproof housing is also necessary. The larger lot sizes separate people from each other and the services they need; the time cost of pedestrian trips introduces a need for personal vehicles, and the roads and parking space they require further increase the separation of households.

The desirable alternatives have justifications that are simultaneously cultural and technical. Java has a history of small kingdoms governed from palaces which provided shade and protection from the rain but left public life open to the breeze. Officials created minor versions of the palace for their households. Cushions and hangings made up most of the furnishing, while flowing water seemed to be an important ritualized convenience for bathing. The ideal kampong (which rarely existed as such for very long) was built of poles, thatch, woven bamboo and daub, and was simply decorated in classical style. The simple life can be restored, kept compact, and rendered as convenient as any in the world by selecting modern technologies appropriate to Java's climate.

Electrification, for example, fits very nicely. The light it provides is highly valued but uses less energy than kerosene or acetylene. Fans bring comfort to the enclosed private spaces and pumps save a huge amount of effort otherwise spent carrying water. Refrigeration is a delight that may have to be limited to commercial facilities like ice cream vendors.

Some improvements in house furnishings may be noted. Synthetic fibers and filaments (from plants in nearby Asia, although soon Indonesia will be a producer) do not mildew, foam plastics are vermin-proof, and plastic film is waterproof. Aluminum screens and doors will not rust, and resin-based paints with new pigments will not blacken when exposed

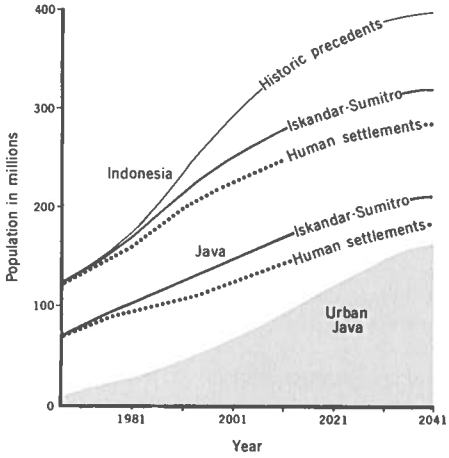

Fig. 1. Estimates of urban growth for Java during the demographic transition. Historically a population has more than trebled in size from the time that birth control was introduced to an age-structure affected by a strong drop in death rate in preceding years. Sumitro Djojohadikusumo (*9*) projects a markedly more efficient transition, while the preliminary draft on Human Settlements (*10*) waxes still more optimistic. The growth of urbanism in Java is my own estimate starting from the Iskander-Sumitro judgments and allowing for the gradual introduction of resource-conserving life-styles.

to vapors from marsh gases. Concrete slabs can be formed to assure well drained flooring, and concrete ditches or sewers can carry away excess water. Building, shaping, patterning, and arranging should be left to families, the kampong, and the bargains in the markets.

The service yet to be added to urban settlements in Java is a fully integrated water center. Partial solutions have been designed for the squatters on the edge of Chandigarh (India), and another kind of institution evolved around the bathhouse in new urban places in Korea. Local experiments have been initiated by Jakarta's municipal government. A water center might offer, besides baths, adjacent facilities for laundry and food preparation; it is obviously a site for a public toilet and for a children's day care facility. A caretaker family might provide services similar to those provided by a bathhouse operator. Packaged water should be sold where the regular supply is not pure enough to drink.

The most important contributions of such a center are the potential for conserving water through recycling and reuse during the occasional periods when water is scarce, and, in larger facilities, the concentration of sewage for recycling. Once energy is truly scarce, refrigerated food lockers could be rented at the water center and use of solar energy should become economical.

Over the next quarter century Indonesian leaders expect a fourfold increase in the value of human time; this puts great pressure on the transport system. Pedestrian trips (beyond the kilometer or so required for exercise) use up calories of food—a more precious fuel than petrol. Therefore, Java should retain the bicycle-tricycle mode of movement in the flat areas with tiny motor assists for gentle slopes, and carry on with the powered, three-wheel helicak, bemo jitney, and bus. However, because it consumes so little space, priority should be given to the telephone. Many new innovations are being added to telephone service in various parts of the world. Portable telephones could be free for civil servants down to the intermediate level; for most of them it could be a substitute for a publicly supported automobile. Congestion in the telephone exchanges is much more economically handled than the stoppages on the boulevards that generate demands for flyovers and freeways.

With telecommunications capacity available, the next steps in the organization of transport would coordinate the family-run enterprises, co-ops, and terminals so as to fill the needs of various kinds of consumers. Because of higher residential densities, a call-a-ride service can evolve. One can imagine a pedicab system that uses radio intercoms retaining a niche for generations to come in the most densely settled communities. After Saigon, Jakarta has been the most innovative metropolis in Asia in designing vehicles in the no- to low-horsepower category for both passengers and goods. These vehicles are an asset that deserves to be fostered by providing special networks of lanes surfaced to expedite their movement (*13*).

Paying attention to the buildup of commerce at interchange points and rationalizing the flows of passengers and goods in all kinds of weather will be particularly useful. A bus station needs to be as carefully designed as an airport and will require redesign as frequently. Scarce land and expensive human time can also be conserved by encouraging round-the-clock operation of services and industrial estates. By such means people can live densely without stepping on each other's toes if they organize themselves differently. Singapore is now the best model for distributing activities round-the-clock, and it will become even more efficient when it is able to make full use of world market situations transmitted to it through communications satellites.

Diffusion of technique from one Third World country to another has been accelerated through the improved network of airlines. The best technology transfer

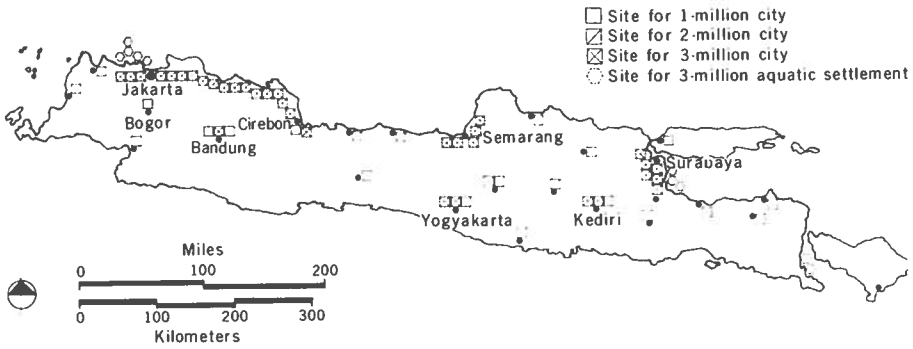

Fig. 2. Growth of the megalopolis on Java to a level approximating steady state. Size is based on demographic transition such as that projected in Fig. 1. For each decade from 1980 onward, an increasing share of Javanese population is presumed to undertake transmigration to other Indonesian islands or the rest of the world, but an even larger number will be forced to seek homes in the cities. Landless people were assigned to the nearest locales that offered reasonably adequate water supply, access to materials, and low-cost infrastructure. The method is illustrated in *Planning for an Urban World* (*11*, pp. 144 and 145) for South Asia. The open squares represent the size of settlements of a million people that could, under continuing migration pressure, increase to 3 million.

agents now flying in are itinerant professionals, artisans, journeymen, and sales representatives arriving as refugees and adventurers, either as individuals, family groupings, or clans. They find niches, in the metropolises of open societies, that can be expanded over time. Borrowing of innovations from neighboring societies has so far been conditioned more by political relations between ethnic groups than by pressures to improve living conditions, not only in Java but elsewhere. Scattered transfers happen with increasing frequency; an informed immigration policy could increase the rate at least a full order of magnitude.

Feeding the Growing Cities

Any new community added to the cities should quickly become responsible for the production of food. Three different approaches are available. The first, almost traditional, uses intensive gardening techniques, while the second pays close attention to the urban ecosystem as a whole and uses the urban periphery to enhance the efficiency of recycling processes. The third starts with the given tastes, including the edibles many will learn to like once they become available, and reconstitutes raw foodstuffs into the popular, nutritious snacks and specialty dishes that are already a large part of Javanese diet. A judiciously balanced diet can save as much as 20 percent of the caloric intake in a culture where rice is a staple.

The single most useful innovation for the food processor in Asia is the plastic bag, which increases shelf life to several weeks. Previously, a typical container for an individual portion was a patch of banana leaf or a cone made of old newspaper. Now, local surpluses can be dried, baked, steamed, stewed, spiced, compounded, pickled, or fried in oil, and than distributed in small sealed plastic bags to shops and and street vendors. Customers appreciate the protection from flies and dust. Thin, tough, transparent polypropylene seems likely to win out as the most economical material. Although it is pure hydrocarbon in composition, the amount of energy consumed in its synthesis is small compared to what is spent in cooking or lost in spoilage. Bags do produce a litter in public places, but they make much less mess than previous containers and offer an even greater reduction from the cans, bottles, and speciality papers used for containers elsewhere. The vegetable-based snacks can compete adequately as meat substitutes, especially in preference to the American hamburger and the European sausage (which are becoming the most resource-extravagant obsessions of the Orient). Compounded single-cell protein, like the pond-grown algae from Taiwan and Japan (*19*), should soon start appearing in packages like these to complete the image of high status food. However, quality control must be vigorous and trusted if people are to accept packaged foods as a major component of the diet.

Planned diet shifts for surplus people crowding into the urban areas may be anticipated as follows.

1) Green vegetables, roots, tubers, and small fruits grown intensively within the boundaries of the settlement can replace some rice and cassava (products now imported from Taiwan, Malaysia, and Japan) (*20*).

2) Single-cell protein, substituting for soy beans and peanuts, can enter the diet through soups, flavorants added to a starch dish, and manufactured snacks (as in Taiwan and Japan).

3) Carp, tilapia, clams, and shrimp that eat algae grown in sewage can be used to recycle the fixed amounts of nitrogen and phosphorus back into the urban food web; these items would replace beef and chicken satay in the diet (ponding techniques are those of China and Japan).

4) Rice, cassava, maize, sugar, cooking oil, legumes, and (possibly) potatoes and yams brought in from the countryside will constitute perhaps 60 percent of the caloric intake of people living in urban areas, although consumption of these products would represent only a quarter of the food intake by weight.

5) Wheat, rolled oats, rye flour, soy beans, and other foodstuffs from the temperate zone can be imported in small quantities (from Australia), presumably in exchange for spices, sugar, and tropical fruits.

6) Nuclear power plants planned for Java should be designed to allow their waste heat to be used for desalination of seawater and the acceleration of growth in mariculture. Properly planned, the nuclear complex could substitute for holding a large stock of grain and oilseed in case of a failed monsoon (*21*).

7) Indonesians should extend their offshore drilling experience to enterprises that exploit the sunlight that falls on their shallow inner seas. Mariculture that converts kelp into food would be welcome (*22*).

8) Food processing industries must encourage the opportunities that flow from the discovery of another path (via glycolic acid) to photosynthesis, which promises to be particularly important in a humid tropical environment. In ideal growing conditions this biochemical process permits yields from genetically reconstructed plants to reach levels recorded in sugar cane and maize (*23*).

9) To match the choice in China or the West, consumers should eventually be able to choose from several thousand food products—the bulky perishable types produced close to the consumer should be balanced by packaged items distributed throughout the region.

For an adequate level of living, it is expected that each person will be allowed a million calories per year for his diet, of which 10 to 15 percent would not be consumed but most would enter the recycle system. With Javanese cultivation it is anticipated that 12 to 20 tons dry weight per hectare per year could be produced—enough to support 50 to 80 persons per hectare. If 60 percent of the caloric value is introduced from the outside of the urban area—requiring, roughly, a

doubling of current rural production—and each household is allowed 150 square meters of public and private living space, the density for the "urban village" engaged in intensive gardening is about 43 to 64 persons per hectare (11,000 to 16,000 per square mile). This is a respectable urban density; it can be served efficiently if it is clustered around transport corridors.

A New Kind of Megalopolis

Initiation of new growth in urban settlements through self-help procedures has been outlined by Laquian (*24*). With the resulting high densities, metropolitan services can be distributed with less demand on scarce resources. Within a decade or two, telecommunications, mass transport, higher education, world trade, advanced medicine, high culture, and opportunities for travel (pilgrimages to Mecca have early priority) will penetrate the self-built communities, eventually transforming them into indubitably urban districts. Much of the Japanese post-war experience, good and bad, is relevant here.

Very critical to the completion of the urbanization process is the creation of a water economy similar to that of Israel. There, underground flows and aquifer volumes are entered into the supply accounts as carefully as surface flows and reservoirs. This information facilitates a calculation of what land reclamation will be economic by determining how many people can be fed and sheltered within each watershed.

When the settlement program associated with the demographic transition is projected into the future, and when the most suitable remaining land is occupied, the agglomerations will be linked and a scarcity of access to metropolitan services seems likely to be felt. Airlines and "bullet trains" will then be needed. However, an invasion of the seas to the north would provide desirable living space. The overspill can be directed to floating communities, organized in ways complementary to those that occupy the adjacent wetlands. Lifestyles of the present water people of Indonesia, mainly uneducated fishermen, will almost certainly be rejected in favor of urban forms similar to those now arising in the marinas of North America and Japan (*25*). By accepting the sea as suitable habitat, Java does not run out of living space, even for somewhat higher degrees of urbanization than now anticipated (Fig. 2).

What stands out most prominently, whether on land or sea, is the need for progressive self-organization—the social function of urbanization (*26*). New organizations take the form of firms, companies, societies, syndicates, cooperatives, unions, bureaus, offices, agencies, authorities, associations, clubs, teams, groups, ensembles, collectives, parties, gangs, and many others. A viable organization has at least a name, an address to which messages can be delivered, and a charter, including a mechanism for replacement of individuals in key roles. As these organizations accumulate, social development progresses and politics becomes increasingly an interaction between coalitions of these groups.

In Indonesia the most serious lack is for organizations at the intermediate level, where capital is scaled at around a thousand to 10,000 times the annual subsistence wage. The number of employees may be as few as 30 or as many as 3000, depending on the technology, but all organizations require at least one professional manager. As organizations emerge they need better data on the actions of their suppliers, operations, and members so that waste of resources can be prevented. Statistical abstracts published annually like those of Seoul would accelerate the improvement of organization. Finally, a modern cultural synthesis is needed to advance the creation of national language and arts, since these activities channel creativity into directions that do not require extraordinary amounts of scarce resources.

The urban ecosystem to be expected when population growth is closely approaching a steady state could serve as the new goal for the society, and the targets in successive Five Year Plans could mark progress in this direction. A carefully constructed scenario has been prepared at human scale as a first proposal for what this stage might look like for Java (*27*). It presumes that the deficiencies in the present society will be overcome and pitfalls along the way will be avoided, both by Indonesians and the societies to which their future is most closely linked. Once an apparently feasible, yet satisfactory, outcome has been formulated, people become more conscious of the new scientific, technological, or philosophical developments that cause us to change our image of the future (*28*).

Conclusions

The habitat of man at the time that the world reaches steady state must have a predominantly urban character, mainly because no alternatives have been proposed that will support such large numbers of people. A pathway to stable population and adequate levels of living can be worked out even for the most difficult cases—densely populated societies now near subsistence. Java serves as a fair example.

From the Third World come crucial contributions to the needed urban transition, including (i) invention of added inducements to limit human fertility; (ii) self-help settlement with decent environmental standards; (iii) energy-saving transport systems; (iv) arrangements for economical domestic water use; (v) techniques for intensive food production in town, combined with waste recycling; and (vi) social institutions that extract human satisfactions and cultural productivity from high densities of people and artifacts. These recent innovations now exist, often separately, in only one or a few isolated locales; therefore accelerated diffusion is necessary.

Indonesia's greatest lack now is varied formulas for intermediate level self-organization for the provision of a broad range of services. An improved apparatus for gathering data is needed to collect information representing the true state of affairs instead of polite fictions. If Bangladesh, Egypt, Nigeria, or some other case had been used as a model, it seems likely that the critical deficiencies identified would have been similar but the immediate steps to be taken in meeting them would be different.

References and Notes

1. Neo-Malthusians gained public attention for a while during the decade after World War II. F. Osborn's *Our Plundered Planet* (Little, Brown, Boston, 1948) was one of several warnings of hard times to come. Even then, the technologies that could support the world at levels well above subsistence could be identified. They could be fitted to a quite tolerable "minimum adequate standard of living" (*2*); however, such technologies could not be developed rapidly or disseminated widely during two decades of declining costs for energy, water, and food.
2. R. L. Meier, *Science and Economic Development* (MIT Press, Cambridge, Mass., 1956).
3. Thus far the adjustments to energy scarcity have produced the most pained responses on the part of consumers, so the price changes were moderated by administrative action. Indicative of the new rationalization is the energy budget in the program commissioned by the U.S. General Services Administration for a pace-setting office building in Manchester, N.H. [Dubin-Mindell-Blum Associates, *Energy Conservation Guidelines for Office Buildings* (General Services Administration, Washington, D.C., 1974)].
4. Sophistication can only be expected about now, primarily because we have seen three decades of relative peace in the Third World countries, during which localized social learning could occur with minimum likelihood of disruption. Expanded opportunities for commerce have also been available. If one imagines several thousands of communities challenged to invent solutions to common problems, starting from radically different traditions, he expects a few of them to build innovations on innovations and make social adjustments to the result. Usually it takes at least a decade after an innovation has been verbally expressed before it can become well established.
5. Many city dwellers think of the rural village or the farmstead as a secure haven in a food crisis. During World War II people in cities starved while farmers still had food. A review of the history of that period reveals, however, that the urban shortages were caused by military operations or by intervention that prevented the cities

from drawing on international food stocks. Henceforth, when stresses caused by scarcity of food are most extreme, city populations will often be bloated by refugees from devastated rural areas. Peasants know that they must pick up their households and move when local water supplies run out and food stocks are insufficient to maintain them to the next harvest. In these circumstances cities switch to other suppliers—even to the extent of liquidating capital—and buy food from overseas. This is feasible because they could not have become cities without a transport capability that is sufficient to handle changes in the sources of supply. When desperate cities draw on world food stocks, other cities will feel immediate price increases in their wholesale markets.

6. The model formulated by M. Mesarovic and E. Pestel [*Mankind at the Turning Point* (Dutton, New York, 1974)] is relevant but not very explicit in its recommendations. They pose the issue of large-scale urbanization in South Asia, the most problematic of their ten regions, but explore the implications no further. The solution their model offers for minimizing the likelihood of Neo-Malthusian catastrophe does not differ from the one inferred in (*2*). They show that future urban development is necessarily limited by global scarcities, agreements about fair division, and the absence of long-term dependence on food aid, while requiring effective population control and widespread diversification of industry.
7. It is no longer possible to achieve an overview of solid state physics and its applications to "entropy machines." But see W. O. Baker [*Am. Sci.* **62**, 83 (1974)].
8. The modern concept of steady state was first applied to sociocultural systems with the use of Indonesian case studies [G. Bateson, in *Social Structure: Studies Presented to A. R. Radcliffe-Brown*, M. Fortes, Ed. (Oxford Univ. Press, New York, 1949), pp. 35–53]. D. Schon [*Beyond the Stable State* (Random House, New York, 1971)] describes the social learning process in public and private organizations and raises the question of how information is to be collected that tells decision centers in society about deflections from the norm, the resources available for restoring the stable state, and the social technologies that can use these resources effectively. Indonesians have just begun their perspective planning effort. Thee Kian Wie ["The Indonesian Economy Toward the Year 2000: Problems and Prospects" (LEKNAS, Jakarta, February 1975)] laid out some of the domestic product and per capita income estimates. Policy issues were introduced by Sumitro Djojohadikusumo (*9*) and policy statements were discussed by the National Preparatory Committee on HABITAT (*10*), both of which use projections by Iskandar.
9. D. Sumitro, *Indonesia Towards the Year 2000* (National Academy of Sciences, Jakarta, February 1975).
10. National Preparatory Committee on HABITAT, W. Rachmat, chairman, *Human Settlements in Indonesia* (Bandung, May 1975).
11. R. I. Meier, *Planning for an Urban World: The Design of Resource-Conserving Cities* (MIT Press, Cambridge, Mass., 1975).
12. G. W. Jones, *Pustaka Universitas* **43**, 39 (1973).
13. Population Council, *Studies in Family Planning* 1973–76, international comparisons of progress in population control.
14. In all instances attempts are made to appraise current conditions rather than report official statistics at some past date. A useful source for understanding the population dimensions is provided by G. McNicoll and S. G. M. Mamas [paper presented at the Population Association of America Conference, April 1973, Central Bureau of Statistics, Jakarta (mimeo)]. I thank M. Soetedjo, J. Clinton, and others from the National Family Planning Coordinating Board for providing a thorough statistical base for making planning projections. M. Tan [in "The Social and Cultural Context of Family Planning in Indonesia" (LEKNAS, Jakarta, 1971)] introduced me to the unique family characteristics prevailing in Indonesia. N. Keyfitz [*Bull. Indones. Econ. Stud.* **9**, 107 (1973)] provided a link between theory and outcomes. Discrepancies, apparently caused by the closing of the city to immigration, were revealed by P. F. McDonald [*Pustaka Universitas* **43**, 33 (1973)].
15. The status of women in Asia has advanced most rapidly in the metropolitan areas. There it has been associated with higher levels of education. In some societies (Java may be one of these) urbanization is associated with the loss of the woman's entrepreneurial role in the marketplace, a loss that reduces opportunities for employment at a time in life when access to the offsetting opportunities for increased educational facilities is extremely limited [R. B. Dixon, *Rep. Popul. Fam. Plann.* **17**, 1 (1975)].
16. The puzzles about the underlying reasons for excess fertility were reviewed in a number of ways by the prime minister of Singapore, K. Y. Lee (*Singapore Straits-Times*, 25 January 1974, p. 8), as he rehearsed the options available to a government intent on achieving a demographic steady state. Singapore policy had already employed more coercion than any other open society when it declared that the third child and all succeeding ones would become "socially illegitimate" in the sense that each of them would be required to attend different public schools outside the neighborhood, thus being prevented effectively from participating in community affairs that revolve around the school. This threat can be outflanked only if the family has enough money to send all of the children to unsubsidized private schools. Extreme policies like these are not recommended to Indonesia before the degree of attendant backlash is understood. However, the final statistical effects of these strict policies were in the desired direction, perhaps because they were reinforced by superstitions concerning the characteristics of girls born during the Chinese Year of the Tiger [S.-H. Saw, *Stud. Fam. Plann.* **6**, 166 (1975)].
17. J. E. Laing, *Natl. Fam. Plann. Coord. Board Q. Rep. No. 4* (Jakarta, 1975) (mimeo).
18. An unpublished review of appropriate technology for passenger transport already in use in a wide variety of Asian metropolises was prepared by A. K. Meier (Department of Chemistry, University of Pennsylvania, Philadelphia, 1975). The original inspiration for these vehicles seems to have come from England, Italy, and Japan, but marked initiative in the three-wheeler market is now being shown by Greek firms. South Vietnamese entrepreneurs developed a passenger-carrying bicycle suited for mixing with the pedestrian and Honda motorbike traffic. South Asians have a versatile three-wheel scooter cab that is displacing regular taxis. The most sophisticated designs for pedicabs are still found in Penang, despite lack of interest on the part of authorities. Manila, Hong Kong, and Bangkok have evolved some remarkable jitney services. Madras gets unusual performance from its bus system. The next major development will probably be the introduction of mopeds with 1- to 3-horsepower engines; they would add another 10 kilometers to the commuting range of industrial and commerical employees. Handcart designs are much more distinctive because artisans adapted materials at hand to local needs. The Korean two-wheel, push-pull cart with reinforced bicycle components appears to fit a wide variety of requirements and may well be the most efficient solution yet for locales with low incomes. The industrial bicycle is also an effective substitute for a minivan when wage rates are low. The light South Asian hawker's cart (four cycle wheels) can also serve many urban uses. Oxen, mules, donkeys, and camels seem to have declining value for goods transport in cities because men, aided by improved levers, are taking their place.
19. Most of the single-cell protein synthesis projects produce algae, bacteria, fungi, and yeast for feeding cattle, pigs, chickens, and fish. The world market already open to them seems to be about a million tons per year if it is produced within a cost range of $300 to $500 per ton [K. J. Skinner, *Chem. Eng. News* **53**, 24 (25 May 1975)]. Japanese firms quite understandably have been responsible for a large share of the pacemaking early investment in process designs. Hopes were dashed, however, when a cancer rumor about hydrocarbon feedstocks for bacteria spread through the press. The most promising energy source that avoids these possibilities is methanol—a simple industrial chemical that will be increasingly synthesized from natural gas that is now flared during the production of petroleum. In the long run it is anticipated that textured protein resembling meat will be made by spinning and forming single-cell protein [F. Huang and C. K. Rha, *J. Food Sci.* **36**, 1131 (1971)]. Textured protein created from soybean meal entered the American supermarket in 1973 and will play an increasing role as an acceptable meat substitute. Various green algae and a few nitrogen-fixing blue-green algae, such as those now grown in Japan, appear to be the most likely long-term soybean and peanut substitutes.
20. Transformations in Japanese vegetable production foreshadow changes in Taiwan, Malaysia, Indonesia, and the Philippines, despite climatic differences. Their yields of tomatoes, Chinese cabbage, and radishes run 60 to 70 tons per hectare per crop. At the margins of major metropolitan settlements "green land" is designated for cultivation, and 20 to 40 different crops are grown on each small farm. The farmer retains about 40 percent of the retail selling price (more at the local farmer's market), and his agricultural income makes up less than half of the family earnings [M. K. Kambe, in *Some Studies of Fresh Fruit and Vegetable Marketing in Asia*, H. Southworth, Ed. (Agricultural Development Council, New York and Singapore, 1974), pp. 106–132.
21. R. L. Meier, *Ekistics* **26**, 419 (1968); *Bull. At. Sci.* **25**, 16 (1969).
22. Seaweed remains virtually unexploited although it offers a means of maintaining photosynthetic rates as high as in the best forest and grassland. Repeated field reports from studies carried on throughout the world suggest annual yields of 40 to 80 tons dry weight per hectare. Thus far the industrial use of seaweed has failed to materialize because the protein is difficult to extract and the principal components, mannitol (a soluble reduced sugar), laminarin (a relatively indigestible carbohydrate polymer something like cellulose), and alginates (oxidized sugar polymers) are not in significant demand. The natural kelp forests are preyed on by bacteria and sea urchins, which in turn support lobsters and sea otters. The detritus will support abalone [K. H. Mann, *Science* **182**, 975 (1973)]. Mariculture of lobsters and abalone would probably return less than 1 percent of the solar energy fixed, thus keeping these food sources in the luxury class. If a large-scale transformation to a paper substitute or a fermentation process is worked out, it might be possible to raise nitrogen-rich deep water that contains phosphate from the south of Java to fertilize kelp growing in the shallower areas north of the island. Such industries could sustain millions of people living at sea or on small islands (H. A. Wilcox, personal communication).
23. Broadleaf vegetables (spinach, bean, and the like) have a tendency to lose an important share of the carbon dioxide they fix from the air for conversion into organic substances. This loss process is called photorespiration; it is genetically inhibited in a few domesticated grasses and weeds (maize, sugar cane, sorghum, pigweed), thus allowing them to produce much more organic material from tropical sunlight than do other crop plants. Recent experiments suggest that it should be possible to breed many crop plants so that the photorespiration is similarly inhibited; increases of yield of as much as 90 percent under optimum growing conditions should result [I. Zelitch, *Proc. Natl. Acad. Sci. U.S.A.* **70**, 579 (1973)].
24. A. A. Laquien, *Science* **192**, 950 (1976).
25. This description of an active life on the water with minimal personal property is based on interviews conducted by journalists among residents of early prototype houseboat colonies in America and Europe. In large-scale aquatic settlements, graduated alarms sounded from the communications satellite overhead during storms would signal a disciplined battening down for all small craft and, on the worst occasions, general resort to cyclone havens on atolls or stable floating structures. Thus the rhythms of life would not be very different from those of the water people of Hong Kong [E. N. Anderson, *Floating World of Castle Peak Bay* (American Anthropological Association, Washington, D.C., 1970)].
26. Exercises like this are intended to aid foresight in planning transport, reclamation, and watershed development [R. L. Meier, *Inst. Urban Regional Dev. Working Pap. No. 213* (Univ. of California, Berkeley, July 1973)].
27. R. L. Meier, *Inst. Urban Regional Dev. Working Pap. No. 259* (Univ. of California, Berkeley, September 1975). The content of this article makes up a part of that working paper.
28. Since about 1965 the attention of development technologists has been concentrated on intermediate or, more recently, appropriate technology [N. Wade, *Science* **189**, 770 (1975); Office of Science and Technology, *Appropriate Technologies for International Development* (Agency for International Development, Washington, D.C., 1972); S. Sapiie, *Indones. Q.* **3**, 37 (1974); W. J. Waworoentoe, preliminary reports from the Institute of Technology, Bandung, 1973. Long-range planning must take into account the needs for successor developments in evolutionary sequence, as well as the anticipated short-term improvements in efficiency.