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DESIGN OF RESOURCE-CONSERVING CITIES

Part I

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Fourth Draft

PREFACE

The ideas behind these studies upon future urbanization have been growing for a long time but they came together while I was a member of a team of planners working with the Venezuelans in 1965. Five years earlier the Venezuelan government had decided to build a new port city on the Orinoco River with the specific intent of maximizing the social product obtainable from the extraordinarily rich combination of resources in the region.

In many ways this was an ideal assignment for the American planners convened by the Joint Center for Urban Studies of Harvard and M.I.T., because the hypocrisy and autism normally associated with "foreign aid" was not present; the Venezuelans had committed a large part of their oil royalties for the implementation of the development plan and were willing to pay for the best advice available. This was not an exercise in Utopianism but a practical effort to accomplish as much as possible for the nation as a whole within a short span of years.

Gradually the vision of a new city of more than a quarter of a million people was built up out of the cross-currents of proposals, critiques and experiments in the field. Meanwhile immigrants were arriving at a rate of a thousand a month to occupy the site of the new city; a smaller, variable number left disappointed. Over 75,000 were in residence before the consulting planners departed.

Most of us from the United States had gone into the project hoping to learn through experience how to plan and design humane cities that were capable of developing regions and possibly whole societies. The outline plan for Ciudad Guayana may not have been optimal, but it was close to the best that planners from developed and developing countries, when yoked together, knew how to do. Nevertheless, as I reviewed the prospects, this was a kind of plan that should never be done again on this scale or any larger one. Although designed to develop and export natural resources, this city was too wasteful of those resources to be repeated elsewhere. No combination of deposits of highly marketable minerals, waterpower potential and forests is ever likely to be found so close together again on this earth. Reluctantly I came to the conclusion that although the approach taken was adequate for this instance, I could not as a responsible planner transfer what I had learned to other places in the world. That determination set me to speculating how a developmental metropolis should be planned when, as would be universally true in the future, the society has limited access to natural resources. What strategies were open that would conserve these resources?

Thereupon I found myself working many hours at night in a small Caracas hotel room spelling out policies for conserving water, energy, materials, capital and human time, while during the day at the office my calculations for the Guayana region of the 1970's were allocating them almost profligately. I knew that my contemporaries working on urban development in India, Pakistan, Nigeria, Turkey, Thailand and elsewhere were reaching approximately the same official recommendations about

the resource mix as the teams with which I worked, because we were all using world prices and had available to us the same basic urban technologies. Our proposals could not be completed however, because even if those plans were accepted for the development of these countries, severe scarcities would appear and frustrate them. My knowledge of geology and technology was sufficient to recognize that the anticipated urban population was so large its needs could exceed prospective supplies by two to five fold. I felt a bit uncomfortable in the role of a professional who presumed he was doing good as well as he knew how but who also recognized that he was reinforcing a trend likely to resurrect the Malthusian spectre, through the lessons he was teaching by example.

The foregoing arguments were sufficient to explain my concerns to others, but were still too superficial to suggest solutions. I also needed a conceptual framework which indicated how an assembly of new facts and ideas might shift strategies for development. That framework did not exist in any single discipline, but would have to range over a number of established fields and encompass subjects that had still not emerged from the mother discipline -- philosophy.

I would have been incapable of thinking of urbanism as an outgrowth of living systems had it not been for associations with James G. Miller, Ralph Gerard, Anatol Rapoport, Kenneth Boulding, John Platt and the circle around them starting ten years earlier in Chicago and Ann Arbor. They patiently (and on some occasions impatiently) disentangled nested levels of organization and formulated a number of cross-level principles.

As a consequence, it became possible for a few of us to jump to the realization that the city may be usefully considered to be a self-created environment that determines the continuation of the evolution of the human species.

A trenchant memorandum was written, and the Ford Foundation responded with a grant for sabbatical travel, enabling me to see first hand the changes wrought within cities by economic development in Japan, and the means of coping with unprecedented residential densities in Hong Kong. I was able to observe how the Industrial Revolution with its strong organizational implications was being installed quite ingeniously by all kinds of Indians in the alleys of Howrah and other smoky extensions of Calcutta, but disastrously in the huge complex adjoining the new city of Durgapur. However the threat of famine became very real at that time, so I moved on to other cities where I developed further a technique for identifying new developments in a metropolis when the native language was known only through a dictionary.

Since then I have been particularly indebted to students who came from all parts of the University, and from many countries of the world. First in Ann Arbor, and then in Berkeley, they enrolled in classes on Regional Development and Futures of Urbanism and the City. There the implications of resource-conserving strategies were mapped out for several of the metropolises where conditions were due to become critical over the next several decades. Other

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trips to Asia were undertaken with the help of a small grant from a fund provided by the Ford Foundation for overseas training in professional schools.

I am indebted in a very different way to the National Institute of Mental Health, particularly its Metro-Studies Center, for a grant entitled "Gaming Simulations of Community and Social Organization." It provided an opportunity for experimentation with new techniques in modelling urban development and yielded a variety of new insights, particularly for testing political and administrative feasibility. The Institute of International Studies and the Center for South and Southeast Asia at Berkeley assisted me in making further checks in the field, and for library research as this stage of the study was being completed and a follow through organized. The staff in the Institute of Urban and Regional Development helped produce the intermediate working papers and drafts. Kiki Skagen Munshi and her South Asian experience became available at a critical time, as did Arthur Stamps and his design background. It always comes as a shock to an investigator to discover how many persons spend so many hours for the preparation of a single book. The efforts of others in this case are estimated to have required five times as many hours as were put in by the author, and the majority of them were unpaid.

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INTRODUCTION

What follows is really a contribution to economic development, but it rarely uses strictly economic argument and does not fit into the genre devoted to Gross National Product maximization. It is also a study devoted to the achievement of social justice but it seldom uses the language of socialist ideology or of advocacy. It attempts also to introduce a needed reformulation of city planning that will be needed soon. The conceptual framework encompasses all of these and more, so the problem of choosing what language to use, and how to order the ideas, became a very serious one; there is no line of progenitors which sets a tradition for this kind of discourse.

I chose a living systems idiom for two kinds of reasons. The first has to do with structure -- it is multi-leveled in abstraction and therefore powerful enough to encompass a wide variety of phenomena, yet it is open enough to admit bodies of independently conceived theory. Economic principles then become special cases of ecological principles, and technological forces can be made to serve instead of dominate. Politics and culture can be conveniently superimposed as developmental potentials. Ecology is obviously a more suitable frame than organismic biology because the urban world almost always lacks purposive control and a discussion of the future of cities requires a macro outlook.

The other reasons for adopting living systems modes of discourse, instead of sociological, politico-economic, or journalistic, lie with the audience. A new readership is coming into being. The wave of environmentalist enthusiasm in the 1960's brought about a popularization of ecology -- a word stretched to include an ideology, a body of legal opinion, a dogma, an ethic, and an esthetic that shared very little meaning with the scientific subject of many decades standing. Nevertheless the movement generated a huge amount of curiosity; ecology was adopted almost everywhere in America, and increasingly in Western Europe, as a component in general education. Humanists were forced to admit its relevance to their concerns and they, too, began to read widely in the subject. The principal transmitters of ecological concepts overseas are those young people who feel comfortable communicating in the English language in addition to their own. In Asian cultures, in particular, they found the holistic outlook of ecology very appealing, and the new kinds of political action it engendered were very exciting. Penetration of other parts of the world has been significant, though it has proceeded more slowly.

The mood transmitted by the environmentalist movement has been one of antipathy for the city and its technology. They are viewed as joint causes of an impending collapse of natural systems and therefore, the formulation of designs for resource conserving urbanism must combat a series of preconceptions that have diffused world wide. This objective can be carried out most persuasively by starting with basic principles affecting the survival of man and his communities.

Biologists long ago pointed out that the fitness to survive and reproduce in humans is now determined more by cultural factors than by the challenges presented to individuals by the natural environment. Fitness now depends neither upon quickness of wit nor upon alertness to threat. Brawn is equally obsolete. It represents the capacity of a population to survive and reproduce itself in a given matrix of environmental forces. Cities have encapsulated a variety of significant cultural forces, causing them to become loosely institutionalized so that most individual crises are succored now by some body of specialists, such as doctors, police, welfare workers, etc. by differentiating peoples into social classes and occupational groups, cities are introducing new capabilities for the collective control of the total environment of man. Once these conditions are recognized, we can proceed to ask what selective pressures exist that are traceable to the kinds of competition maintained in the urban environment. What are the genetic and somatic characteristics of the generations that will succeed in getting along in urban environments while consuming much less in the way of familiar natural resources per head than city dwellers at present?

Some of the facts cause apprehensions of doom. Note, for example, the larger implications of the principle stating that once a species has established itself in a new environment its biomass increases to a level close to the limits set by the energy chain. This can be disastrous for a growing population that is rapidly depleting limited supplies of both its fossil and fissile fuels. The generalization drawn from living systems theory causes us to measure the biomass

of man, comparing it with what is known about other species, leading to the discovery that Homo sapiens appears to be second already among all species, while the first -- a combination of some 231 breeds of cattle -- is a species that is now fully domesticated by man. Its fitness depends upon human protection and manipulation. Most of the other plentiful species, plant and animal, have also been domesticated. Moreover present trends suggest that humans will shortly reach the top in the protoplasm contest, and that most of the human biomass will converge upon cities for life supports because systems involving the closely integrated organization promoted by urban life can be more efficient for utilizing scarce resources than those that are dispersed over a countryside.

As cities have grown and developed, they have streamlined the food web so that an increasing proportion of the original calories of energy fixed from sunlight is used in the metabolism of the city. Surprisingly, though hortatory argument abounds, there is no scientific literature as yet which takes up the synthesis of balanced urban ecosystems, even though millions of dollars have been expended in researching closed systems for spaceships. Fortunately, one can find abundant bits and pieces, even some subassemblies, in the technological literature so that several quite different systems for the transfer of energy and recycling of protoplasmic building materials can be proposed that appear to be both technically and economically feasible.

Back in 1965 the idea of recycling certain key components, such as water, phosphate, fixed nitrogen, metals, and polymeric materials

of construction was rather novel. Shortly thereafter the recycling concept was picked up as a popular fad and then incorporated into the ideology of Nature worship. It has by now accumulated many unneeded connotations so that public discussions can generate many misunderstandings. For all of this, an economically integrated program for recycling, a true urban metabolic system, cannot yet be found in the literature, and it is time that the attempt at formulating such a program be made for situations where scarcities are most keenly felt.

Constructive approaches to meeting a food and energy crisis do not follow directly from ecological analysis. The living system, as understood by biologists, has directions for development or evolution but not goals. It is influenced in the directions it takes by forces and structures in the environment, but it cannot make decisions that are subsequently implemented. The living systems theorist plays the role of external observer-analyst, endeavoring to discover an economical means for presenting the range of possibilities that actually exists for the continuation and evolution of man, while estimating the likelihood of each distinctly different outcome. As long as he employs the discipline of biology, or of "black box" psychology, he remains an outsider to the system, similar in many respects to the traffic analyst interpreting the movements of impersonal automobiles and trucks through a maze of freeways, arterial roads and parking places. Both are able to provide warnings based upon observed trends, but observational science by itself offers no strategy for avoiding catastrophe.

In fairness, however, it should be said that the observational methods occasionally identify points in the system where a small intervention can have amplified effects of a largely predictable kind. Nevertheless, for decision, or calculated avoidance of inferior alternatives, we must start from inside the living system. We must look at the individual in the population and his means for affecting his immediate environment by interacting within a group or by his participation in institutions.

This other body of systems thinking applicable to cities starts from a belief that man can gain some control over his collective destiny. History shows that there have been ways of evading catastrophic losses in life and welfare of individuals, arising from famines, epidemics and breakdowns in social order, which may be quite independent of biological forces influencing the survival and maintenance of populations. Strategies for planned action can advance the middle run welfare of individuals and their organizations.

My behavioral model of the typical autonomous urbanite presumes he bargains with organizations, offering a portion of his own time, effort, and attention in order to obtain goods and services. He walks around in a synthetic environment viewing the living system from the interior as a "participant observer" who is altruistic on only a few occasions, follows along in the rut of tradition most of the time, while calculating self-interest on a number of occasions.

An individual living in a metropolis must make repeated decisions about what niche is best for himself. In order to make satisfactory decisions for himself, however, that individual needs to have a relatively stable environment which holds a large share of the less important factors constant. It should not be dead or static, but offer a limited variety of opportunities for self-improvement at low risk to himself, and provide a basis for ordering his decisions. A review of the ways in which urban dwellers spend their time suggests that they allocate 10-30% to restoring order in their immediate physical environment. This is time spent in personal grooming and the maintenance aspects of housekeeping. However, an even greater amount of attention is devoted to making choices for others -- family, friends, peer groups, face-to-face associations, firms, offices and others. In all of these a kind of micro-order must be created by cooperation. There the individual needs to appear altruistic or conforming in order to gain the needed cooperation of others.

The urban system, from the insider's vantage point, is no larger than the microcosm which includes the detectable effects of a choice. External effects tend to disappear the further one moves away from the locus of that choice. Normally the initiation of a branching chain of transactions is reviewed in prospect and the net consequences calculated. The problems of project appraisal are well known to economists, because they have specialized in formulating techniques for optimization; the individual is assumed to use the same approach to choice but in an informal way. These methods

fail frequently in the metropolis, however, because unprecedented chain reactions can occur very easily in a densely packed space. Experiences with unanticipated reinforcement or a damping out of secondary effects of a choice cause the decider to ask for much more information about his immediate environment and he wants this information at very little cost to himself. Control over the essential features of the urban environment therefore depends upon a flow of relevant information to a population of decision makers acting relatively independently of each other.

Increasingly, therefore, the urban environment must be designed to produce reliable signals for the micro decision-makers. It also needs to record data on its flow of transactions for the managers of the environment to assess. They, too, must improve their strategies for conservation and utilization. Almost certainly there are ways of defeating the stringent effects of the aforementioned biological principles, or at least ways for deferring or mitigating their impact. This hope seems most possible in the modern metropolis, because the dependence upon the chanciness of weather and disease has been greatly reduced by constructing an artifact surround.

A participant's view of urban control systems draws upon law and tradition for its source of order. Physical property and the spatial ordering of the environment provide another set of phenomena one expects to remain constant for a sizable part of a human lifetime. These factors provide the setting for the metabolic

activity in the city, the system maintenance features that call into play a multiplicity of feedback loops. The modern city has evolved many mechanisms for reporting deviations from the steady state, and urban institutions have set up alarm systems for detecting shifts that may become destructive. Action mechanisms for restoring the status quo, or making an adjustment upon it, have often been prepared in advance -- contingency plans. Response times range from a matter of minutes in the market place to years in the case of some political and social reactions.

We need growth models for the metropolis that go beyond the shifts in structural proportions and spatial relationships as size increases. We need models for enhancing capabilities -- learning by planning as well as learning by doing -- of metropolitan decision systems. How can a Tokyo-scale economic development rate be installed in other metropolitan areas? How has this record achievement sometimes been improved upon as it is transmitted to Taipei, Seoul, Singapore and elsewhere? Tokyo comes as close as anything yet invented to the leviathan that reports continuously about itself to itself concerning how it is doing and what may happen in a few days or months. To its present regret Tokyo has discovered that it has much less competence in techniques for coping with the middle to long run; it has, for example, waited for pioneering to be done in America or Western Europe before attending to the effects of insults to the natural environment.

The modes of metropolitan government are obviously relevant to the social and economic development process, but so are the operations of headquarters offices of trans-regional and multinational organizations in both the private and public sectors because the relative competitiveness of urban regions shows up in the data assembled. Rapid improvements in security and welfare are possible when the mobile capital and skills can be attracted away from the less effective urban environments. Competition of this sort offers an indirect but higher order equivalent of "prediction at a distance." We need now the kinds of metropolises that not only can provide opportunities for life superior to those available in rural areas and the small towns, but are strong enough to compete with other large cities as the supply of capital, material, and scarce skills is expanded.

Therefore, the presentation of ideas must oscillate from the philosophical, detached observer's view of living systems to the internal, advice-oriented image of the way a city should work on the basis of what is known. The first allows me to gauge what new challenges cities may have to face in the future as a result of increasing size, age, resource depletion, and new knowledge available to all. The second allows me to find strategies, define policies or describe institutions that should be able to cope with the prospective challenges. The most powerful strategy appears to be that of expediting the self-organization of residents, sojourners, and immigrants, the best policy seems to be that of substituting information or communications channels

for the most scarce resources, and the key institutions are those that find devices for operating across national boundaries.

The principal difficulty is that of communicating to other observers who are intellectually anchored in only one of these viewpoints, but not both. The rules for disciplined reporting are violated. However, I shall commit these sins as long as productive insights emerge.

Chapter One

REDEFINING URBAN ECOSYSTEMS

Fourth Draft
March, 1973

Cities are due to become the normal habitat for man. When human populations are numbered in the multiple billions, the metropolis must become home for all but a minor fraction. Only in the highly organized, carefully designed, and globally interconnected metropolis does any hope exist for coping successfully with prospective resource scarcities. Cities must diversify activities, acquire new competencies, preserve knowledge, and accumulate structure in dimensions and directions that are only now becoming evident. In the long run they should be able to provide the stable, natural environment within which further evolution of living species, including man, will be accelerated.

The prospect is quite contrary to the widely circulated and commonly believed reports that our modern metropolises are about to die.¹ Actually our great cities appear to be undergoing natural changes due to maturation, since after a long period of growth starting from insignificant origins the rates of increase of the first of them to be established appear to be levelling off. Many associations and institutions in such cities are feeling the emotional storms and uncertainties that accompany adolescence. The most highly developed of the great cities of the

world -- London, New York, Paris, Boston, Toronto, Chicago, Stockholm and others -- must now anticipate a "middle-aged spread" with rates of increase in the range of 0-2 per cent per year in biomass and physical supports instead of the 3-10 per cent rates previously experienced. With maturity comes a willingness to engage in the creation of enduring organizations so that growth is transferred to a non-physical realm. Preservation, renewal, and conservation of scarce local resources then become the central issues for such cities, though elsewhere in the world the urgencies are more elemental. Newer metropolises must still learn how to overcome the grave threats to survival that arise from an increasing scarcity of natural resources and the consequent rates of social change.

Critics of cities usually repress facts embarrassing to their theses. They should be encouraged to explore in depth the recent histories of a few representative metropolises and compare their series of formal reports and statistics with others. Selecting any of the commonly used definitions of welfare they like, they should judge the shifts in such welfare generated in these cities over time. Those who have already done so cannot find a single city that is not a significantly better place to live for a majority of the population than it was a generation or so ago. The "bads" that have been recently recognized as potentially debilitating, such as the deterioration of atmospheric quality, traffic congestion, and crowding, are strongly outpointed by improvements in education, communications, most aspects of health, and in spatial mobility. More impressive yet is the performance

in meeting emergencies, because an ability to detect threats in advance and to mobilize resources to counter them is evidence for the viability of a community in the environment with which it must interact. Reduced typical reaction times, which can be used as sensitive indicators of improved capability to overcome crises, prevail all over the world.

The great fault in standard intellectual opinion about cities is that it arrives at judgments by comparing current urban conditions with concepts of what should be, and not at all with what has existed in the recent past.² Such specifications of ideal conditions are not invariant, but as information about best examples is acquired, and the technical possibilities that allow further improvement is explored, they are strengthened over time and made more demanding. It is not unexpected then that the gap that separates the present situation from the utopian ideal continues to grow larger, nor is it unanticipated that shortfalls will excite a litany of pessimism, anticipating that cities will become unlivable. Objective data that point to improving conditions are ignored, because they are not relevant to programs for action that hopefully will bring about truly substantial amelioration. Past gains, it is commonly believed, have been far from good enough -- because felt deficiencies have increased still more.

Having contested current "doomsday" doctrine by indications of the existence of strong contrary evidence, an alternative concept for visualizing future society is required. Simply stated it is the following: The fundamental problem for most people presently living and soon to be born is still that of survival, preferably

at a state noticeably above bare subsistence, not how to achieve affluence for everyone. Moreover, the emergence of levels above subsistence must be achieved with increasing equity. Since resources are limited, how might a secure existence which allows hope for improvement be achieved? What are the principles connecting scarce resources with the functioning of cities? It is possible to take them up in order: first the significance of resources for cities, and then the city as ecosystem in a synthetic (designed?) environment.

Metropolis as Resource Transformer

A living system is characterized by a set of inputs (or resources) and a set of outputs, with multiple, cybernetically stabilized pathways inside the system that effect the transformation. The metropolis therefore converts resources into something else; resources, together with the internal institutional environment, are used to grow people. The function of cities for generations to come will be to "create human capital" from inputs of unskilled immigrants and the newborn cohorts.³ The metropolis must gather in commodities won from the earth's crust and convert them into civilized, whole people able to make their way in an increasingly interdependent world. Neither waste, nor rubble, nor pollution should be allowed to accumulate, nor should instabilities in the internal pathways be permitted to develop to the point where they affect the survival and competence of the next generations.

As yet metropolises have achieved very little coordinated control over their resource supply or their own organization. The

national state still jealously retains formal responsibility for constructing modern environments and programming the development of human resources. Thus far national states have done little to increase the efficiency of the consumption process (although they have on occasion instituted effective procedures for equitable rationing), they tend to intervene in production schemes that draw directly upon natural resources in the hinterlands, insisting upon a more orderly exploitation. However nationalism is losing its hold upon loyalties and, with the spread of television, its control over character development. Multinational organizations are inventing ways of moving knowledge, cash, people, commodities, and organizational forms across national boundaries faster than new controls are being devised. Therefore the future opportunities for great cities are more diverse than at present.

What is a resource? Everyone has a generalized idea of what resources are and the ways in which they may be identified. Each of us puts minerals and forests and waterfalls into this category almost automatically. Any person living near the sea will add fisheries to the list. Those who are in food enterprises recognize the significance of the living soil -- micro-organisms, worms, moisture, and humus -- as a fundamental resource. More recently highly unusual environments, the kinds that excite wonder in man, have been marked as a scenic resource. The common meaning of the word is based upon these agreements between people with quite different personal experiences.

It is important to examine further the implications of the idea of a resource. It starts with some unusual quality found in a

locale that makes the area appear different from the typical physical environment. This difference is great enough to assign a functional name (e.g., clay banks, oil pools, pine woods, fishing reefs, fruit belts, waterfalls, and natural harbors, to name a few) to the type of locale. Each is a resource, however, only when the information about it can be combined with technological experience -- a body of human knowledge that can be passed along from one place to another and one generation to the next. Only then can the locale produce something of value to man and become a resource. The knowledge embodied in a technology is, by definition, general enough to be diffusible across cultural boundaries; it can also evolve or develop over time, accumulating small scale improvements as it is applied. Normally a technology is made up of a sequence of operations or processes that can be spelled out as a series of directions or recipes for what should be done with one or more resources in order to accomplish the conversion to a desired commodity or service.

The knowledge component of resource use has been increasing in quantity and significance over time. It is recorded in images -- diagrams, blueprints, laboratory analyses, mathematical equations, sets of specifications, technical terminology, etc. The resource has real value only if the effort invested in its use is more than compensated for by the returns to people. Most of the so-called natural resources in the world are not worth the expense involved in extracting or making use of them, and are therefore relegated to the submarginal class. They become true resources only when the scarcity of the primary commodities or services produced from such resources has increased, and price rises have occurred, or when a

significant improvement in technological efficiency has been established. Of the two, advances in applied science have been more effective recently in creating resources worthy of development than has a rise in prices brought on by the exhaustion of deposits of richer concentration.

Most of the common mistakes in future-oriented public policy can be easily avoided when thinking about resources as grounded in this information-based formulation, rather than upon depletion-obsessed doctrines. According to the teaching of a past generation we could look forward to a day when resources essential to civilization would be universally depleted; this would be a time when our great grandchildren would be doomed to a way of life sustained only by the renewable resources of soils, vegetation, and waterpower. Feature stories in magazines and newspapers and university lectures on conservation dwelt upon the hard times in the future brought about by the accelerated exhaustion and waste of our richest resources. These early projections were inadequate because they did not consider the specific effects of the steady growth of knowledge about technology, nevertheless this mode of thinking has continued up to the present.

The acquisition, storage, and transmission of knowledge are all uniquely human activities. Some individuals have greater aptitude for this work than others, but almost everyone can improve his mastery of such knowledge by the expenditure of time and attention. As natural resources are depleted, the knowledge about substitutes and alternatives that specific people possess or can quickly obtain may be drawn upon to prevent deprivation in the

population as a whole. As far as society is concerned, the possessors of knowledge are a resource -- the human resource produced by cities -- and as valuable and dependable as any options on a new discovery of oil or the mapping of a new fishery.

These recent insights are revelation; they greatly broaden the development strategy for a modern society. The planning horizon was once limited by the expected depletion time of energy sources, but now it can be extended by building up knowledge of substitutes that are more plentiful, just as nuclear fuels can replace coal and fuel oil by advancing the technology of nuclear reactors. Having dispensed with the misconceptions of the extreme pessimists, however, we should not make the mistake of extreme optimism. Energy and most other basic non-renewable natural resources will become relatively more scarce and expensive over time; their price is likely to rise as rapidly as that of skilled, organized attention by permanent employees.

The Interdependent Constituent Populations

Continuing this analysis of the urban eco-system we must consider the interactions of populations -- relations of men, machines, animals, and plants with each other and with the supporting environment. Knowledge about environment is acquired by men, but imbedded and stored as information and pattern in the other populations. When existing together as a community, the location, appearance, and responses of each of these populations is chosen so that it becomes better adapted to the others. Interdependencies can become very strong as the community matures and

approaches the climax stage. These inter-dependencies are not merely day-to-day relationships but of a kind that can heal wounds and redress insults as long as the injuries are normal for the community and have been sustained several times before. All the principles by which we have come to understand living systems apply, as well as others barely glimpsed as yet.

Human populations are significant forces in a wilderness, and controlling agents in the countryside, but in the city they became clearly dominant. Note that the plural has been used; the biologists' assignment of a single species to homo-sapiens is based upon the same criteria that are applied to animals -- the capacity to maintain a common gene pool -- but the peculiar properties of men allow them to transmit much more information from one generation to the next through nurture of the young and through highly organized social institutions than through gene recombination, so sub-speciation is exceedingly important. Cities have always had markedly plural human societies, and the tendency is toward increased pluralism rather than homogenization. When urban locales dominated by a single ethnic, religious, occupational, or avocational group (now often referred to as ghettos, quarters, or districts) are dissolved, several new sub-communities find a place in mosaic structure; in them a significant number of individuals study and discipline themselves voluntarily to a distinct set of traditions that maintain the community against forces of assimilation. Cosmopolitan groups do not demand total commitment of members, so a single individual may belong to several different sub-species and divide his time according to requirements for the roles to be

filled. Boundaries of the territories maintained by the respective populations are marked in ways knowable only to initiated members of the communities, because they are increasingly overlapping and interpenetrating each other in the multi-storied metropolis. An observer of the cityscape sees nothing but a jumble of partially decipherable pattern, but because he is an acknowledged member of some of the groups he will see the phenomena of dominance in the urban system with a personal interest not available to the field biologist observing a community of plants and animals.

The populations that men most dominate and control in the urban communities are machines. They are slave populations, imported mostly from other cities, that come in all sizes, appearances, and many specializations. In the workshops of cities that still operate close to subsistence, the transition from tools to machines is still incomplete, and the supply of the actuating juice of electrical power is not drawn upon universally as yet. The growth and elaboration of these electrical machines require a huge expansion of the segment of the human population specializing in their maintenance. More potent self-propelled species of machines, which range in dimensions from diesel locomotives and jet aircraft to wrist watches and battery radios, consume refined or predigested energy sources instead of electricity, consuming up to twenty percent of all energy in the urban community. An even greater proportion of the humans addresses itself to their direction and maintenance as a full-time income-producing occupation, and the population of the self-propelled species expands even more rapidly than their masters.

They entered the most advanced cities in the 1950s, and penetrated the poorest before the end of the 1960s. Just as the first wave of machines in the nineteenth century relieved humans of most of the backbreaking labor required for civilized existence, the automata, a prolific new breed of machines possessing complex cybernetic capabilities are relieving them of mind-deadening routines and similar drudgery.⁴ The basic input for these new machines is information, which may come from the physical environment through a sensor type instrument, from records of human transactions or, to an increasing extent, from the action of other machines. The automata of our era rarely locomote because they need minor but very steady sources of electrical power, but they are now going through a process of micro-miniaturization, reducing size for a given capability by a factor of a hundred, so that the 1980s will bring a huge variety of peripatetic automata. Normally automata affect situations and conditions at a distance through the networks and switching gear of a telephone system which was originally designed to meet human communication needs. Computing centers, which provide the physical supports for most of the automata, are coming into continuous contact with each other and most of the information-based transactions among metropolises are carried out through them with the aid of microwave beams that reinforce the coaxial cables.

This new population of actors does not seem to have affected the numbers of animals living in cities. The urbanized wild animal species are primarily parasitic upon man, living off of the surplus and inadvertent waste from his household. Rats, mice, birds and

insects are the most common, though they stay out of sight most of the time. Almost as numerous are the domesticated species of animals which have been bred into diverse strains and have extraordinarily little resemblance to the original wild type. Their associations with humans are very close and their presence is especially evident in the less densely populated portions of the metropolitan area, where individually they serve as human companions but carefully bred populations reappear as delicacies providing variety in the diet. Populations of the parasitic species are usually kept down to convenient levels through indirect controls over habitat and food supplies, while reproduction in the domesticated species is generally controlled directly by men. The biomass of these tamed species tends to range between 5-20% of the human, depending heavily upon the sub-cultural values attached to associations with them, since dog lovers, cat owners, equestrians, and bird keepers are usually quite different kinds of people. Some city dwellers are beef eaters, some consume pork, many like chicken, but quite a few are vegetarians. Modern cities maintain in addition large populations of domesticated animals at a distance on ranches and market farms, from which they import milk, carcasses, and packaged flesh. Others are hosts for communities of fishermen who engage in organized predation on marine life.

Very few of the plant species native to the territory occupied by the city can continue to live in an urban community. Even weeds, the wild species springing up untended in the less trafficked interstices, most often belong to the introduced category. In the parts of the city where activity is most incessant, domesticated trees,

shrubs, flowers, and grasses predominate. Their function is purely ornamental since the fruits, if any at all, are rarely harvested. Edible plants begin to be numerous when moving out to the edges of the metropolis; the ornamentals still hold sway in the land facing the roads but patches and rows of fruit and vegetable monoculture are found very often in the back.

A metropolis consumes huge quantities of vegetable materials, many of which are imported from great distances, but almost all of them have been pre-processed before arrival into commodities like flour, sugar, lumber, paper, cloth, and soap, and have been rendered sterile so that they can be safely stockpiled. Once introduced and digested, most of these plant substances also sustain life among the animal species and the micro-organisms.

Invisible plants in the soils and water bodies of the urban community are less modified from the natural state. Even the quantity of such life, considered as biomass, is not greatly changed, because the huge volume of imported organic substances needs to be decomposed. Thus ponds, streams, and tidal pools are likely to have more bacteria, and the soils have at least as much litter for them to decompose as elsewhere; the wild species of micro-organisms present are very much the same as those before urbanization. Civilization intervenes to the extent of introducing pure cultures for a few purposes -- domesticated strains of yeast for breweries, distilleries, and breadmaking, molds for cheese-making, and varieties of bacteria for commodities like vinegar or yogurt. Close inspection of the city also reveals that special cultures of aerobic and anaerobic micro-organisms are

maintained in large stirred tanks in sanitary facilities that have been explicitly designed to expedite the decomposition of waste organic matter. The domestication of the various micro-biological species has proceeded further in Japanese cities than in Occidental metropolises.

These populations, with all their relationships and transformations, are not as simple as suggested by the foregoing generalizations, but actually constitute the most complex ecosystem ever evolved. It must be further emphasized that they form total communities which are not in equilibrium. Many are invading new territory and expanding their dimensions by as much as ten per cent per year. Quite a few observers regard the growth as "cancerous"; Ian McHarg in his broadcasts calls it a "brown fungus" attacking the Earth. In North America the chief populations in the front lines of the invasion seem to be made up of a variety of piloted automotive vehicles, while in tropical Asia and Africa the frontiers of the metropolis are usually extended by human squatters, often accompanied by vehicles and domesticated animals.

Taken together, urban ecology is a fascinating subject. It is a pity that it is not studied as such, but only as a series of limited specializations. The term itself was appropriated by a subspecialty of sociology; bio-ecological investigators drew upon relatively undisturbed natural distributions to inspire their theories. Though ignored by the systems scientists, maintenance of the urban ecosystem has become a series of inter-related arts which are improved and transmitted from one generation of practitioners

to the next. Thus it is possible for the web of life in cities to become ever more intricate, and the overall system can more consistently restore conditions to the viable range than in earlier times. Neglect of this newly synthesized system cannot continue for long however, because a huge pressure of human population is building up in the countryside that requires life supports regardless of where they decide to reside and these can only be put together with the semi-manufactures and machines produced within an urban framework.

The Designed Urban Habitat

Cities contain the most intensively constructed habitat. Nature offers no real parallel for building and controlling physical environment, so theoretical systems based upon natural observations can be stretched to encompass cities only with difficulty. The structures are so elaborate that they are seen, when approaching a city, much sooner than the populations -- towers, office slabs, factory chimneys, water tanks, church steeples, and microwave relay stations come into view very often even before entering the first suburb. The first living population to be seen -- trees -- stand out at a somewhat smaller scale -- they are not only abundant but most are carefully ordered and spaced, thus moderating the severity for the eye of the architectonic structures. Once inside the city, where the populations actually interact, one sees objects at the scale of the individuals -- poles, fences, hedges, signs, mailboxes, waste receptacles, parking spaces -- all of them subject to certain constraints, because they are not randomly distributed, but are nevertheless in a kind of complex disarray

that produces low level generalizations. A practised eye, able to detect aging processes in materials, would note that networked sub-systems were introduced piecemeal into the built city, and the resulting local conflicts are either tolerated or treated cosmetically with paint or landscaping.

An efficient means for discovering order is to watch a modern urban precinct grow, from below the ground to the roof tops. Kings and emperors sometimes made it their lifetime ambition to will a new city into being, reserving many of the crucial decisions to themselves while delegating the major effort to architects, clerks, and builders. Today the launching of an urban shell is carried out by an entrepreneur backed by public or private corporations, the gestation period is about five years, and the period of high speed assembly is eight to fifteen years.

SCENARIO ONE

Creating a Contemporary City

The recipe for a modern new city, sans technique, finance, and style, is as follows: Take a few thousand hectares of land, well-drained, preferably with a rolling surface, used until then for orchards, pastures, and some row crops. Reshape the land form with bulldozers, scraping off brush, rubble, and sod from most hillsides. Fill the ravines and gullies, and guide the brooks into underground drains. Dig ditches in the flat areas to conduct away surplus runoff, and prepare special hollows for lakes, reservoirs, and ponds. Sculpt the hillsides into terraces 20-100 meters wide, but save a few middle-aged trees to break up the symmetry.

Set out stakes at measured intervals with coded plastic ribbons which tie into the blueprints for the next wave of construction activity.

Install a series of distributive networks on the site. First the street and road pattern is cut more deeply into the soil. Then ditchdiggers come to lay water lines and sewer pipe. A smaller machine can follow to put down gas pipe (soon to become an anachronism for new urban settlements, unless it becomes feasible to distribute hydrogen) and then the lines for the electric power and telephone grids. Nowadays an extra cable is laid alongside them to be ready to transmit cable television and computer signals. Then tidy up everything by compacting and paving the roads and levelling the mounds of spoil. Finally bring in new teams to dig up the interiors of the blocks, lay foundations, and erect the buildings. Import young new trees and shrubs for the more open and public spaces.

The various urban populations are expected to stream in at this stage -- vigorous people come with still growing families and bundles of artifacts, the vermin species originally displaced by the bulldozers reinvade the territory battling those brought in with the domesticates that live with humans, stationary machines are installed, and vehicular types stand by the doorways ready to move. New trees and shrubs are planted, seed beds for annuals are freshly prepared, patches of lawn are laid down, and the native weeds are pulled out wherever they appear. Within a few years of interaction a totally new set of associations between humans, animals, plants, machines, and buildings has been instituted.

The automata are introduced more gradually into special niches, primarily the central business district, the industrial estates, the medical districts, and the school system. Arriving as metal boxes with dial or TV screen faces, semi-conductor guts, and servo-mechanism limbs, they speedily take control of the routine backroom type of operations. They maintain flows through the networks and the transactions between individuals and groups within the new city, especially their contacts with the rest of the world. Automata are particularly needed for holding down the frequency of error in the goods and services (thus maintaining their quality) that are exported from the new city in exchange for commodities and assistance obtained from elsewhere.

The urban habitat is incomplete without its signs. The central business districts use neon and fluorescent-backed lighting for emphasis, as do most roadside installations, and for announcing the function of the site at night. Billboards go up along principal channels of movement, street signs are placed so as to direct vehicular traffic and to label roads and plazas in the residential areas, poles carry ephemeral notices of opportunity at eye level, and the vehicles often carry insignia identifying the corporate operator. Images, displayed as form or presented on the face of buildings, together with the kinds of order imposed upon landscaped plots, serve as unlettered signs that tell strangers (and remind residents) moving about in this complex habitat much of what they need to know concerning the standing of the respective households and organizations in the "pecking order" of the locale. As a result, the strangers in a locale are able to judge better what proprieties to use when approaching a citizen of the new city.

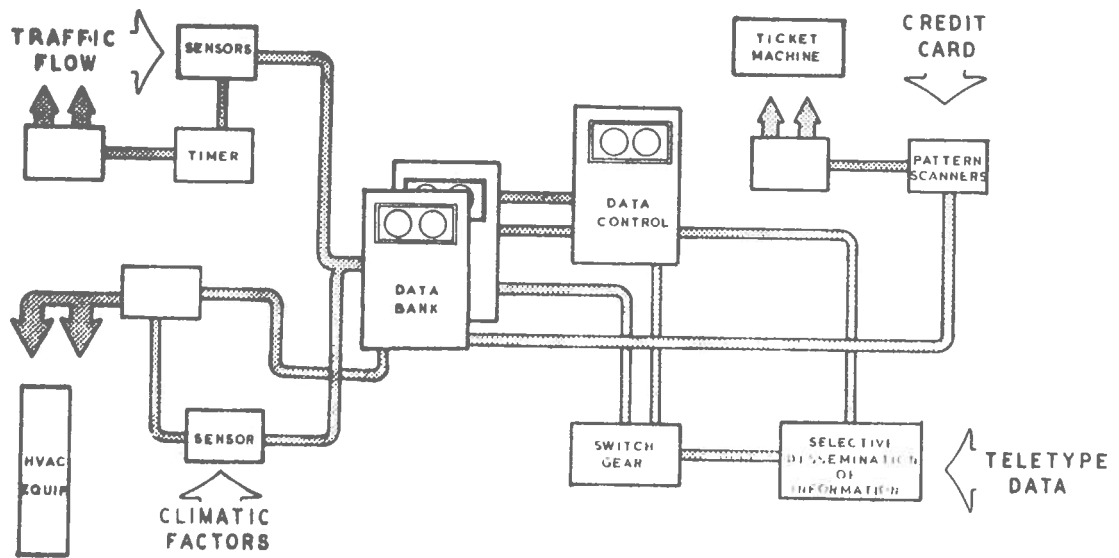
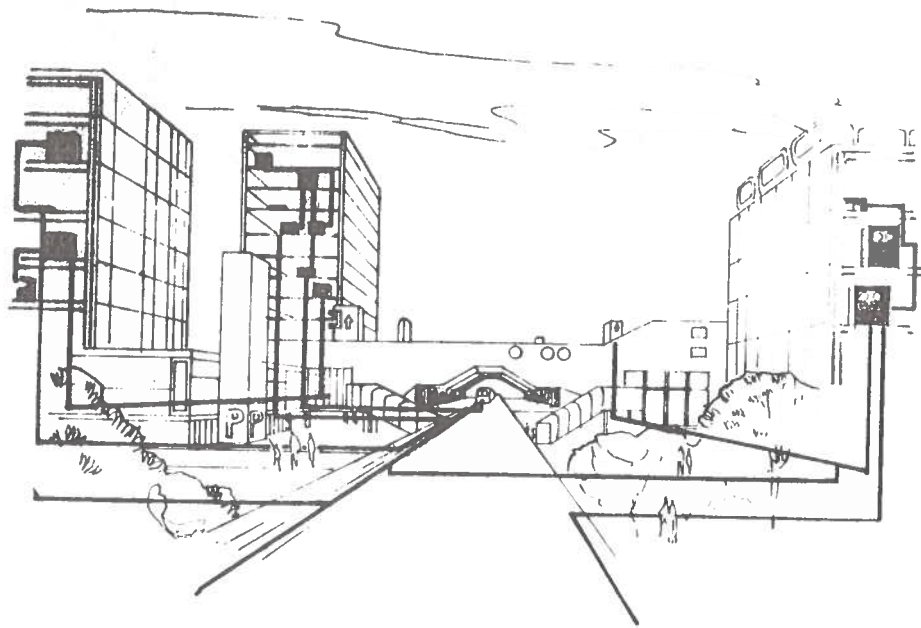


Fig. 1. Automata in cities are usually employed to make routine decisions, while participating in assemblages clustered around a computer installation that resemble organizations or communities. The automata draw their sustenance from grids distributing electric power -- their sole energy source -- and relate to each other via telecommunications channels.

This version of metropolis is energy-intensive, water-wasting, and it uses land, scarce materials, and labor in a profligate fashion. Whatever displaces the present formulation of the "modern" urban environment must nevertheless be competitive with it from the point of view of the human population. A large fraction of humans must prefer the successor habitats to those provided by the metropolitan areas now in existence. Fitness of a sub-species now implies its ability to fit the environment to human capabilities more intimately than at present. This need for close fit means that the web of interdependencies that evolves in an urban ecosystem should be made more explicit so that networks installed in the habitat will permit easy adaptation to external stresses.

The Product of City Life

The concern thus far has been with requirements for a viable urban habitat. The respective ingredients can be combined with the populations and they transform the habitat into a city. What does a city do that non-city finds difficult or impossible? What is the output of a city? Objectively, how can one formula for a city be said to be better than another? The metropolis has been pictured here as a self-repairing, homeostatic social reactor that can, when necessary, obtain from its hinterland or from other cities whatever it needs in the way of natural and human resources.

The fate of the natural resources, once they have been removed from the original site, is quite readily traced. The first step must refine the crude product; therefore we see grain

dried and winnowed, trees are trimmed and debarked, petroleum is de-emulsified, gas is desulfurized, and ores are milled at sites not too far removed from the original mine. The graded and standardized products are then moved on to processors at cross-roads, many of which have not become urban centers but have remained mill towns and factory settlements. There a wide variety of basic commodities are produced -- grain reappears as flour and middlings, trees as paper and board, petroleum as a hundred different refinery products, each of them held to strict specifications, gas is transformed to electric power or petrochemicals, and ores are moved on as ingots and shapes of metal. The ultimate destination for eighty per cent or more of the tonnage of these commodities is a metropolitan area where the complex, market-oriented manufacturing is carried out in as many as a dozen successive steps. Moreover the inorganic transformation of mineral resources has now reached a physical volume twenty to thirty times as great as that observed for formerly living materials, such as crops, animal products, and wood.

A few months or years later, the usefulness of the manufactured products runs out and they become only so much scrap. A bit of salvage may be possible, so that some materials go through another cycle of refining, fabrication, and distribution, but even then the end is ultimately the same. Nothing remains but some polluted water, some solid waste, carbon dioxide, a small amount of the more noxious gases, and a quantity of heat that escapes built-up areas (mostly as low grade infrared radiation because the metropolis itself is maintained as a "warm body" with a temperature several degrees higher than its immediate environment). The

material balances and the energy accounts for the urban system are thereby settled. As much goes out of the ecosystem or is stored in it, as originally went into it.

It is important to consider the residues over the long run, because they change the immediate physical environment. The solid stuff transported to an urban settlement becomes an indigestible waste; the most convenient use is to fill low places in and about the city, especially to build up levels and dry up marshland. However after a generation or two the detritus and rubble accumulate onsite so that the city raises its average ground level above the surrounding plain several feet each century. Long-lived ancient cities left tells raised as much as fifty feet above the desert, but much of that material -- dressed stone, sun-dried brick and ordinary clay-based stucco -- was employed for defense purposes rather than ordinary living. Nowadays most major defense installations have been moved out to the empty, interstitial areas. The modern metropolis, if abandoned, would very likely not be seen as a mound of rubble but as a jungle of grass-grown girders, reinforced slabs, with interstitial shrubs and forest undermined by elaborate grids of wire and pipe, much of it connecting catacombs made up of sub-basements and storm drains. The most time-resistant material below the surface would be the enamelware, particularly toilet equipment, much of it more lasting than potsherds of past millennia. The trend thus far, however, is pointing directly away from any significant abandonment of cities but moves in the direction of increasing scale of urban settlement. Momentous forces have been released by the processes conducted within the urban social reactor

TABLE ONE

NET CONSUMPTION OF NATURAL RESOURCES IN METROPOLITAN AREAS: 1970

(Metric tons per million population per year)

<u>Mineral</u>	<u>United States</u> ¹	<u>India</u> ²
Water ³	1,800,000,000 (10% domestic; 35% industrial, 55% cooling)	180,000,000 (30% domestic)
Fuel ⁴	8,000,000 (30% coal, 40% oil, 30% gas)	400,000 (80% coal, 20% oil)
Sand, Gravel and Stone	8,000,000 (60% sand and gravel, 40% stone)	1,000,000 ⁵
Clay, Lime, Cement, Gypsum, Salt, etc.	1,600,000	300,000 ⁶
Iron Ore, and Ferro-Alloy Ores	800,000	200,000
Non-Ferrous Ores and Metals	100,000	10,000
<u>Renewable Organic</u>		
Wood, Paper, and Natural Fibers	400,000	30,000 ⁷
Foodstuffs, Staples ⁸	150,000 (50% cereals, 30% sugar)	200,000
Foodstuffs, Perishables ⁹	600,000 (25% dairy, 25% poultry, 20% veg.)	100,000

¹The Standard Metropolitan Statistical Area (SMSA) based upon county lines is becoming steadily more obsolete, so it is assumed here that 70% of the U.S. population was living in metropolitan areas in 1970.

²The urban population of India was set at 120,000,000 persons for 1970.

³This assumes that water use in an industrial nation is somewhat greater than in non-urban areas. The total for non-irrigation uses in the United States is 2,300 tons metric per year per capita. Indian domestic use is set at 25 gallons per capita per day, since reports from various cities range 22-30 gallons per day. Perhaps 30% more than that is filtered and treated, the difference being lost in leakage. Industrial water appears to demand comparable volumes of water, on the basis of very scattered reports.

(continued on next page)

⁴ Railroads are a heavy user of coal in India, so only 60% of the total fuel consumption was assigned to urban users, but 90% of all U.S. fuel was assigned to these consumers.

⁵ No figures available; this level of consumption was deduced from the amount of cement used and the scale of flood control projects designed to protect urban areas.

⁶ Figures not available; these numbers were deduced from the amount of pukka housing and facilities installed (cement and brick) while allowing one kilogram of salt per capita per year. Sulfur is known to be very scarce.

⁷ Assumes that only half of the timber products get to the city, but about 70% of the paper and board are used there. Fibers have small volume.

⁸ Adjusted upward from the estimated consumption so as to allow for spoilage.

⁹ About 20% more is re-exported to surrounding non-urban areas.

(This table appeared in The Proceedings of the Second International Future Research Conference, Kyoto 1970, Challenges from the Future [Tokyo: Kodansha, 1971], p. 389.)

and they are enabling the metropolis to become still more influential and populous.

Social reactors produce the opportunities that stimulate the appearance of new autonomous units, called organizations, with larger-than-human capabilities. Human organizations are created much more readily in the city because density promotes frequent interaction among individuals and the facilities are designed to keep the conflict level low. These organizations are what remain in the city after the fuels have been expended and the imported commodities have been used and returned to the earth's crust as solid and liquid waste. Vital, active groups will achieve a higher degree of organization, since the transactions of city life produce both an accumulation of knowledge, and a diffusion of it, that can be readily drawn upon. Speaking thermodynamically, at the same time that a city catalyzes reactions with high entropy gain, it conserves negentropy or order in small, carefully protected cells.⁵ In the long run, such new organizational structures -- for example the IBMs, Comsats, Social Security Administrations, health maintenance organizations, and university institutes -- comprise the surviving output from urban life.

In an urban milieu organizations are continually formed and others dissolve. They are more highly specialized in modern cities and ~~there~~ are many more of them than for the same dimensions of human population in rural areas. The reasons are readily apparent -- organizations imply transactions between members (otherwise their names may remain, but they no longer exist as living entities), and a city distributes its physical facilities:

so as to expedite high rates of social transaction. Over time we see an enhancement of the number and variety of human organizations in cities; there can be organizations of organizations as well, which try to cap the pyramid with still further organization. Using a minimum set of conditions for existence, it is possible to count organizations present in a city: At the least, a viable organization has a name, an address at which it can be reached (which at a minimum may be only a telephone number or a postoffice box), a membership, and a mechanism for transferring the responsibility for communication in the organization's name to other individuals.

If the founding rate for organizations is higher than the dissolution rate, the city is productive. Although no counts have been published, a number of indirect indicators suggest that virtually all cities are currently increasing their number of organizations although for periods up to several years at a time a city under great stress may experience heavy mortality (via bankruptcy, dissolution, amalgamation, removal, etc.) among its organizations.

The principle of "survival of the fittest" among organizations, together with the capability of an individual for cooperation in groups serving as one of the traits most likely to insure his own survival, suggests that human evolution has been displaced upwards to this level. The idea by now is quite old, since geneticists, anthropologists and philosophers such as Haldane, Julian Huxley, Linton, Waddington and their successors agree that the selective pressures which led to the appearance of the remarkably

plastic homo sapiens as the dominant predator species in Nature have ceased to be effective.⁶ They recognize that the less fit individuals, whether measured biologically or intellectually, now do survive and, even more significant, reproduce strongly (although the least fit, the bottom decile, do not).

Thus the succeeding generations of man no longer adapt to the challenges set by Nature as individuals or bands, but as members of groups formed with other men, animals, plants, machines, and automata. The other species multiply man's adaptability by at least a thousand times -- as judged by the intensity and variety of forces he is able to withstand. A few modern organizations now promote ad hoc groups in a way that yields still greater adaptability, while most others find ways of incorporating some of these behavioral modes into their standard operating procedure. The organization is preserved as long as it appears to be efficient for controlling the external environment or responses to change in it. These organizations with their artifacts comprise a social system operating in an almost wholly synthesized environment.

Thus a special function for cities can be proposed. They are the places in which new controls over the interface with the environment are devised, and the base of operations from which such controls are field-tested and implemented. The best indicators of control are extension in operating range -- distance, bigness, smallness, grossness, fineness, invariance, speed, purity, evenness of distribution, heat, cold, etc. Each year teams in one or another of the most highly cultured cities announce their capacity to move one of these frontiers a bit further out. A decade or so later an

organization advertises its ability to do so routinely. First knowledge is added to the presently existing stock and then as long as it remains potent, it is distributed to an ever-widening circle of users.

In summary, then, a metropolis is a social reactor -- an engine for socio-cultural and economic growth that works by expediting interaction between humans. It also contains special facilities for the acquisition of new information about Nature. The first product of urban life is flux of public transactions, each of them a voluntary internal adjustment intended to improve or maintain the welfare of an individual or group. Information is diffused through such transactions, leading to decentralized stocks of knowledge. A few of the transactions will be novel and therefore add items that have never before existed in anybody's stock of knowledge. Novel diagrams, images, later often new words, are invented to convey the knowledge, making them part of the culture. Repeated voluntary transactions between individuals, animals, their machines, and automata, taken two or three at a time, create bonds of trust, the bonds often close to form groups, and the groups stick together in organizations. Therefore new organizations represent another special product of cities, a few of which may last for decades, even centuries after the initial expenditure of resources for their founding. Finally it becomes apparent that biological evolution can be propelled at a vastly accelerated rate, perhaps in a new direction, by the environments maintained in the great cities because human organization sets the criteria for reproduction and survival of individuals of the other species brought into the city.

The concept of efficiency for the design and operation of a social reactor follows directly from these observations. The idea of "resource-conserving" implies obtaining greater flows of voluntary transactions, numbers of organizations, amounts of knowledge and diversity of culture for each unit of resource expended. Increases in an index representing any one of these will be highly correlated with advances in other such indexes. One provision reflecting political realism must be added however: most of the existing organization, knowledge, and culture will be stoutly defended and therefore will be preserved for a while, despite demonstrated inefficiencies.

Future Designs

New cities and the expansion of existing metropolises must grow in diverse directions. Admittedly that is not the trend today; we see instead imitative cosmopolitanism reinforced by the current accelerated expansion of international exchange. Primarily because the countries and cultures most in need of urban growth sent their sons to Great Britain, the United States, Canada, France, and Scandinavia to study the present crop of urban projects, whether transport, housing, environmental engineering, or offices, repeats the wasteful standards and building forms of the West. The proposals of these overseas-trained members of the responsible elite set out to solve the problems of overcrowding and expansion in their own cities their proposals could not deviate very far from the conventional wisdom they were taught, otherwise they risked being criticized severely by their peers in the most developed countries. If they lost the support of fellow professionals overseas, they would then also lose the confidence of

those associates at home who were unable to get away to study. Imitations of solutions learned in foreign schools are now all headed for crisis, however because, in the long run, the resources are insufficient for the relatively wasteful Western technologies now being introduced into the cities of the Orient. Therefore a resource-conserving design must buck the mainstream styles, whether bureaucratic or idealistic, and yet discover a means for getting built.

The strategy to be employed in the course of applying this outlook hinges upon the urgencies produced by internal crisis. Imminent catastrophe narrowly averted provides the shock that overcomes conventional wisdom. Only then are alternative plans likely to be carried forward. In the future each group taking this approach must consider prominent risks inherent in its own geographical and political setting. The possible catastrophes can be starvation, thirst, disease, inability to operate due to lack of energy, inability to compete due to lack of communications, revolution due to conflicting ideologies, and international war. The most promising technical and organizational potentials for avoiding such catastrophes are outlined below as an indication of the scope of change implied.

Famine. The threat is threefold, the quickest being a shortage of caloric value in the diet, next that of protein, and lastly that of a continuing drain upon initiative and morale due to a lack of vitamins, minerals, and ritual foods. The foodstuffs rich in caloric values are the fats and carbohydrates. They are best stored in steel tanks, silos, and dry godowns. A metropolis

should have access to buffer stock sufficient to overcome the worst exigencies that might be encountered over a century or two. An alternative could be to design a food production scheme independent of weather and breakdowns in international trade such as a nuclear-powered agro-industrial complex ("nuplex").⁷

Lack of protein-rich foods causes kwashiorkor, which afflicts the growing children and the sickly first and has been claimed to cause some permanent brain damage. The best solution is likely to be found in a number of prepared foods, which also meet the needs for vitamins and minerals, taking every edible form from soups and stews to beverages and snacks as well as sausages and vegetarian steaks without depending upon livestock. The underlying microbiological technology has been developed in Japan and America over the last two decades but acceptance by the consuming public, although expanding 10-30% per year, is still extremely limited. In the future livestock should be limited to the quantity needed for efficient recycling of organic wastes from the metropolis. In this case livestock population is likely to be held at levels not very different from those presently found in poorer countries, which is about a third to a tenth of the man-animal ratios in North America, but the animals can be tolerated in much closer conjunction to the city. There should be enough meat on hand with that arrangement to maintain all the ritual occasions now defined as holidays and festivals.

Thirst. Cities will die very quickly if water supplies become exhausted. Fresh water can be obtained by distillation, recycling, or importation via tanker, but the requisite import

and distributive facilities generally require more than a year to install. Crises can be postponed by paying careful attention to water-using urban processes and arranging for reuse. A pricing system that responds to the respective demands for different water qualities and faithfully reflects prospective as well as existing shortages may be required. Domesticated plants and stationary machine populations will be most affected by these economies. Much of the new urbanism should be able to function normally when consuming (i.e., converting to reject vapor and brine) only about fifty liters of water per capita per day for months at a time. This is less than a tenth of the demand created by new settlements in America and Europe.

Epidemic Disease. Packing people more tightly together with each other, as well as with animals, plants, micro-organisms, vehicles, and automata, increases the tendency for a given disease to be transmitted to a larger population. The most effective counter-measures are based upon the removal of specific vectors from the environment and quick detection, followed by isolation, of the initial infection. Antibiotics serve as a last line of defense, though one that is still being extended in potency. The risks of illness must be low, otherwise key personnel that move between cities will avoid the area, and the city's sources of livelihood will dwindle away.

Critical Supplies. Several non-ferrous metals and phosphorus will become much scarcer in the foreseeable future. The large scale urbanism anticipated will then need to depend upon improved salvage techniques and substitutes.

Energy. All of the food, water, and material shortages now foreseen can, when known a few years in advance, be "solved" through the application of considerable amounts of imported energy. Fossil fuels have been drawn upon in the past to produce that energy, but soon only the expensively extracted reserves will remain, and insufficient quantities of those. Energy-conserving technologies are known but are little used. Energy, and the capital equipment producing and consuming it, is best economized by packing everything into a much smaller space and paying a great deal of detailed attention to the interfaces between the various urban species. When such approaches are fully employed, cities as effective as (and therefore competitive with) the leading American metropolises can get along on perhaps a tenth of the energy used by the latter, and most of the needed energy can be obtained from nuclear sources. Pollution effects must be designed out, and rejected heat and many wastes reused.⁸ The overall flow envisioned is outlined in Figure 1.

Physical Catastrophe. Large parts of a city have been known to burn, drown, blow away, or tumble down. Vulnerability to such extreme forces depends upon precautions taken in advance -- controls on materials used in construction, the location of levees and dikes, the assembly of skeletal structures, and the design of foundations. The large crippling losses of the past are now preventable although, of course, at a cost. Spontaneous building of the physical city by family groups, speculators, and various associations must be brought under some centralized control; usually supervision requires licensed contractors whose work is regulated by regional

or central government though, all too often, such controls proliferate and combine to prevent imaginative solutions to the problems of creating efficiently designed environments. Building codes, zoning provisions and labor agreements in America together inhibit the application of the promising new ideas regarding structures, methods, and materials arising out of modern technological progress. The physical city can be lighter, stronger, and more transformable to other uses on short notice, yet still cost only half as much. The future approaches to building systems must incorporate self-help construction, cooperatives and evolutionary building as well as factory prefabrication.⁹

Breakdowns of Public Order. Human communities are not infrequently riven by civil strife that destroys not only the participants but inflicts grave damage upon interdependent urban populations and their surroundings. New urbanization is far more vulnerable to such violence than older cities because many of the feuds and long standing enmities of the countryside are swept in along with the new settlers; thus insurgencies among the peasantry can become explosions in the metropolis. A city must therefore have enforceable law, particularly regarding public property, grievance procedures, arbitration, and political representation for all interest groups. It needs an effective police force. These legitimating institutions by themselves will not be able to prevent breakdowns in public order unless backed by large investments in an integrating infrastructure such as an education system that pushes most students well beyond literacy, accessible mass media with varied content, and active recreation.

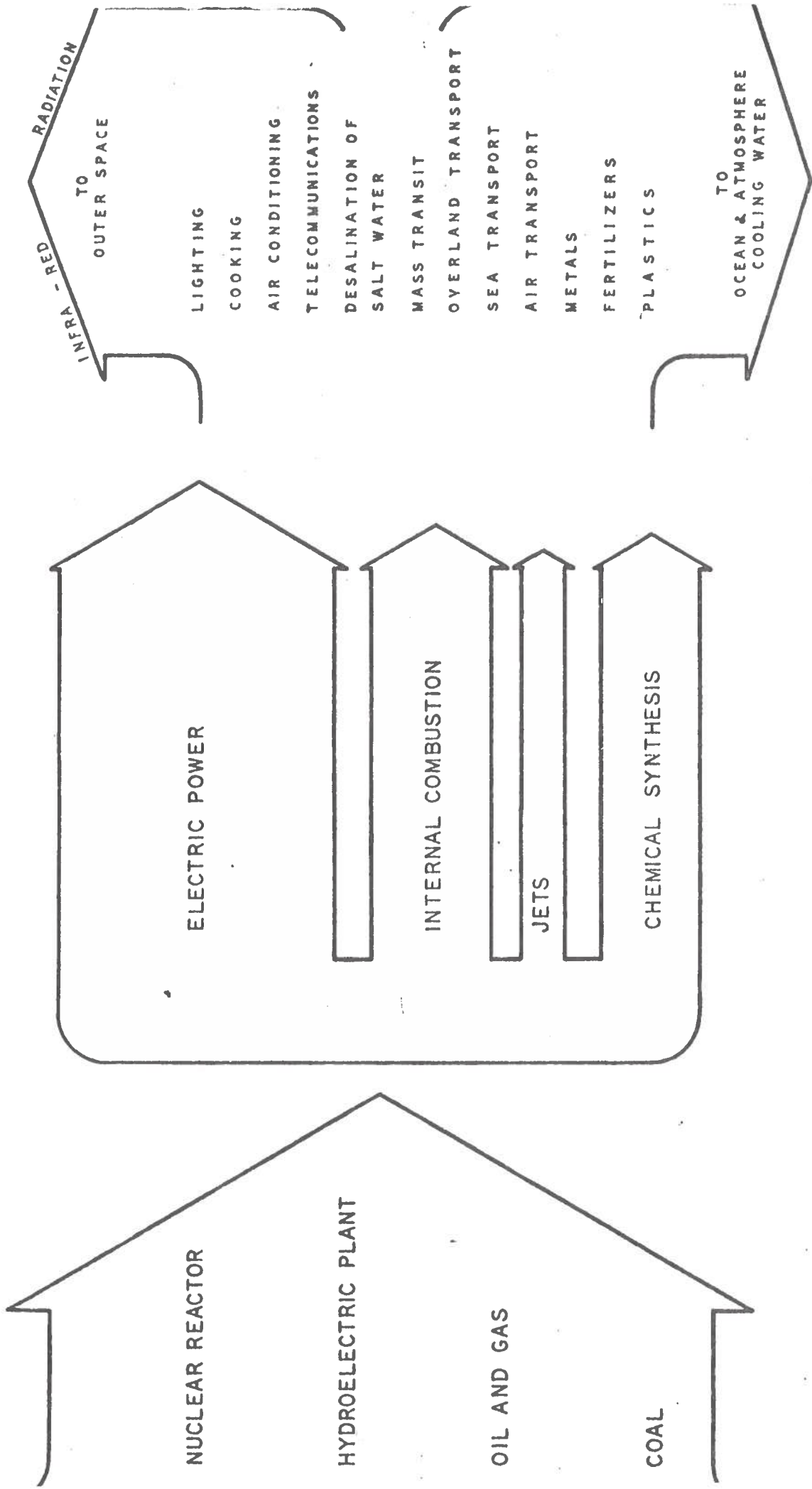
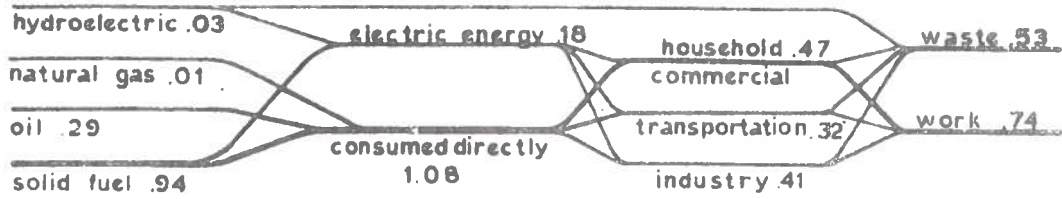
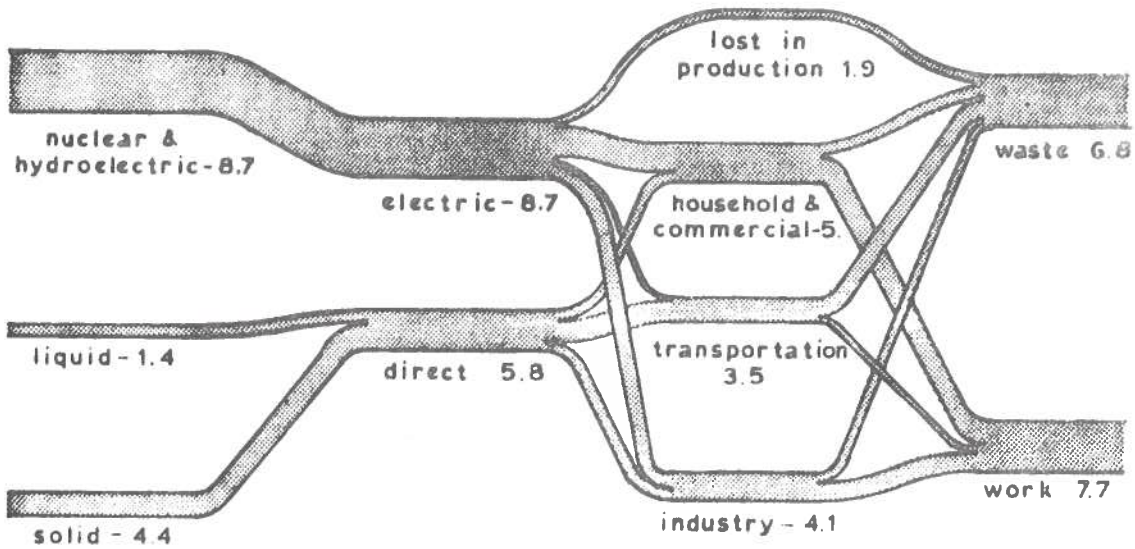


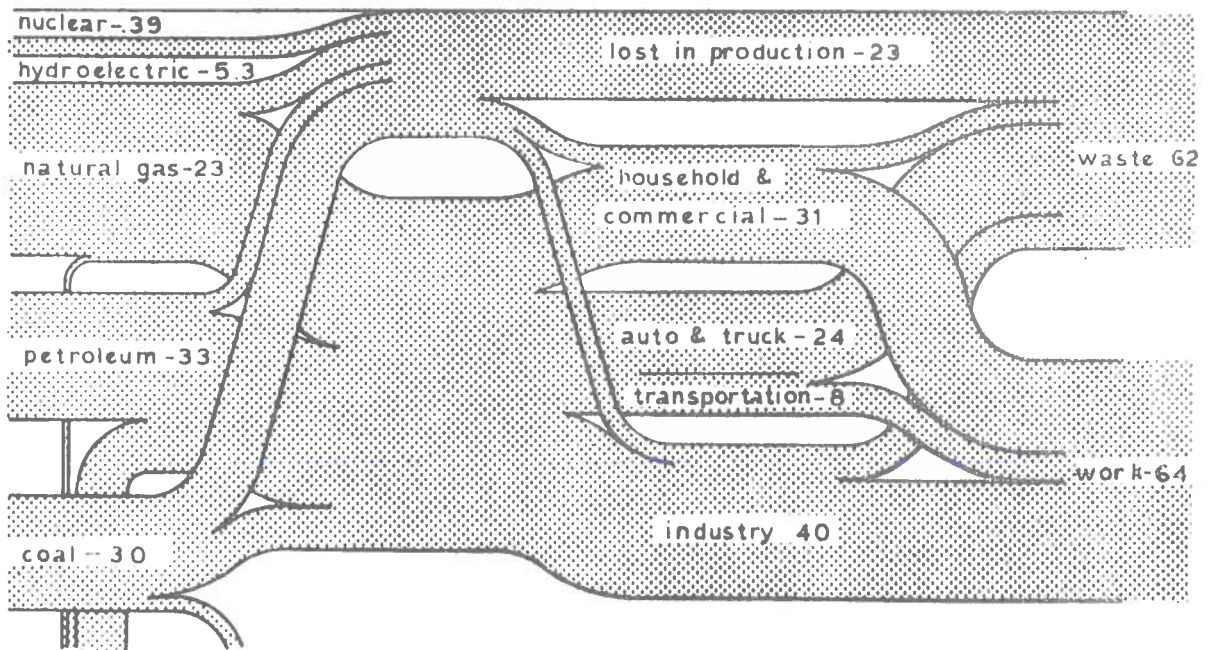
FIGURE I ENERGY ECONOMY
 800-1200 kg per capita/year coal equivalent
 This sequence of energy transformations for urban activity can be designed for
 temperate to tropical environs for about a tenth of the present consumption of the
 United States. Substitutes for the automobile provide the principle opportunity



INDIAN ENERGY FLOW 1965
 1.26×10^6 Kcal / capita / yr.



URBAN RESOURCE CONSERVING DESIGN
 14.5×10^6 Kcal / capita / year



U S ENERGY FLOW 1970
 126×10^6 Kcal / capita / year

Fig. 2. Energy Flows

Such preventive agencies do not halt incidents but losses can be kept small and localized, rather than catastrophic.

Designing new living arrangements and the physical backup systems to go along with them is a trivial exercise unless a continuing capacity to implement necessary change is incorporated in them. Since most of the catastrophes to be avoided are relatively unprecedented, prevention will make extraordinary demands upon human organization. Cities that overcome stresses and manage to move whole regions toward conditions supporting adequate levels of living are already discovering that their most creative effort is the work of fitting individuals and groups together to form organizations that get these complex jobs done. "Institution building" is a rather inadequate term applied to the process. The inventions and designs must be almost wholly indigenous; outsiders can only offer suggestive ideas based upon micro-level experience gained elsewhere in solving problems that seemed closely related.

Cities have until now done relatively badly in the job of organizing themselves so as to gain control of their destinies. The fact that surpluses have been accumulating most rapidly inside urban institutions should have given cities the freedom to act on their own behalf, but control of the new assets has usually been lost. In most instances the liquid funds are siphoned off by state and nation. If the nation fails in the attempt to capture control, the assets either flow out to other parts of the world where they are more secure or they remain hidden in unproductive niches. The creation of suburbs often frustrates the ability to act as a coherent unit. Declaring themselves a sovereign city state would

normally cause greater losses than could be gained through comprehensive planning. Even the self-generated proposals for restructuring and for increased control of internal operations that have been repeatedly produced by city administrations are timid and inadequate, mainly because small communities in the same state or the regions feel threatened, do their best to exert vetos, and often succeed.

Yet a few great cities have accomplished wonders in some key sectors with only modest amounts of capital. Tokyo, Seoul, Nagoya, Hong Kong, and Singapore continue to improve their physical organization. A number of others, such as Sao Paulo, Caracas, New Delhi, and Bangkok seem to have been keeping up with the huge rates of immigration to which they have been subjected. One must ask how the relatively successful cities contrived to maintain and even improve physical as well as social conditions. Was the future borrowed from in some way to overcome stringencies? What was their formula for putting together an increasingly efficient apparatus for conducting commerce, industry, and government? Studies on the scene have thus far unraveled parts of the local strategies,¹⁰ but the inferences must wait for the exposition of a suitable theory.

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1. Jane Jacobs, The Death and Life of American Cities, (New York: Random House, 1961); Lewis Mumford, The Myth of the Machine (New York: Harcourt, Brace, 1967, 1970), The Urban Prospect (New York: Harcourt, Brace, 1968).
2. Although not directly aimed at cities, a number of books arguing with ecological concepts have been concerned with the debacle of modern world society. They include Paul R. and Anne H. Ehrlich, Population, Resources, Environment (San Francisco: W.A. Freeman, 1970); Barry Commoner, Science and Survival (New York: Viking, 1966); and Max Nicolson, The Environmental Revolution (London: Hodder and Stoughton, 1970). A reply has now been addressed to such expositions by John Maddox, editor of Nature in his carefully argued The Doomsday Syndrome (New York: McGraw-Hill, 1972). Nothing is really settled however, because two strikingly different viewpoints regarding the responsibility of scientists to society are imbedded in the approaches taken. Critics of present trends feel that their duty lies in calling attention effectively to the hell into which the world is sliding. In order to be effective they take the role of advocates and emphasize possibilities instead of probabilities, even though unlikely. Then the alerted activists and politicians must pick up the baton and effect the changes in policy. The counterview points out that unbalanced presentation of the trends, and the vividness of the pictures of ecological collapse has induced the public and its usually reluctant representatives to choose inequitable and wasteful policies. In general I find both sides inadequate, so I shall start again from the data, using living systems principles wherever they seem to apply and not bother to associate myself with one side or the other. An excellent foundation for treating the transition from bio-ecology to human ecology to urban organization has been formulated by Amos H. Hawley, "Ecology and Population," Science 179, 1973, 1196-1201.
3. The concept of human capital and of human resources are concepts that were actively developed by economists during the early 1960s. It recognizes that investments of attention and effort can be made in many individuals which produces expectations of earnings beyond the costs; a parallel observation is made for human associations, including corporations. For many human associations

providing nonmarketed services, such as communities, some capital value may be attributed to the degree they prevent loss or wastage of other assets. The economic concepts are relatively straightforward and are admirably presented by Theodore W. Schultz, the man who contributed the most to launching the concept in the International Encyclopedia of the Social Sciences 2, 284-6. A more extensive review is provided by Melvin R. Levin and Alan Shank, eds., Educational Investment in an Urban Society, (New York: Teachers College Press, 1972). The social psychological concepts are akin to morale and integration within a community or corporation, and the units of measurement are more subtle (Rensis Likert and David G. Bower, "Organization Theory and Human Resources Accounting," American Psychologist 1969, 241 (6) 585-92).

4. Defining the exact difference between automata and ordinary machines encounters the same kinds of difficulties biologists have in distinguishing the living from the non-living entities, and the chemist in separating organic from inorganic. Thus there are highly elaborated types, such as the autopilot in aviation, which are paralleled perhaps by the protozoa in microbiology. Incomplete, plug-in types, such as the battery-charging mechanism in a vehicle or a thermostat for a room, may be equated with the smallest crystalline viruses. A good standard example of an automaton is a weather reporting station that collects environmental data, reduces them to a record, and transmits the stored information upon request to a center where world weather maps are assembled. It gives out periodic signals reporting that it is still operable, and may be designed to transmit an alarm if it detects a hurricane or a tsunami.

The theoretical formulation of the characteristics of automata is attributed to Turing. The concept has been important to philosophy, logic, decision theory, and computer science. A Turing machine has a finite tapelike input with discrete information, a set of transforming, adaptive criteria, and an output tape with similar characteristics. To operate in the real world, transducers are required at both ends. A number of such automata are likely to be maintained in a multipurpose computing installation. Cf. J. McCarthy and C.E. Shannon (eds.) Automata Studies (Princeton: Princeton, 1956).

5. This model of the city was elaborated in R.L. Meier, A Communications Theory of Urban Growth, (Cambridge: M.I.T., 1962). The importance of stimulating autonomous organizations was elaborated less formally in R.L. Meier, Developmental Planning (New York: McGraw-Hill, 1965).
6. Theodosius Dobzhanski, Mankind Evolving: The Evolution of the Human Species, (New Haven: Yale, 1962); Anne Roe and George G. Simpson (eds.), Behavior and Evolution (New Haven: Yale, 1958); Conrad H. Waddington, The Ethical Animal (London: Allen and Unwin, 1960); Leslie White, The Evolution of Culture (New York: McGraw-Hill, 1959).

7. The concept of a nuplex is simple: take a large coastal desert, add a large nuclear reactor which produces power, fertilizer, and desalinated water, irrigate several crops per year, manufacture electrochemicals and electrometallurgicals on site, then export power, crops, and semi-manufactures to the metropolises requiring food and raw materials. Important economies of scale can be realized, so the first installations to be able to meet world prices will be very large. Large scale studies aimed at discovering the best technological mix have been carried out at the Oak Ridge National Laboratories, but only the preliminaries have been published (Oak Ridge National Laboratory, Nuclear Energy Centers: Industrial and Agro-Industrial Complexes, Summary Report, July 1968).

The Indian government is proceeding with a more modest scheme in the Indo-Gangetic plain where the nuclear reactor produces power for pumping water off of flooded land into canals one season and up from the aquifer most of the rest of the time, at the same time that fertilizer is produced and power for the metropolises is fed into the Regional Grid. Studies in both countries suggest that food scarcity must reach levels much more severe than in the 1960s and early 1970s before this approach becomes economic. A review of the applications to Israel is provided by David Vofsi in The Bulletin of the Atomic Scientists 28, October 1972, 45-51.

8. R.L. Meier, "Technologies for Asian Urbanization," Economic and Political Weekly 4, July 1969, 1-7; "Resource-Conserving Urbanism: Progress and Potentials," in Challenges from the Future, Proceedings of the International Future Research Conference, Kyoto, 1970, Vol. II, 385-408. See especially a series of reports from Environmental Engineering, Asian Institute of Technology, Bangkok, Thailand by Michael G. McGarry (1969 to 1973).
9. The literature in this field is simultaneously vast and non-existent. A largenumber of case studies reporting on the construction of barriadas, favelas, bidonvilles, bustees, and hutments of satisfactory quality, and the few describing cooperative urban community redevelopment (as in Japan especially) are usually premature; personal experience has shown that most are not trustworthy. Generalizations arrived at by comparing experiences in various parts of the world reduce to a reiteration of common sense and cliches. What the field seems to need most is a handful of open-ended franchise operations fitted to specific building technologies based upon bricks, concrete, light panels, foam plastic, and possibly one other material. The users must be designers as well as builders. The provision of technical services accompanying the franchise is the real problem and there seems to be no adequate descriptions in the literature of ways to organize it.

10. R.L. Meier and Ikumi Hoshino, "Adjustments to Metropolitan Growth in an Inner Tokyo Ward," Journal of the American Planners 34, July 1968, 210-22; "Cultural Growth and Urban Development in Inner Tokyo," Ibid 35, January 1969, 1-9. R.L. Meier, "Exploring Development in Great Asian Cities: Seoul," Ibid 36, 378-92; "Singapore and Bangkok: Pacemakers for Southeast Asia" to appear in the second volume of a series edited by Leo Jakobsen and Ved Prahash as the South and Southeast Asia Urban Affairs Annuals, Sage Publications, Beverly Hills, "The Central India from the Great Cities: Delhi, Calcutta, Bombay," Institute of Urban and Regional Development, University of California, Berkeley, December 1970; "Developmental Features of Great Cities in Asia IV: Physical Expansion, Institution Building and Political Crisis in Karachi and Bangkok," Ibid, Working Paper No. 157, October 1971; "The Performance of Cities: An Assessment of Hong Kong and its Future," Ibid, January 1972.

Chapter Two

CRISES ARISING FROM RESOURCE SCARCITY

Fourth Draft
April 1973

The alarms of the past generation, one might say "since radio began," have been raised in a relatively sudden, sharp and disconcerting way. A border is invaded, an ultimatum announced, currencies reshuffle their values over a weekend, massive strikes are called, a great flood or a massive hurricane threatens. The scale of a crisis nowadays tends to be shaped by the properties of the media by which the progress of events is most closely followed; the size of the headlines and frequency of extra editions of the newspapers have been displaced by the amount of over-ride assigned on telecommunications channels that can be discerned by audiences.

Crises arising from resource scarcity will rarely demand public attention in such a fashion. Instead of quick breaks in the web of human arrangements, followed by a series of adaptations moving away from the fracture like ripples on a surface, the Malthusian spectres of famine and exhaustion of energy stocks nag and deter action; public announcements of depletion of stocks that would lead to hoarding tend to be postponed until it is too late and price shifts that signal the shortage lead to price controls that diminish the release of added supplies. As a

consequence, those who have relied on past experience rather than informed calculations of supply and demand are destroyed, their firms and agencies along with them. Malthusian-type crises seem likely to cause a great deal of suffering, but it will usually be attributed to more immediate causes, such as breakdowns in public order, conspiracies, or uncontrolled emigration.

One reason for this lack of imagination is the scarcity of premonitory events. There has not been a widely known and reported upon crisis of this kind since the Irish Potato Famine, which occurred while Malthus was still alive. The famines in China, Bengal, and Russia since then may well have been more severe, as measured by loss of life, but they were difficult to reach and their victims out of contact with the world. Drama was lacking.

One specific attempt to forecast a likely sequence of events in one of the most overpopulated places of the world was undertaken in the 1950s as a part of an early instance of technology assessment. The prediction reflected the time it was made; this was a period in world history during which the population of many poor countries had stepped up growth to unprecedented rates. Marked improvement of public health had led to an extraordinary increase in survival -- death rates were cut to a half or a third of former levels. Even persons without demographic sophistication could extrapolate trends and conclude that a critical situation would arise within two generations or less. However the 1950s were also a period which saw the shock of the Korean War lead to a world wide peaking of commodity prices which was followed by expanded production and rapidly

accumulating food surpluses, so that farmers in North America were soon in distress due to oversupplies. Simultaneously a strongly held belief prevailed in the capability of organized scientific research for solving long range human problems. A combination of these factors implied that the first famines to appear would be alleviated by the food surpluses and that the knowledge resources of the sciences would be mobilized to meet middle run shortages.

A reasonably adequately reported microcosm that seemed to be well advanced toward crisis was the island of Mauritius. A scenario for the transition to a new state of survival was elaborated to illustrate the implications of the existing conditions and fitted to the circumstances of Mauritius. It is most useful to review that projection and discover the reasons why catastrophe of the magnitude envisaged has not struck as yet, before undertaking a wider ranging assessment. Such an exercise can tell us what kinds of events become significant when the margin of safety is very thin and a whole society teeters on the brink, becoming increasingly unstable as it makes more desperate efforts to survive.

SCENARIO TWO

Malthus in Modern Dress:Forecast versus Outcome

Quoting directly from Modern Science and the Human Fertility Problem,¹ which drew upon sources available up to the middle of 1957:

Mauritius: A Case of Imbalance in Welfare Measures

Mauritius is a remote island of volcanic origin in the Indian Ocean, containing altogether about a half million inhabitants. It has been a British possession for well over a century, but the basic culture remains French creole. It gains its livelihood mainly from sugar cane growing and the conversion of cane juice into raw sugar.

Some reasons for the choice of Mauritius for an analysis of population crisis have already been given. Not only was it among the most rapidly growing populations registered in the mid-1950's, but it is also one of the most handicapped areas with respect to migration.¹⁴ There are very few places its residents can go. For one reason or another the decanting of sizable numbers into other territories bordering on the Indian Ocean is likely to be unwelcome. South Africa has its *apartheid* policy, and most other territories do not wish to aggravate their minorities' problems. The costs of moving people to England or to British Honduras, or Brazil, are forbiddingly high. It is much easier for these territories to be supplied with immigrants from distressed societies closer to home.

The various racial stocks of Mauritius were assembled in the course of the slave trading of the eighteenth and nineteenth centuries, the importation of indentured servants when slavery was outlawed, and as a normal consequence of mercantile activities. In 1953 there were about 1000 British, 10,000 French, 150,000 Creoles and Creolized Indians, 350,000 Indians, and about 20,000 Chinese. The rate of population growth had been fairly gradual before the end of World War II, seldom averaging more than 0.5 per cent per year. But, thereafter the Welfare State arrived, bringing with it programs for the improvement of public health, particularly the elimination of malaria and the improvement of the water supplies. It also brought marked increases in education and various social services. At the same time, unemployment continued to increase, reaching 40 per cent in the Indian sector of the population by 1952.¹⁵

¹⁴ *World Population and Resources*, Political and Economic Planning, London, 1955, pp. 123-26.

¹⁵ A large share of this material on Mauritius was drawn from the notes of Leo Silberman, who conducted a social survey in Port Louis, the Capital. His manuscript is to be published by van Hoeve, The Hague, Netherlands. The remainder of the information was drawn from various articles and documents that were available.

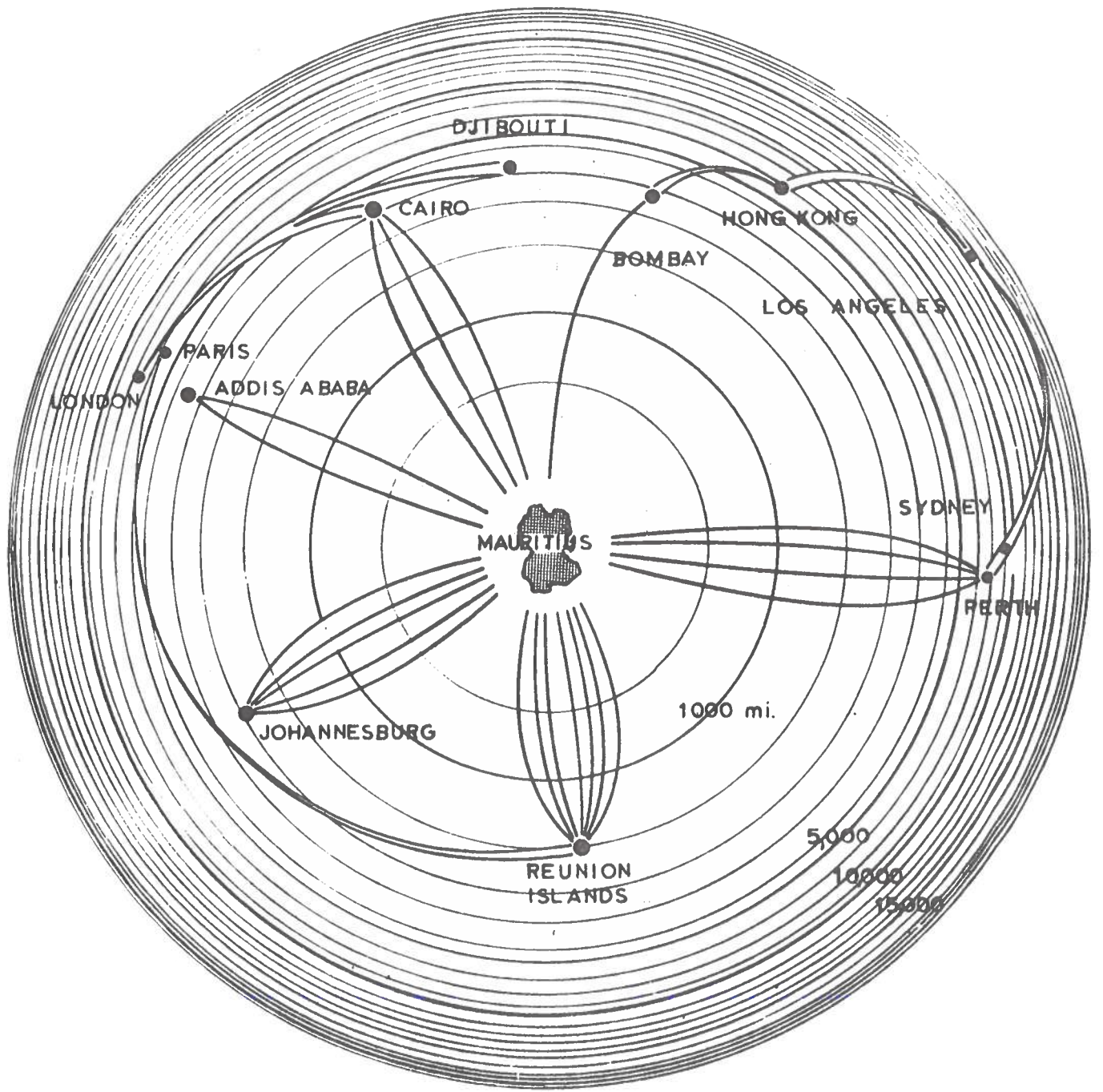


Fig. 3. Mauritius in the Contemporary World

The basis for manufacturing on Mauritius has been quite limited. There is sugar, of course, twelve plants in all, and a sack-making plant to supply their needs, matches, tobacco processing, shoes, and printing, if we include only those units which employ more than thirty workers. There are no valuable untapped natural resources, nor do geological surveys encourage any speculation in this direction. Transport and communications costs have precluded the establishment of many of the more mobile enterprises of the type which moved into Puerto Rico. Because of the great distances in the Indian Ocean area, and the lack of rich metropolitan centers on its periphery, the tourist trade has remained very small. There seems to be little hope that it will develop into a strategic military base, nor is there any evidence that its airport will become an important way station. Mauritius has no hinterland like Singapore or Hong Kong, which would enable it to act as an entrepôt. It is too far from the oil fields and the tanker routes to serve as another Bahrein or Aden.

The power to plan for those things that are necessary to the society over the long run is out of the hands of the local leaders. For every major administrative change, for each unusual item in the budget, London must be consulted. Economic interests—sugar, banking, and shipping—are in the hands of absentee directors of companies, whose headquarters are also mainly in London. This fact means that each change in Mauritius must be considered in relation to the Barbados, Singapore, Guiana, and many other spots. Thus, change comes slowly unless initiated as general policy in London. Such a situation is not very suitable for making rapid internal adjustments.

The Breaking Point

The future livelihood of Mauritius depends upon sugar and allied industries. However, the amount of land on the island that can be used is limited and, for all practical purposes, that limit has been reached. If the world market improves there will be incentive to improve the irrigation systems and apply more fertilizer in order to increase the yield. These measures, combined with the spread of improved varieties of cane, should make it possible to increase production by 20 to 30 per cent. Some advantage may be obtained by further processing a part of the sugar, molasses, and bagasse on the island. The establishment of tea plantations is a possibility. Paper and fermentation products are technically possible, but such plants are almost fully automatic, providing only a few jobs, so the returns are reaped mainly by the outsiders who provide the necessary capital. The best an industrial planner can see for Mauritius is a leveling off of primary income at a ceiling perhaps 30 to 40 per cent greater than was obtained in 1953-55. This assumes that general world conditions are propitious, and that internal affairs remained relatively orderly. The time required for such industrial changes is one or two decades, with the latter more likely than the former.

Sixteen years later: The island economy has evolved very much as anticipated; although tea, tourism, and contract labor for international engineering firms working in that part of the world have been added, income remains almost 95% dependent upon sugar and its byproducts. Sugar output seems now to have reached an irregular plateau. Per capita income also seems to be on a plateau but only because of the buoyancy of the world sugar market. Prices are higher than one would attribute to inflation, primarily because the major sugar producer, Cuba, has failed to meet either former production levels or present targets. Potentially lower cost producers, especially Brazil, Indonesia, and the Philippines, are expanding to enter the market so the relative price of sugar is expected to fall over the 1970s.

On the other hand, the population may be expected to expand more rapidly than 20 per cent per decade, and no ceiling for it is in evidence. The birth rate cannot continue indefinitely at the level of the first half of the decade. Let us assume, as a first approximation, that it dropped rather rapidly to 35 per 1000, which is roughly equivalent to the level observed in Jamaica. Of course, the death rate should also continue to drop, as an aftermath of the improvement of water systems and public health in general, probably to the neighborhood of 8 to 10 per 1000. That would put the 1960 population at 610,000-630,000. Under these same conditions the 1970 population would reach the range of 800,000-850,000, an increase of 50 to 60 per cent over the last census. Therefore, given even the best foreseeable use of local resources, a reduction in the level of living would become noticeable long before 1970.

The population growth rate did fall off over the interim, so that the estimated population in 1970 was 810,000. Between 1952 and 1968 the per capita income declined from U.S. \$192 to \$189. The level of crowding in urban areas exceeded 7.6 persons, or 1.6 families, per dwelling unit of one to three rooms.

Nevertheless, as long as no major disturbances are evident, this increasingly depressed kind of life should be expected to continue. There should still be a few odd jobs, or some months of work in the cane fields. These resources, along with the dole, and perhaps a bit of rocky land than can be gardened, will be enough to keep body and soul together in a tropical climate and to maintain the reproduction level. The daughters in families intent upon preserving respectability would have to wait longer for a suitable marriage, perhaps well into their thirties.

According to Christos Xenos,² the level of employment, particularly of women, is still declining. On the other hand, the literacy level is rising from 50% to close to 90%. A family planning program was initiated in 1964 and by 1970 twenty per cent of the married women of reproductive age were enrolled. The average age of women at the start of a union increased from 17.5 years in the 1950's to 18.5 in the mid-1960's, and indirect evidence suggests that it has been rising still more rapidly in recent years.

The society could not remain suspended in such a state indefinitely. Something is bound to give. It could be an earthquake that shatters the irrigation systems for the canefields and tumbles into rubble many of the more substantial structures in the cities. It might be a direct hit by the severe windstorms that move eastward on the Indian Ocean, or it could be a new disease, or pest, that devastates the sugar crop and requires a decade for the development and extension of a new strain. Since these are all relatively common disasters, one or more of them must be expected every generation. In addition, there is a much longer list, continuously being added to, of unusual catastrophes whose frequency is indeterminate. For the long run, one or more of these emergencies must be anticipated. What then might be the consequences for an overpopulated Mauritius?

The consequences of a disaster like this a century ago have often been recorded in diaries and official records. The initial destruction would very likely be followed by some epidemic which would erase 1 per cent, 10 per cent or even more of the population. Crops would be neglected, due to sickness and disorganization, and famine would ensue within a year. In the wake of the famine new epidemics would spread. Mortality would remain high for some years. Finally, some new equilibrium would be found, but in the meantime the population would have been reduced by 5 to 30 per cent. It would then take a generation of reasonably good fortune to reach the former levels of prosperity.

However, the world has now become too much One World for a single disaster of this magnitude to change the face of Mauritius. The rest of the British association of peoples would lend a helping hand. The Catholic international charities would be of assistance. The United Nations agencies and the Red Cross might also take part. As a result, few lives would be lost.

Such a disaster hit in 1960. The island was visited by two cyclones, levelling most of the sugar cane and dropping production by 60%, but the total loss of life was less than 0.1%. Relief funds were collected in London, reorganization was rapid, and epidemics were not significant. The population pyramid remained intact.

It is true that a few more subventions from colonial funds would be required to keep the island's economic affairs in order. The liquid reserves of many households and firms would be exhausted by the reconstruction effort, and various private relief funds would no doubt keep funneling some of their charitable gratuities into respectable institutions for succoring the needy. As a consequence of such a disaster, Mauritius, like so many other territories, would become increasingly dependent upon gifts from the outside world, but in a manner so invisible it would hardly detract from the pride and independence of the inhabitants. The seesaw contest between population and resource limitations is thereupon resumed on virtually the same lines that it was carried on before, only the vulnerability to further disasters is markedly increased.

Mauritius was saved by a perfect season for cane-growing immediately after the cane had been replanted and the factories rebuilt. The 1962 record crop year exactly made up for the loss in production in 1960. Therefore the relief received actually provided a stimulus similar to investment from overseas.

Two or three disasters of differing kind and quality, when occurring in quick succession, would appear to have quite different consequences. Such a string of ill luck is not impossible—the odds are obviously longer—but it happens frequently enough to enable us to sketch out some of the implications for Mauritius.

In many instances the financial reserves are spent after the first disaster, so that the second completely wipes out a large share of the firms and households as independently functioning units. It might no longer be profitable to rebuild sugar production, so that insurance payments

would then be spent elsewhere in the world. Life would become entirely disorganized. Martial law would be enforced but, since Mauritius is not an important military base, the forces available might be inadequate.¹⁷

If the world is not preoccupied with its own troubles the onset of critical conditions on the island of Mauritius would be noted in the major newspapers of many countries. The response would undoubtedly be generous and heartwarming. An airlift could probably be organized within a few days. A few hundred plane loads of cargo would be enough to prevent extreme suffering prior to the arrival of relief ships. The British Army and the Royal Navy would set up many emergency services such as electric power, water, telephone, and radio. The Red Cross would take care of extra needs for medical services. The Salvation Army might dispense food and good fellowship from their soup kitchens and canteens. CARE would route a stream of its packages to the destitute isle. Church relief organizations, Protestant and Catholic alike, would come in to help set family welfare problems in order. UNICEF might be brought in to help with the orphans and the child feeding programs. There is little doubt that collectively these organizations would succeed at their self-appointed tasks. The loss of life would be limited to some thousands, and almost all the sick and injured could be expected to make a satisfactory recovery. The dimensions of the island, even with its expanded population, are small enough to be well within the means of the existing agencies.

Then what? In the catastrophes envisioned here, an important part of the subsistence was erased and the local sugar economy crippled. This leaves hundreds of thousands without a place in the productive system. Some will certainly retain their freedom, reconstruct their *bidonvilles*, and starve in easy stages. Most of the homeless and jobless are likely to find themselves in hastily assembled tent settlements, under semi-military discipline, where the conditions of living are not dissimilar to

"Most scholarly analyses would stop at this stage. It is normally felt to be proper to leave to the reader's imagination the succession of events that would follow upon this situation. Experience shows, however, that reflecting upon catastrophe is painful for most readers, and they studiously avoid it unless the evaluation is made easy for them. The minority who are willing to study the anatomy of catastrophe—some say it is for masochistic reasons—very seldom make competent projections. The few pages that follow present my own ideas as to the consequences. There are many possible outcomes, but this sequence seems to be the most likely. The advantage gained by carrying the arguments through to a conclusion is that serious value conflicts are discovered for the future which may be prevented, at least to some degree, through the use of foresight.

those presently experienced by the displaced Palestinian Arabs. They would become wards of world relief agencies, living out their days in meaningless, unproductive routine. The Arabs in the existing camps have at least a grand hate with which to illuminate their lives so that they can spend their time developing schemes for small-scale revenges. But posterity indigent Mauritians will have none of this; they will have to sustain themselves only on the occasional quick angry demonstrations directed at the procedures employed by their benefactors. Since such frictions are guilt-laden, and there are no other foreseeable outlets for action, the camps are likely to encounter extremely severe morale problems. The purposes of living would be lost; self-respect would be shattered.

If contemporary experience is at all typical, we must expect that the international civil servants in charge of the 100 to 200 thousands deprived of livelihood will actively seek arrangements for migration. But this way out has already been explored, and the prospects have been found to be dim indeed. Places might be discovered for a few thousands of the artisans and their families, but that is about the limit. The international civil servants will know from the start what to expect, but they will have to go through the motions anyway, in order to demonstrate that they are trying.

The absence of meaning and hope in the lives of their charges induces equally meaningless behavior on the part of the administrators. A routine of inspections, reports, and reorganizations will be created. This administrative job is a nasty one which must be accepted as a necessary step to more responsible and desirable posts higher in the hierarchy. The administrators are sent there to be representatives of the world's conscience, because these impoverished victims of disaster must not be permitted to die without a helping hand being extended. Once rescued, however, the world would prefer to forget the plight of those who were saved because there are other problems which demand attention. It is not easy for the respective nations to liberalize their immigration policies, particularly when there exists no readily apparent niche for immigrant Mauritians. The people who are surplus in Mauritius are, for the most part, surplus at any other point of the globe. They are not likely to be able to pay their own way. In fact, the cost of keeping them alive elsewhere would almost surely exceed the cost of maintaining them in Mauritius.

Thus, the camps for the indigent population, once they have been established, become a special kind of prison. It may take a few years, but it is inevitable that the inmates will discover they are really serving life terms. Problems of petty theft and policing will probably lead to demand by the independent residents of Mauritius that the camps be surrounded by barbed wire.¹⁸ The decay of the fabric in the tents will lead to the construction of barracks type buildings. By that time it will not only feel like a prison, it will also *look* like a prison.

The chain of events can be traced somewhat farther. For the convenience of administrators, the population which speaks Hindi would very likely be separated from the Creole-speaking elements. Much smaller camps might be organized for the Chinese-speaking element and perhaps even for the immigrant natives of Rodrigues. If that were the case, at least four distinct "indigent cultures" will be likely to develop. Each one, no doubt, would come to despise the others. Perhaps, to break the ennui, a kind of gang or guerilla warfare would break out between them. A decade or so of this will make it impossible to prevent general communal strife in Mauritius.

¹⁸The present tendency is to set up camps complete with military guards and barbed wire within a month, but the breakout of the Hungarian refugees in France in December 1956 may change this approach in future emergencies.

No nation has yet really faced the problem of "keeping people alive" in just the fashion that is likely to be encountered in overpopulated societies of the future, of which Mauritius is typical. The refugee and displaced persons camps in Europe were temporary establishments which, when left with a residue of persons that could not be placed, became, in effect, asylums for the defectives and the disabled. Because of age and other incapacities deaths exceeded births by a large margin. The problem therefore diminished with the passage of time. In Asia, the peasant households in refugee camps, whether they be Arab, Hindu, or Korean, seem to be as fertile as when they resided on the land. Indeed, there is usually present a strong feeling of having been done an injustice, that the land from which they were dispossessed *belonged* to them and it is the duty of the household to see that a line of legitimate claimants continues to survive. For most of these Asian camps there is no end in sight. We see as yet no process by which they may wither away into non-existence.

Elsewhere in civilized countries a set of separate institutions, ranging from poorhouses and asylums to the dole, have been delegated special tasks and responsibilities for keeping persons alive who would otherwise be unable to do so on their own initiative. In the past, many limitations have been placed upon the behavior of such inmates and clients so as to reduce their demands upon society. One class of these restraints is directed to preventing reproduction. The measures that are used range from enforced separation of the sexes to sterilization. Yet, for reasons not easy to explain, it seems unlikely that international civil servants will demand that these same limitations upon fertility be applied to indigent populations supported in camps. Lacking any important constraints upon reproduction, it may be expected that the Moslem, Hindu, and Catholic elements will continue to grow in number by 2 or 3 per cent per year; the relatively minor Protestant groups may or may not grow, depending upon the general morale, the sects represented, and other features.

Thus, once started, there would seem to be no conclusion to the problem. In event of a new world war, such camps would, of course, dissolve. Very likely the consequences would be tragic, but the scale would be small compared to the world tragedy brought on by war, so the disappearance of camps of indigents due to lack of supplies would amount to a small footnote in the chronicles of those times. But, if the world avoids war, the flow of supplies would continue and the two societies would live uneasily together. One of them, comprising the communities of paupers, will be contained by barbed wire fences and walls, while the other is independent, but fenced in by the Indian Ocean and the barriers to migration set up by the respective nations.

Within smaller societies these are, we may expect, the normal consequences in modern times of unrestrained fertility followed by a sequence of bad luck with respect to the behavior of the elements or the world markets. Very likely they apply to many parts of the world, but densely populated and fertile spots may be expected to experience such outcomes earlier than the others.

Over a fourteen year period nothing happened to Mauritius or to related portions of the world that would have caused a change in this portrayal of Malthusian catastrophe in small countries. The situation was actually made more precarious because Mauritius was scheduled to become one of the mini-nations of the United Nations and the United Kingdom was resolutely divesting itself of its colonial obligations. During that period a number of occasions arose elsewhere in the world where large numbers of refugees needed support, but no improvement in the administration of relief evolved. The tendency for prolonged residence in camps to lead to extreme ideologies and violence untempered with mercy was re-emphasized by the feuds and civil wars set off by encampments of Arab refugees in the 1968-73 period. The violence engendered was so bitter it triggered the tragedies of the 1972 Olympic Games and in a number of airports around the world.

In 1971, however, the prospects of Mauritius took a new turn that seems to be a harbinger of the future, not only for that flattened piece of volcanic rock but for many other places. The original impetus began with the achievement of full employment in Japan, which led to heavy sub-contracting in Hong Kong.³ Soon Hong Kong, too, reached full employment, despite the turbulences of the 1960s. That condition led to a round of raises in wages which put a squeeze on margins in the garment industry. One of the leading entrepreneurial groups of Hong Kong, a multinational conglomerate called Hutchisons International, discovered the labor force of Mauritius. The island's 30,000 Chinese could communicate in detail with Hong Kong, while the Indian component could work

smoothly with managers trained in Hong Kong garment operations, which had always depended heavily upon local Indian labor. Moreover, governmental processes in Mauritius were very similar to those in Hong Kong. Thus Hong Kong textiles could be flown or shipped to Mauritius and there fabricated into garments which could then be flown to markets in Europe or America. Telecommunications between all three points were due to be vastly improved in the 1970s so that markets could be well served with low inventories in readymade clothing. Two competitors of Hutchison's were forced to make the same move shortly thereafter.

A possible rescue for Mauritius therefore, seems to depend upon linking its increasingly accessible, literate labor force to the mobile elements in international trade. The key institutional element in this diversion of destiny -- the hero in the melodrama -- is the multinational corporation which finds free trading societies and similar zones in coastal metropolises to be convenient sites from which to sell to the world. By such means the unemployed of Mauritius and similar mini-nations should be able to make a living somewhat above subsistence with long run opportunities for "trading up" their skills in a manner pioneered by Puerto Rico in the post-War era.⁴

This turn of events is indicative of one essential feature for the future design of cities -- openness to international transactions. The range of economic and cultural opportunities is thereby increased, and effects of natural catastrophes can be greatly moderated. A price must be paid for these boons, however, in the form of speedy abandonment of externally resented traditions

(but with the resurrection of others, equally old, that can be shared with visitors) and a loss in the feeling of autonomy. For example, when a metropolis is open to international transactions the local officials are much less able to maintain wage stabilization programs and a stable currency simultaneously. Also, repression of dissident elements -- a term employed by military men in high political or administrative posts -- is made much more expensive for the financial elite, because when international traders become skittish many sources of livelihood for their members and dependents are cut off. Fortunately Mauritius is subject to few such inhibitions to growth arising out of the international marketplace.

Meanwhile, the demographic transition for Mauritius is approximately only a quarter completed. The gloomy alternative for the future remains very much as depicted -- it is still a real threat -- but it no longer appears inevitable. The external contacts should reinforce the family planning programs, and factory employment should increase the independence of women. For economic security Mauritius should acquire dyeing and finishing, plastics, jewelry, paper, electronic assembly, watches, instruments, and other industries. Moreover, the next generation must move to parts of the Island accessible to the airport and seaport. Hope for the million plus future residents comes from a projected evolution into a metropolitan satellite of the fully employed economies in Japan and the Common Market. With improved skills and connections Mauritian citizens should be able to gain the freedom to move and settle elsewhere in the world.

Famine in Asia

Larger societies living on major land masses add new dimensions to the Malthusian ordeal. Larger societies have more degrees of freedom than a bottled up microcosm, and the responses to extreme stress are generated from a wider range of alternatives. When dealt a wicked blow by Nature, for example, the immediate impact on a large society will be uneven. Some parts of its territory may emerge virtually unscathed initially, but then become subject to an aftermath which could be more convulsive and inducive of change than the triggering catastrophe. The failure of a breadbasket region, for example, might lead to the breakdown of interdependent industrial areas when the local reserves of the latter are exhausted.

Since most of the world's population lives on and immediately around the Asian land mass, and the highest population densities are found there, the threat is most serious there. But what are the specific conditions likely to produce disaster? An investigation of history yields some mild surprises. Shocks are perhaps most attributable to extreme variance in conditions affecting the society. The variables include temperature, precipitation, infestation, disease, earthquake, price of principal export, and cutoffs from principal imports. Thus the north and north central regions of China with their records of great droughts and floods are more vulnerable than the southern provinces. An exclusively rice-eating population in southeast Asia will be more vulnerable than one that eats maize, wheat, millet, or manioc as well. In order to gain some idea as to where within Asia the

next Malthusian catastrophe may occur and what form it will take, we are guided by an intensity of shocks criterion more strongly than indices reflecting either existing population density or present rates of population growth, although these other indicators are obviously important. A fourth factor, which may be described as the quality of organization in public and private institutions, is exceedingly important but virtually impossible to appraise accurately in advance.

The last great test occurred in India so recently that the appraisals of the response to it and its after shocks have only been journalistic or particularistic. The monsoon failed in the north of India in 1965, whereupon a great drought set in; moreover it failed again in 1966, so that many of the ordinarily secure irrigated areas that drew their water from reservoirs also suffered crop failures. Some areas of India suffered from a lack of precipitation that, statistically speaking, is not likely to be repeated in a span of two hundred years. The food deficit had to be made up with imports from the surpluses of North America, but the demand was so great that it exceeded by a large measure what could be obtained and transported. The Indian civil service collected food locally and distributed these commodities along with the imports so as to spread rather evenly across the country the estimated 20% deficiency that still remained. At many points the margin beyond actual survival was very small indeed. In Calcutta at one time there was only enough food to meet minimal rations for eight days. It was also the season for the bore tides which affect the channel in the Hooghly River so that, as on many occasions in the past, the port of Calcutta

had been cut off from the ships standing in off shore waters. Nevertheless, as with the other great cities of India and the relatively hard hit agricultural areas as well, food was distributed with very few instances of interruption. As a result the population of India did not suffer a detectable loss when viewed as a whole, although in scores of instances districts faced the prospect of massive starvation because they had eaten into their seed stock, and isolated incidents of extreme malnutrition were claimed to exist by the political opposition.

Again, in the deltas of the Ganges and the Brahmaputra, disaster threatened during 1972-3. Always a food deficit area in recent times, the east wing of Pakistan that became Bangladesh after a bloody revolt suffered from a greatly reduced capacity to plant and harvest crops. Distribution was hit even harder because bridges, railroads, ferries, and docks were incapacitated or destroyed in the conflict. The United Nations and other assisting groups hindered by poor communications and a lack of clear authority, could not move quickly to the succor of a population that had been rendered homeless to a large degree as well as deficient in food stocks. The odds were discouragingly high that Bangladesh would suffer the greatest famine since some of the poorly recorded instances associated with the fighting of World War II. Malnutrition was expected to bring on an unusual cholera epidemic in the following year since cholera has always been endemic in this region. (This even though a new and relatively simple clinical treatment has been introduced for cholera so it is not likely ever again to be the scourge of populations.^{3a}

Future epidemics are expected to be restricted to the most isolated and disturbed districts.) The stress was, therefore, very great, and intensified because expectations set off by the achievement of political independence were so high. Famine and pestilence were overcome for the moment, but hopes for building up buffers and local reserves to prevent similar crises are far from being realized. Outside help will be required in increasing amounts, but the fact of aid generates resentments and xenophobic pressures, so Bangladesh politics are expected to become very unstable.

These near catastrophes have demonstrated that the bureaucratic apparatus in South Asian societies, when aided with free grain and some technical assistance from surplus-producing countries, is competent enough to cope with the drought experienced in the course of a hundred years. They can administer rationing systems and keep hoarding under control. The armies of these countries have sufficient discipline to enforce redistribution of food stocks in an emergency.

Some observers may dispute this, arguing that the next deficit in rainfall of this magnitude in monsoon Asia, the fifty or hundred year drought for a major area, will have an amplified effect. They might emphasize that the water that is lost would have produced food, irrigation-based grains in particular would register a sharper reduction in supply. Most of the new production is based upon small scale irrigation systems that may be expected to go dry in a catastrophic year, and be out of use if a bad year follows. At the same time the requirements for meeting the minimum

rations will have expanded by 25-40% over those of a decade earlier. India barely survived a 20% food deficit in 1966-67; the absolute quantities of such a deficit would roughly treble by 1980. The harbors were a constraint before; there is strong doubt that their capacity has been increasing rapidly enough. On the other hand, it must be admitted that information about the seriousness of the shortfall will be gathered and interpreted more quickly, so the dock facilities would be in operation longer. Also the LASH and SEABEE systems of shipment allow many smaller harbors to be served and the harbor bottlenecks now appear to be of a kind that can be overcome within a year after the decision to import. Growth in transport flexibility and capacity in and around the coastal metropolises is now making as important a contribution to the postponement of famine as any of the river development programs or the advances in fertilizer. A wholly independent factor has been the new capacity to draw upon water stored in aquifers, so tube wells plus electrification allowed India to hold down imports to two million tons in the severe drought year of 1972-3.

The year 1972-3 served inadvertently as another testing period for the existing capacity of facilities in the surplus areas to respond to needs elsewhere in the world, pointing up those specific bottlenecks, such as railroad car supply, which could not be overcome in times of crisis and would require long term investment. Food stocks in exporting countries are maintained at lower levels now than in the 1960s because large carry-overs depress prices to uneconomic levels. This response to

market conditions is unfortunate because crop failures in the Soviet Union in 1972 resulted in purchases of close to 25,000,000 tons of grain, or enough to meet the caloric requirements of 60-80,000,000 people and the associated animal population in that climate. At the same time China was importing several million tons of wheat though still exporting some rice. These grain movements strained the capacity of terminals in the exporting countries and created temporary shortages in the supply of shipping.

It might be possible that bottlenecks in food production and movement from the regions with throttled capacity could be overcome to the point where in 1980 the caloric needs of 150,000,000 people elsewhere in the world could be met on an emergency basis for the period of a year, but that would require coordinated international planning on agricultural and transport issues to a degree not yet achieved even among Common Market countries. Thus the expected capacity is somewhat short of that level, which means that the world could, by straining, respond to one famine threat at a time as severe as that experienced on the Indian subcontinent in the 1960s.⁵ The requisite aid emphasized when considering the competence of internal distribution systems should be forthcoming if the number of claimants does not exceed 100,000,000 persons.

In September 1972, the professional forecasters of Asia convened in Seoul and arrived unanimously at the conclusion that there will be a calamitous series of natural disasters in Asia in 1974.⁶ Although their techniques are regarded as pseudo-scientific, since they depend primarily upon astrology and direction-finding with bamboo stick (haigaku), these men are eminent in their

profession. They have excellent networks for gathering a kind of information that does not flow in the channels tapped by journalists, and they use that background astutely by posing their own questions and in framing the answers. It is well known that every year brings extraordinary natural events somewhere on a continent as large as Asia but that they only become catastrophes when societies are unable to respond appropriately, allowing amplification of the initial disruption of society. Therefore, one must interpret such a prediction to mean that the seers sense a reduced capacity in Asia to cope with adverses.

The Semantics of Famine

This discussion of famine has been struggling against an inability on the part of any audience that can be readily defined to perceive what a famine is and what it does to its victims. The principal reason that people in general, and scientists in particular, do not find the threat of famine credible is that the experience has never been made to seem real -- being hungry for a day or perhaps even two or three, an experience many of us have had, is not enough because the experience is private or familial and not collective. It represents a microscopic mistake in the working of a large system. Nor have the phenomena associated with famine been dramatized in the media in the way that concepts of justice or exhibitions of various forms of violence have been used to grab popular attention. In the short selections of film and text that have portrayed generalized hunger only the concentration camps of World War II stand out in the memory, and they represent the inhumanity of fascism or a consequence of struggle against an

authoritarian regime rather than a fundamental breakdown in the social processes that supply food.

Even William and Paul Paddock in their dire forecast, Famine 1975, which was committed to persuading Americans that a failure in food supply was imminent, did not spell out the attributes of the catastrophe they had in mind.⁷ Moreover, their forecasts were faulty because they are simple and deterministic rather than probabilistic and interactive. The latter approach seems more realistic because it encompasses a range of the most likely responses. It includes the effects of the best societal responses to stress we can think of making at this time, but it is still certain to deviate from an actual sequence of events because all the relevant facts are not available. The range of outcomes to be considered are suggested by analysis of precedents, while the odds to be assigned to any alternative path into the future are strongly determined by the standard reactions to threat resorted to by affected institutions, and are always influenced by local political circumstances. Human reactions to the outcomes of famine may range from guilt to outrage, leaving long-lasting attitudes similar to those that recall the "bad old days" of unemployment in the 1920s and 1930s in regions that were seriously affected by the Depression. Famine and its aftermath could drag on for so long that institutions collapse; studies should identify the threatened areas as much as possible in advance, and trace some of the structural changes to be anticipated in surviving institutions. It is apparent that the social, political, economic, cultural, and urban effects of famine can be illuminated by analytical research

but that such work has yet to be done. No graded assessments exist equivalent to the description of the effects of hydrogen bombs, nuclear radiation, and downwind fallout.⁸ Historical precedents must be drawn upon to illuminate the range of effects of localized famine; in order to obtain a complete picture we are forced to go all the way back to the Irish Potato Famine.

SCENARIO THREE

The Irish Potato Famine

Most bursts in population growth are brought about by sharp improvements in the efficiency of exploiting natural resources. For Ireland this was the adaptation of the potato, an exotic high-yielding vegetable from South America, by European plant fanciers to cultivation in bog soils. After introduction to Ireland -- a society that had lived upon barley, oats, some wheat, fish, and game -- the potato quickly became a staple food for the common people. Hoe cultivation of a small plot of marginal land planted to potatoes provided security from a hungry winter. Accordingly, the Irish population almost tripled in size during the 1779-1841 period to a level of 8,175,000. Its agricultural density reached levels as high as any in Europe, with 800 persons per square mile being recorded in some instances.

The 1840s were years of grain panic throughout the world and a major net importer, such as Great Britain, had reason for concern. Therefore the supply of wheat from Ireland was carefully

secured and much cheaper coarse grain, such as maize, was imported to meet the food requirements of the agricultural laborers.⁹

The blight on the potato appeared first in England in August 1845 and, within a month, then in Ireland, where it spread over almost the whole island within a few months. Prompt action of the traditional sort was taken during this year by the (English) Government. Relief ships loaded with maize (then called "Indian corn") were brought from America and the cargoes put on the market to depress food prices and minimize hoarding. Meanwhile, wheat was still being loaded for the British ports -- a paradox that has been long remembered and decried. Bread was so highly valued that wheat brought several times its weight in cruder grains with roughly the same caloric content, so the poor could not afford to bake bread. Many despised corn bread, or were unable to prepare it, so they suffered. Nevertheless, by drawing upon sometimes invisible resources, as well as hastily organized assistance from the outside, no one starved in the 1845-6 season, as was admitted even by the political opposition.

The blight struck again in the autumn of 1846, so that almost all of the new potatoes putrified in the fields or in storage. All the recuperative activities, which had been mobilizing effort in large part, by mortgaging future expectations, collapsed when those expectations became impossible to realize. A fatalism set in, and hundreds of thousands starved to death in a winter of misery.

The principal social consequence of famine, however, is not death but flight -- if migration had previously been a means

of dealing with stressful situations. In Ireland the pressure of population upon limited resources had been intensely felt in many households and districts much earlier than the 1840s. Migration of the Irish had built up to around 50,000 per year in the years immediately preceding the famine. Literate small farmers in the heavily Protestant Ulster area predominated in the flow before 1830, but they were then outnumbered by illiterate Southern Irish. Women were more certain of employment in America than the men, since Irish maids had become a standard convenience maintained by the middle classes. Their migration was mostly arranged by families, and did not receive any supervision until after the St. Vincent de Paul Society organized a committee in 1850. Seasonal harvest work in England provided many contacts leading to emigration to that country, particularly into the expanding textile industry and the crews needed to move cargo in the vicinity of the ports. The emigration of some paupers was aided with public funds and by landlords, but the mainstream depended on liquidation of the family assets or upon remittances transmitted until an immigrant was established and could begin repayment.¹⁰

In 1846 net migration doubled, and in 1847 it doubled again and then continued at an annual rate of 3-4% of the total population well beyond 1851. As a source of revenue, fares from the human cargo going West began to equal returns from cotton and lumber moving in the opposite direction. Eventually, specialized ships took over the trade, regulated by Passenger Acts that were aimed at reducing the hazards of ocean crossing. The Irish Poor Law of 1847 was the first legal response to the famine that affected

migration. It included a "quarter acre" clause which deprived individuals farming more than that amount of land of the right to obtain dole. Tenants relinquished their leases and emigrated, leaving wives and children behind to come when it became possible. In addition, the Act initiated taxation on land rents that exceeded four pounds sterling (approximately \$20, or a month's wage at a farm job), which caused a large number of small farmers just above this level to realize that they could not afford the tax for the dole provided to the truly indigent.¹¹ Therefore, migrants were drawn most heavily from the middle groups of farmers and from the merchant class, to such an extent that these activities were virtually paralyzed for lack of managers and entrepreneurs. Thus, the casualties were heaviest among the very poor, and the channels of emigration carried away many of the more competent and independent individuals.

Both these pressures arising from the Act led to a rapid aggregation of small holdings into farms requiring greater capital and more planning. It also instituted an aversion to subdividing land into plots that provided less than subsistence. The prudent father thereafter designated which son would take over the farm or business, therefore the opportunities open to the others involved either going to the city or emigrating to foreign shores. Waiting for the chance to assume responsibility on the farm or to find a niche overseas led to postponement of marriage. Connell attributed the extraordinarily late age of marriage in Ireland, which has persisted for more than a century, to the shocks of the potato famine period.¹²

Institutions adjusted also. The Catholic church began to inveigh against irresponsible marriage and sexuality. With the aggregation of the land by people strongly connected by blood ties or social class to the clergy, the Church became a very potent institution within Ireland. Conditions of surplus combined with bonds of loyalty to their religion caused Irish nuns and priests to be willingly recruited in large numbers and dispatched to posts all over the world in a form of sponsored emigration.¹³

Over the course of a decade the population of Ireland was reduced to about half. An estimated two million people are known to have left Ireland altogether, and perhaps half that number died in the famine or in the epidemics that followed. A large number, amounting to almost a million, remain unaccounted for.¹⁴

Overseas the Irish fitted in where they could. They provided the labor for building the railroads, the extensions of the cities, and hired hands on the farms, but a predominant portion settled in the cities. This was as true in Australia, Canada, and Argentina as it was in the United States. In many cities near the ports of entry the Irish settlers made it possible for the Catholics (then called Papists) to overturn power structures controlling local government; the Irish then took over management of the political apparatus, enabling them to monopolize employment in many urban services. Starting from shanty towns by the railroad tracks and tenements next to the harbor they eventually joined the mainstream and moved to the suburbs.¹⁵ In Ireland itself, however, the rural character was retained longer, and is still more strongly emphasized than elsewhere in the British Isles. Very

likely the slowness to change can be traced in considerable part to the psychic scars left by the famine.

A Modern Malthusian Catastrophe

The scattered arguments about vulnerability to famine and the scale of effects can now be pulled together and fitted to a most likely place and time. Meier and Meier suggest that famine potentials of the future be gauged in Irish Potato Famine Units (IPFUs).¹⁶ Identification of a specific locale and the dimensions depends upon (1) current population-resources ratios; (2) the likelihood of interruption of local food production; (3) distance from stockpiles, measured in political as well as physical terms; (4) cultural limitations as to what is considered food; (5) prevalence of local customs and attitudes that maintain high fertility rates; and (6) precedence of military or geopolitical factors that delay or complicate responses to needs. The leading nominee is some large part of the Hwang Ho (Yellow) River watershed in Northwest China.¹⁷ It could easily reach a scale of 30 IPFUs, with odds estimated as one chance in three per decade.

Data from China itself are fragmentary, but from a post in the Chinese University of Hong Kong, Ching-Siang Chen has compiled relatively current estimates.¹⁸ It appears that a combination of railroad building, water conservancy, and mineral development has made possible enhanced urbanization and industrialization in the Hwang Ho basin while residence in the coastal metropolises has been resolutely restrained. Cities like Lanchow (1,450,000 estimated for 1970), Sian (1,600,000), Taiyuan (1,350,000), Changchow (1,050,000),

Paotow (920,000), Shikhiachwang (800,000), Loyang (580,000), Huhehot (530,000), and Sining (500,000) are showing remarkable increases. The total population in these provinces appears to have been growing, though at a declining rate, now very likely less than 2% per year. Therefore, despite the industrialization, the population on the land itself has been steadily increasing.

The frequency of famines in China is much better recorded than elsewhere in the world because they were occasions for intervention by the Imperial Government and the archives cover two millenia for the parts of this territory that lived under Han hegemony (some was not in their control during the early part of the period). The provinces of Shansi, Honan, Anwhei, Hupeh, Shensi, and Kansu account for about half of all the famines due to drought in recorded history, but for a much higher proportion in the nineteenth century because their population had expanded very considerably.¹⁹ The reasons for the expansion are not clear, but in areas like this human population usually expanded up to the level allowed by food production and health, so apparently significant innovations had been introduced. This area was also the locus of the severest famines of the twentieth century. The population is now double to treble what it was at the time of the onset of the last famines, and the land has been very much changed by modified agricultural practise and mining.

A convincing account of the future that holds to some relevant track, avoiding sheer fantasy and fabrication and with the structure and shape produced by specification of detail demands a thorough study of the rural background. The most complete of the

village studies is by William Hinton, first a UNRRA relief worker and later an observer of the first land reform, who has provided us with a description of a village and its surrounding county in his Fanshen: A Documentary of Revolution in a Chinese Village. In it he relates the organizational and political forces at work in the larger society to changes in life in the county of Lucheng, Shansi. This county is about six hundred kilometers southwest of Peking, and contained about 120,000 people in the early 1950s.²⁰ For a village in a nearby province to the west (Shensi) Jan Myrdal and Gun Kessle offer reports from the villagers themselves of the changes that have been occurring.²¹

Hinton's community, called Long Bow (a translation of chung chung), is beside the road leading through the foothills of the Taishang Mountains above the railhead of Changchih. The village consisted of 242 families with 943 acres (290 hectares) under cultivation. This is a region that depends upon maize intercropped with beans, wheat, millet, turnips, and cabbage, roughly in that order of significance. Orchards are being introduced in places, as is synthetic fertilizer. Animal husbandry as an occupation is limited to producing beasts of burden which, along with agricultural implements, have always been exceedingly scarce, so they must be shared or put up for hire.

Long Bow possessed about forty different surnames, which is unusually high for China as a whole and is indicative of a history of ebb and flow of refugees from past disasters in which a few from each wave found a means of obtaining land, an artisan's shop, or some other niche that allowed the family to stay

indefinitely in the locale. Hinton reports that Long Bow is a place where the poor peasants frequently suffered from ch'un huang ("spring hunger"), so the margin of subsistence is very narrow.

The mainstay of the diet is not rice or bread but ke ta (maize dumplings) and millet. Except for important people, pork and fowl are in the diet only on rare ritual occasions.

Weather is, of course, all important. The monsoon rains normally arrive in July after a dry, windy spring in which the air masses flow down from frigid Manchuria. Hinton noted the effect of a July hailstorm which destroyed 50-60% of the crop yield. Help flowed in from outside in the form of extra turnip seed, buckwheat and 60-day maize for replanting. Recovery was apparently sufficient to prevent severe distress.

Some years earlier than most of China, Long Bow made the transition into a new era. The number of "middle peasants" operating 2-7 acres per household was maximized and many cultural impediments from the past obliterated. Thereafter the interplay of politics, and perhaps indirectly the pressures of population, forced China to experiment with further reorganizations of the rural districts, of which Long Bow was one among a million, first with decentralized industrialization, then with reform of the government apparatus, with rural reeducation of urban professionals, and with numerous less convulsive centrally-directed changes.

SCENARIO FOUR

Malthusian Outcomes Modernized

The time is a full generation after the transition to Maoism. The county of Lucheng now has a population that is probably in excess of 200,000 people. The land under cultivation has reached 50,000 hectares, due to strenuous efforts in building of small reservoirs higher in the hills and to land reclamation through terracing.

The people themselves are somewhat larger and robust than before because many elements of public health were introduced that made a difference for this last generation. Water was boiled and fly breeding areas were removed, so that dysentery was far less common during their childhood and infant mortality declined astonishingly. Nutritional levels are better equalized between households and over the seasons than ever before. The midwives are now trained and medical orderlies dispense miracle drugs along with acupuncture and bonesetting. As a result the amount of human energy that can be mobilized is much higher than in earlier generations.

The cities have grown proportionately more than the villages despite official intentions. Thus Long Bow has retained 360 families of somewhat smaller than average size clustered tightly together next to a road which has now been macadamized and has concrete bridges and culverts. The nearby coal mines have been greatly enlarged and scores of brutish, black trucks rumble past on their way to the railhead each day. Because of the road and the mine Long Bow has electricity, whereas most other villages in the county still do not. It even has two factories, one making ceramic

electric insulation parts with clay obtained from a pit in the nearby hills. Preformed components are fired in a small kiln next to the coal pile.

Last year the monsoon failed; the winds brought only dust. When the clouds developed into blue-black cumulus, only a sprinkle of rain fell before they dissolved. The labor brigades drew down the reservoirs to save some of the wheat. The maize and beans were a total loss, so the fields were replanted to buckwheat and turnips. But still not enough rain fell to hold down the dust, which in many of the paths was now ankle deep. Late in the year an assessment was made of total stocks of food and it was found that only a third of what was needed to get through the spring was on hand, so rations were reduced to half and an appeal for help was agreed upon. The community officials and Party members had been receiving repeated messages regarding policy from headquarters but none of them seemed to apply to the local situation. Belatedly they discovered that the industrial workers would be sent rations of about 1800 calories per day per capita (one pound of grain apiece) but that peasants would have to depend upon hidden stores, roots, and other famine fare. Somehow though the factory rations, which had apparently come all the way from Canada, seemed to diffuse through the village.

Meanwhile peasants from upland villages where the springs and wells had failed were moving down the road by walking beside bicycles loaded with household goods. Some had carts pulled by sad looking animals, but most merely balanced their loads on two ends of a sturdy pole. Many of the "walking wounded" crowded onto

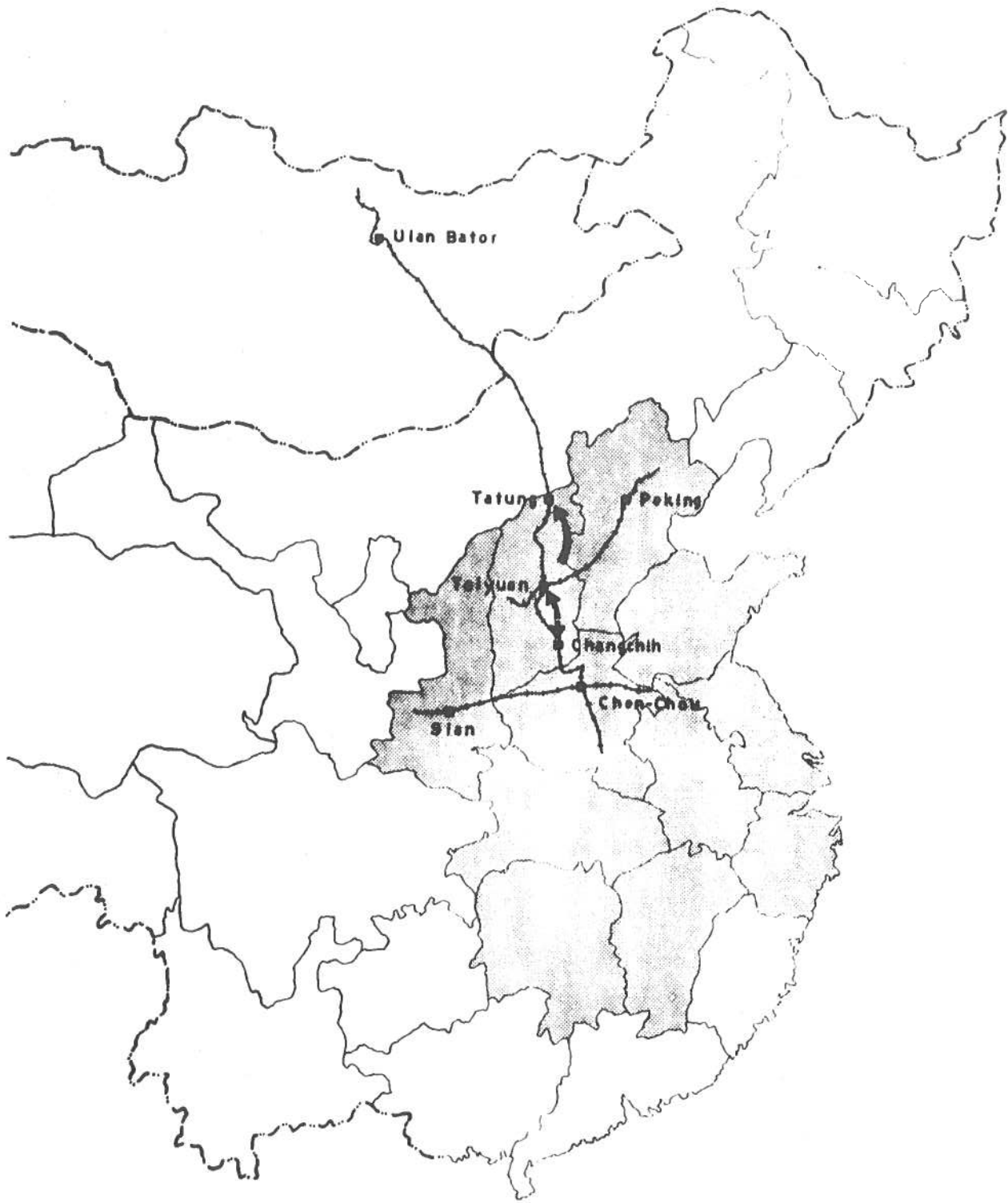


Fig. 4. China -- Population Flows in the Most Likely Famine

the coal lorries which maintained, if anything, an increased frequency of movement.

After an almost snowless winter the last of the locally held seed stores were planted, but June arrived and passed with no more than several centimeters of precipitation. The ropes in the deep wells had to be lengthened, while the shallower ones in the fields went dry. Long Bow peasants unrelated to factory workers decided that migration was the only hope remaining. The most vigorous of them went over the pass into Honan, many headed north to Taiyüan, a metropolis of over a million people at the head of the valley, while the remainder hoped for transport by rail out of Changchih. Up to that time none had died and few were really emaciated. Hidden stocks from the good years had sustained them, though it was noted that most of the animals had disappeared, even those owned collectively.²²

Long Bow families found the roads filled, and water was obtainable in some places only by barter or purchase. Dust was everywhere; the skies were an ominous gray. Huge crowds collected around the railroad stations. There they found railroad guards backed up by troops, hundreds of them at each station and thousands at junction points and yards where the trains were made up. The troops set up orderly procedures for those capable of purchasing tickets, and supervised the loading of families on the roofs of cars. They also distributed relief rations of food, water, and fuel. The trains fell far behind their schedules, so they soon followed the rule of moving whenever they could. Trains arriving at intermediate stations were so full few could get on, so the

refugees who were most mobile took to the roads again, heading for the starting points or destinations of the trains. Thus Taiyuan accumulated a million people beyond its previous million and a half and Changchih doubled its original quarter million. Long Bow's hundreds in both places tried to stick together in separate encampments but by the end of August they dissolved into the stream of humanity moving antlike across the face of China.

During August the pestilences began to appear; small children and old people were particularly common among those who succumbed. At first the causes were influenza and dysentery but then cholera, smallpox and typhus showed up, a few cases at a time, no doubt arriving from some out-of-the-way places in the mountains where they had remained endemic. As time went on the toll accelerated, and the military was assigned the task of supervising mass burials.

In September cities at the end of the rail lines, such as Changchih, received no shipments of food. All the sealed cars designated for them had been raided by troops along the way -- or were their contents sold by convoying troops? The rifled cars were filled with refugees before they returned to junction points in the plains, but that did not seem to diminish the numbers clamoring for relief. In mid-September the colonel in charge at Changchih took over a train and evacuated his troops, leaving the mayor and his council an impossible task. The Party cadre of Changchih (but not those of other locales in the hinterland) departed with the troops. In the days that followed no more trains arrived. The factory-supported contingent in Long Bow was now cut off, as were the miners up the road. Their ration

stocks were down to a matter of six weeks. So they shut down the factory and took to the roads also.

After the decision to halt production, each family began to fend for itself. Theft again became very common. The village loudspeaker radio still bleated, more shrilly than before, but it made no sense at all in the new context. Even those who once had rigidly conformed to the messages originating from Peking and Taiyüan paid no attention at all.

A hundred million people moved away in all directions. Travelling by road and train, most of them arrived in the humid plain and the great valleys of China, where rice was the staple of life. These plains still had green trees, but the fields at the end of the irrigation districts had turned yellow and brown. Rivers ran very low and were thick with algal bloom. However the inland lakes and reservoirs of the rich Grand Canal area enabled it to combat the drought, so about 80% of the normal crop was being produced, mostly in the double-cropping areas. Yams appeared in the market places much more than before, while pork went sky high in price in the black market.

Meanwhile, in Peking and Sian, some bitter decisions were being faced. The buffer stocks -- nearly ten million tons of grain that China held in reserve -- had dropped to less than four million during the first year of drought.²³ At the most about eight million tons from overseas suppliers could be brought in through ports connecting with the famine area per year. Basic survival needs were estimated at fifteen million tons if carefully distributed. This would cause an average reduction in body weight of about 25%; any more would cause widespread loss of

life. Who and where were the thirty to fifty million expendables? The Central Committee was at this time made up of individuals with managerial and military experience who had survived a number of occasions when supplies were grossly inadequate and "amputations" of one kind or another were in order. It appeared that the six provinces to the west of the Taihang Mountains, the original breeding ground for the Maoist version of communist revolutionary organization, would have to be abandoned temporarily to a fate decided by a harsh Nature rather than by man. This meant salvaging as much of the Army and of the Party organization as possible. It also meant pinching off the flow of refugees into the still viable areas, lest the districts that were still self-sufficient be overwhelmed with too many mouths to feed. So orders went out to the Army to decamp to the green areas wherever transport existed; the Air Force was to collect the Party organization.

Disappearance of the leaders who had been stalwart figures, working indefatigably to alleviate the disastrous effects of the famine, and sudden movements by crack troops caused new rumors to fly. The commander at Tatung, a rail junction city swollen with a million refugees about two hundred kilometers north of Taiyuan and just below the Great Wall, sensed that he had been chosen to be sacrificed without having the chance to volunteer. A devotee of the classics, having memorized Sun Tzu's Art of War²⁴ among other things, he pondered upon what great generals before him would have done. The consensus seemed to have been to accept his fate but that, due to the circumstance, he was unwilling to do. Overnight he constructed a desperate scheme, and lost no time in acting upon it.

He and his men were held in this trap by the Gobi Desert, one of the deadliest and most fearsome terrains on Earth. Running through this desert was an invisible, often unmarked line -- the international boundary with Outer Mongolia.²⁵ Far on the other side were the fat herds of the Mongols; perhaps they were thinner this year because of the shortage of grass, but they would be concentrated in places where water was assured. The commander had been on an official mission there years ago, and remembered well the desolate, sometimes rugged landscape. Only one way into Mongolia remained -- the rail line that stretched a thousand kilometers to the northwest. It presented an apparently inseparable barrier, however, because Mongolia retained the broad gauge of the Russian system all the way down to the border station, whereas his Chinese trains operated upon standard gauge tracks. Yet the history of warfare has many instances of the exploits of engineers who overcame the track gauge incompatibility problem. Here it was only a matter of nine centimeters. He brought in his two top engineers, and laid out the alternatives. The men under his command could die on the spot without effect, or they could dissolve allowing each group or man to use his weapons and survive through brigandage, but then each man remaining would live in shame of the acts committed in desperation. Could they somehow make a dash into Mongolia and try to live off the land? It would be another "Long March," but one that could not be negotiated on foot. Are there locomotives that can be refitted, rolling stock bogies that can be respaced, troop carriers that could be driven on the rails, etc.? He had six planes that could be flown for a while. Also, how much equipment could be seized at the border?

A desperate plan unfolded. Fifteen thousand men could cross the desert in three days, if they left virtually all equipment and supplies behind. Should they arrive, perhaps an equal number would join them a week later. If they met serious opposition they were lost. Fortunately the weather was on their side, the calm of autumn was giving way to the bluster of early winter so the dust might offer cover. To be on the safe side a diversion could be set up at the start to obscure their movement. There was no objective stated; once they arrived they would diffuse into the Mongol population at company strength. Ten days later they would rendezvous in the rail yards.

Operating wholly at night, when reconnaissance by earth satellite was less effective, the border post was cut off and taken. There would only be pictures of dust clouds to the West, where trucks were sent to drag the dry desert floor with chains. The coordinated land-air lightning attack on the city of Ulan Bator drew upon an existing plan but was too feeble to have a real hope until the Russians began shelling the city where the Chinese troops had diffused into the population. Suddenly many pent up frustrations were loosed; the Mongols turned their fire on the Russians. The situation became utterly confused and remained that way for four days while the civilian population disappeared into the countryside. Then more Chinese started arriving from the south.

In Mongolia there was meat and milk, but it could not be enjoyed for long. Russians and Mongol diplomats re-established contact and soon military representatives were disentangling the details, but for them a mystery remained regarding the Chinese objective. Where were their remnants holed up, and what should be done about the newly approaching trains? The Mongols effectively

had half the Russians as their prisoners, and were not likely to give up this advantage without negotiating a bargain.

Meanwhile the beleaguered Chinese commander, still alive, did what he could to reassess the situation. Their days in Ulan Bator would soon be numbered. What else could one do that would be so surprising they might confound all of their opposition and last a little while longer? Why not take the rail yard, hijack the trains, seize hostages, and move north? He had all the necessary skills with him. The really sizable stocks and supplies would be found at the Russian border.

Border clashes with the U.S.S.R. had ceased some years before the famine, but the outcomes had been carefully studied by all the Chinese staff. Potential vulnerabilities of the Russians had been reviewed at length and discussed, so the commander from Tatung was familiar with them, but in Ulan Bator he discovered that the Russians had almost stripped their bases and installations -- while the Chinese were preoccupied with famine -- and moved the troops to places cheaper to supply. The commander recognized that he could not go back, because the meat and rough grain available in a thinly populated country were insignificant as compared to the huge need to the south. Nor could he defend the city he had taken when the Russians were ready to move in. So he moved straight into their middle and advanced northwest along the rail line to Lake Baikal in anticipation of Soviet counter attacks.

Moscow received word of the most brazen border incursion to date and could not deduce the Chinese strategy. Photos from reconnaissance aircraft and earth satellites showed masses of

people moving up through Manchuria as well. Most were refugees, very likely, but were they also a disguise for troops? Troop movements had been unusual and mysterious for at least a week. There was a flurry of activity around nuclear operations at Paotou and Lanchow. The attempt to seize Mongolia without announcement or signal was very serious and demanded some response. Should they appeal to the Secretary General of the United Nations? That seemed silly. But nothing else made sense either. The Chinese had underemphasized the extent of the catastrophe partly because reports coming into Peking disguised the amount of disorder at first. The magnitude had to be comprehended there in a matter of weeks and during that period no public admissions of lack of control were possible. The rest of the world presumed China had an empty stomach, judging by the activity of its grain buyers, but it had no basis for suspecting an internal political crisis. One paranoid clique in the Russian Army argued, as expected, that a massive attempt on the part of overpopulated China to take over the empty spaces of Siberia had begun.²⁶ It did not make sense to start such an effort in September, but perhaps the intention was to disregard losses. There existed several fully elaborated plans to pre-empt China's nuclear capability while China possessed exceedingly limited long range ballistic missile capability, but it would probably take sixty days to get fully set.²⁷ In the meantime a non-nuclear response had to be prepared in the absence of any satisfactory intelligence but what could be seen from the air.

In Peking the disorders of the northwestern provinces were also viewed very gravely. A few isolated centers in the region

with guaranteed food stocks were still in daily communication, but they had lost contact with the situation around them and had no hope of regaining control. The regular channels of communication were now operated by that splinter of the Red Army now on a rampage. Peking was worried also that two nuclear weapons being readied for testing at Lop Nor in the desert to the west might be seized. Measures had to be taken to double the safeguards. Fortunately the major nuclear production facilities had already been transferred to the upper Yang-tse region, an area hard hit by drought but not yet in motion, and not in the pathway of the migrating hordes.

Pride in their own achievements, and to some extent the fear of dissension among a relatively new governing clique, prevented any public admission on the part of Peking that China needed help from the world in a form other than imported cereals. Therefore they maintained silence, not even entering into discreet exploratory discussions in New York at the United Nations.

It became necessary to halt the scenario because what was a Malthusian crisis became an international crisis with strong effects upon the prospects for world peace due to the presence of nuclear weapons and a background of mistrust. A different set of precedents applies; another category of experts has assembled the experience which establishes present expectations. They would have to pick up the thread of events from here. How does the nuclear deterrent system respond to provocation by desperate adventures?

Similar projections have been made in following out surprise-free sequences of events for other places in the world that are vulnerable to Malthusian stresses by the 1980s, although significantly less so than northwest China. All of them lead to major international complications, although not necessarily affecting the nuclear standoff. A break in the precarious prospects of Java would affect Australia and Malaysia; Bangladesh involves India, an increasingly organized Muslim community of nations, and possibly Burma. Another famine threat in India would involve the Americans, Russians, and the new wheat bowl on the Indus in West Pakistan. The range of complications arising in the case of Egypt is immediately apparent to anyone reading the newspapers. For smaller places, it has already been suggested, the projections for Mauritius, in a form appropriately modified by climate, culture, and location, should apply. What the exercises teach is that the world has become an amazingly tight web of interests and responsibilities. If any one portion is really devastated by famine, the interactions quickly affect the security of others elsewhere in the world through relationships that go beyond the direct food exchange process and most of them are indirect effects of the flow of refugees.

One last word on a possible sequel for Long Bow and Shansi, based upon insights from the Irish Potato Famine and the history of famine in China.

SCENARIO FOUR SEQUEL

Three years later Long Bow looked green and prosperous. Farmers had higher incomes than they could ever remember before,

but that was mainly because only half of them were tilling more than ninety per cent of the acreage. An additional reason is that the windrows of dust redistributed over the land added to the fertility of the soil. More marginal communities nearby, especially those heavily dependent upon grazing, were not reoccupied at all. The cities were surrounded by teeming squatter settlements sometimes equal in population to the city itself. In them one found mainly people from Shensi, Hopei, and Honan who had somehow survived and now were fairly well established, just as Shansi people had in earlier generations drifted to all corners of China to settle in similar communities. The remainder had joined their ancestors, but the graves were rarely found on ancestral lands, if they could be found at all.

We are faced with the inevitability of urbanization in our era. Even if a prospective famine should reach a scale of 30 IPFUs, with loss of life exceeding all the wars of the twentieth century it would not halt the process. Cities would become swollen with refugees who could be kept alive there through the importation of food and water. The overall population of China might pause for perhaps two years and then regain the momentum that adds an estimated two per cent per year to its size. In China today we see the most vigorous attempts to hold back urbanization, primarily through withdrawal of rations and reeducation in villages, but such measures build up a pressure to urbanize that will make itself felt when control is inadvertently lifted or when the fabric of the society is torn by natural disaster. Thus China seems likely to experience the same outcome as other societies even though it presently maintains much stronger discipline.

A final insight is that the inhabitants of large cities, particularly those in coastal locations, are now more secure against famine than most rural residents. They are now more dependent upon the world rather than upon the immediate suppliers in the region. They have the most competent administrations for coping with rationing and for maintaining public order. They also have assets which can be liquidated in order to buy food, if credit is not available immediately. The security of people living in the interior will depend upon the capacity of such cities to trans-ship and deliver grain in emergencies. Thus the future for Shansi depends upon Shanghai and Wuhan, just as Bihar must depend upon Calcutta and Haldia, and Bangladesh must maintain lifelines through Dacca and Chittagong.

An Energy Shortage

Energy crises, unlike food shortages, rarely have natural origins, and the responses to them are less primal.²⁸ Energy requirements for large cities are strikingly high; they range from perhaps two times the food and feed imports -- measuring both as calories -- in the poorer Asian cities to as much as 30-40 times in metropolises like Los Angeles and Houston. Energy is brought in mostly as fossil fuel, but increasingly it will take the form of electricity generated at a distance from sites with nuclear reactors using uranium as fuel. Both sources are non-renewable, so the present metropolitan community lives off the expenditure of geological capital.

In the short run war and other forms of international politics trigger modern energy crises. Since supply lines are usually quite long, they are vulnerable to disruption. Dependence upon external sources constitutes a source of defenselessness to actions taken by enemies or neutrals which can only be reduced by setting up alternate sources of supply. The last large crisis was caused by the closing of the Suez Canal. This event greatly extended the length of the route for oil tankers to Western Europe when no immediate means existed for increasing their number. The response was a quick reshuffling of routes and a significant rise in prices in and around most cities.

Rationing of fuel and restricting the end uses of electric power are both feasible. Cities under siege or blockade are forced to allocate fuels so as to maximize the likelihood of survival; when under these and other kinds of stress they may "brown out" many power-using but less than critical activities. Recreation, advertising, elaborate cooking, and household appliances are first to go, then the safety factors such as street lights. The stationary machine population designed to produce capital equipment and exports tend to be the next to be slowed down. Note that the activities of the machine population in the city are selectively affected, particularly the movements of the wheeled species when cutbacks are intense. The automata, such as telephone exchanges and computer centers, are now designed to be so independent that a reduction in their performance is barely detectible even when most machines are no longer operating. Plants and animals are affected indirectly, due to reductions in the transport of water

and feed; their death rate mounts as the energy deficit continues. Man survives easily but he may regress temporarily to what he conceives to be a more primitive state.

A new energy crisis began to be freely forecast in the spring of 1972. Experts could identify a number of past actions which have consequences that are likely to converge. They included:

1. The OPEC (Oil Producers Economic Commission) was developing the cooperation and technical competence needed to raise the selling price of petroleum at the point of origin. They can make the price stick in the world market because together they possess a near monopoly.

2. In the largest continental energy consumer, North America, the strict limits set upon the levels of atmospheric sulfur dioxide, photochemical smog, and fly ash increased the scarcity of clean fuels throughout the world.

3. Excessive protection of the consumers of the cleanest fuel, natural gas, by holding the price at an arbitrarily low level, diminished the intensity of search for new reserves, and led to a huge gap between demand and prospective supply, the scarcity will be felt at some times, and in some locales, even at prices four times as great at the point of origin as before.

4. A zealous environmentalist movement sprang up which objected to most of the locations of large energy transforming facilities such as power plants, refineries, and chemical works, causing postponement or long delays in most projects. Thus energy

conversion became more expensive and less able to maintain continuity of service despite fluctuations in supply and demand.

5. Simultaneously an appreciation of (a) spacious life styles and of (b) controlled living conditions inside buildings that emphasized thermal comfort created a demand for greater energy use per capita.

6. The research and development effort, which is aimed at producing new knowledge about the sources of fuels and their conversion into forms usefully employed in cities, has been warped by institutional traditions. Much work has been carried out by oil company research and development organizations on liquid and gaseous fuels for which the supply must soon decline and very little on coal, their natural successor. Breeder reactor studies have been carried forward on too narrow a base. Therefore a new and more economical technology for conversion of fissile elements into power is not expected to be ready for large scale installation until the mid 1980s.

A fair possibility exists that all these factors, and a few localized events as well, may have a simultaneous impact. What are the prospective consequences for the living and non-living populations in a metropolis?

The signal for the shock is a steep rise in the cost of fuel flowing through channels of international trade. An increase of a factor of three for clean fuel over the course of a year or so seems not impossible. Such a shift would cause abrogation of long term contracts because they hold one party or the other in an untenable position. These breaks force new buyers onto a short market, pushing prices up still higher.

Large modern metropolises like New York would shout mightily but would swiftly tap all kinds of secondary supplies, so that most of its luxuries would still be retained. The prices of urban services would be selectively hit but the average should rise by no more than five per cent. New York has the capacity to amplify its anguish, so the increase might seem like more (and indeed speculators may momentarily raise it higher) but that seems to be the maximum effect of the fuel component in New York's standard of living. Thereafter a number of relocation responses would be made by industries and organizations selectively hit by the rise in fuel cost. The installation of electric power plants, for example, is expected to be slowed down, and their design modified to improve fuel economy.

SCENARIO FIVE

Poor Cities Subjected to an Energy Squeeze

It is useful to consider the shock upon a city like Bombay, whose eight or nine millions by the end of the 1970s will be consuming three to four times as much fossil fuel energy as food and feed energy (as against New York at possibly twenty times). Assume three fold rise in delivered price over a two year period. Fertilizer production would be very seriously affected, because most of it is made from imported naphtha; the cost at the plant would perhaps double while the cost to the farmer might rise by half, allowing for the steep jump in transport costs in between. Therefore, the Indian Fertilizer Corporation, after first appealing to the government for a greater subsidy, would be forced to adjust its prices

to world prices, because no provision had been made for such a large extraordinary expense. However, world prices for grain would also rise sharply in response to the increased costs of fertilizer, therefore the controlled prices for grain within India could be raised to match the increased cost of production without adding to the apparent subsidy. The nationalized banks could give bigger loans without added risks. So the farmers find more cash flowing through their enterprises when they maintain the same formulas for production but none of it can be saved. The agriculturists that find ways of saving on fertilizer and fuel, substituting labor, will make a profit, but they will constitute rare exceptions in the first two years after the price shift.

The Maharashtra and Gujerat electric power grids would find themselves in distress. Their fuel stocks are sufficient for only a few months operations, and the funds on hand would be insufficient to replace them. Politicians would try desperately to postpone a general price increase for delivered power, but the rate of rise is too large for it to be absorbed. The New Delhi decision on fertilizer would apply immediately to power generation. Shortly thereafter New Delhi would have to announce a bonus for adjusting government pay scales upward more rapidly than the anticipated inflationary spiral. Painfully battled out, this step may have to be taken twice within a year, and some politicians may destroy their careers by failing to hold the line. The ordinary, non-union workers of Bombay would feel the effects

where they hurt the most -- perhaps a ten per cent increase in the cost of the daily ration, and a lesser increase in the cost of perishables.

The most likely response is a surcharge that would be placed upon electric power and provisions would be made simultaneously for cutting back upon its consumption. Marginal textile mills and energy-intensive operations such as glass making would then be forced to shut down, putting tens of thousands of workers out on the streets. The electric railways, buses and trucks would raise the commuter fares. At the same time the immediate demand inside of India for Bombay's output -- machinery, garments, pharmaceuticals, fine chemicals, plastic ware, financial services, export services, publishing and entertainment -- is likely to increase less rapidly than before, since less income would be available for all of these after paying for higher-priced fuel.

Once the central government recognized that prices of imported energy were not likely to recede very much, it is expected to act in two ways: (1) redirect its investment policy so as to produce more coal and oil internally, (2) accelerate the nuclear power program, (3) push exports still harder, particularly to Iran and the Arabian states which would be collecting cash from higher prices and looking for ways to spend it, and (4) reduce the transport component in production by cutting back on the programs for decentralization of industry.

As the export program takes hold, Bombay's fortunes would shift. The new income would pour through the port, each middleman

taking his percentage as fee for services, and the response of local producers to overseas markets would be more rapid in its vicinity. A few years after the shock it is reasonable to expect that Bombay will have been affected as if there had been a substantial increase in world trade and of Indian participation in it. There would be more jobs in the most modern activities and a wider range of opportunities for the educated classes. A larger share of the national investments program would be sited around Bombay in order to save energy-intensive overland haulage. The development of India as a whole might be set back considerably by a sharp increase in the cost of fuel, but the relative position of the coastal metropolis would be enhanced.

The market is a wonderful mechanism for distributing the shock of increased scarcity of a commodity, providing the law is effective in preventing hoarding and inhibits over-reaction on the part of speculators. By developing marketing institutions as a kind of neuronal network the metropolis is able to buffer itself against many external changes.

The principal result of a quick shift to a new energy cost plateau is a redistribution of the populations of machines in the city. Two-wheeled vehicles would grow in number at the expense of four-wheelers; machines attached to the electrical grid would speedily become more refined and more carefully designed. The need for prevention of waste through tighter controls and more complete information about operations, causes an acceleration in the already rapid growth of the population of automata. As the rising

flow of energy is dampened, the flow of information (negentropy) is multiplied many times over. A more integrated network of organizations is created as a result of meeting the challenge.

The foregoing exercise can be played out in many alternative sequences, but as long as any fossil fuel at all is available on the world market each of them ends at a new equilibrium for urban operations. If breaks occur, they are brief and attributable to human error. In the equilibrium situation the city will have discarded some of its energy-intensive machines, systematized better the use of its vehicles by allowing the inefficient to be scrapped with only partial replacement by other species, and it will have introduced many more automata, since they consume so little energy.

The cities that accomplish these internal transformations most readily will gain a competitive advantage over the others, thus very likely experiencing growth in size. Those which develop a capacity to negotiate with sellers and obtain delivery of fuel from a great distance will gain a similar advantage. The advantages to industrial cities arising from proximity to a plentiful fuel source would be greatly reduced, because transport cost becomes a much smaller fraction of total cost of delivered energy.

Hardships created by an energy crisis are surprisingly mild -- less heating and air conditioning, less meat in the diet, fewer long recreational trips, etc. The greatest impact would be felt in social and political relationships. Internationally the oil and gas exporters would acquire huge amounts of capital that could not be invested locally due to lack of labor force. Therefore

it seems likely to flow into international banking. The foreign exchange required for the capital investment needed to economize on energy consumption should be available at reasonable interest rates, though the risk-minimizing nonfinancial terms attached to loans will appear to be onerous. Asceticism and consumptive restraint will be rewarded, political autonomy reduced, and interdependence strongly reinforced.

NOTES

1. Richard L. Meier, Modern Science and the Human Fertility Problem (New York: Wiley, 1959). This book comprised a technology assessment of new, simple technologies of birth control then being considered at the experimental level or being introduced to the public for the first time. The Malthusian dilemma needed to be expressed in a new way, one that did not moralize or theorize and thus put heavy emphasis on fertility limitation.
2. Christos Xenos, "Mauritius," Country Profile, (New York: The Population Council, September 1970).
3. Business Week, April 29, 1972.
4. Richard L. Meier, Developmental Planning, (New York: McGraw-Hill, 1965). The sections on industrial planning and human resources development describe the process of planning the improvement in skill, based upon experience in similar economies.
5. These capabilities of the agricultural systems of North America and Australia to respond were incorporated into the projections of the O.E.C.D. at the time they were undertaking agricultural planning efforts. O.E.C.D., Paris, 1968, Agricultural Projections for 1975 and 1985. The capacity to support external populations would increase by a factor of three over the 1961-3 level of exports or about 600,000,000 people, if coarse grains such as maize were consumed directly by humans.
6. This item was reported in Time, September 25, 1972, p. 34. Political reporters in Asia say that a good deal of selection occurs among seers, therefore those that survive on the basis of performance demonstrate much wisdom. A great deal of "inside" information goes into a forecast, even if it is presented as a horoscope.
7. William and Paul Paddock, Famine 1975! American decision: Who Will Survive. (Boston: Little Brown, 1967).
8. Most comprehensive by far, because it presents some of the politics and administration as well as the history and physiology, is Famine: A Symposium Dealing with Nutrition and Relief Operations in Times of Disaster, Gunnar Blix, Yngve Hofvander, and Bo Vahlquist. (Stockholm: Almqvist and Wiksell, 1972). Modern society depends heavily upon novelists and script writers to illuminate the human effects of events. The subject of

famine has been dealt with peripherally a number of times as part of history, but it has only been taken up for modern times, as far as I can discover, by John Christopher in his small book The Death of Grass. (London: Michael Joseph, 1956). It was later filmed under the title "No Blade of Grass" and republished by Penguin (1968, 1970) under that title in an effort to take advantage of the vogue in "environmental doom" building up at that time.

Christopher invoked a blight upon rice which was later transformed into a disease that killed all grasses as the immediate cause of famine. In this speculation he is backed up by a recent assessment conducted by a committee of the United States National Academy of Sciences, Genetic Vulnerability of Major Crops (1972), which concludes that "most major crops are impressively uniform and impressively vulnerable to epidemics." The background is England of the 1960s or 1970s and he conjectures speedy breakdown of the social order after food imports from elsewhere are cut off. He supposes that modern civilization would dissolve into a number of lawless bands preying upon each other and a resigned, fatalist population. Changes of character portrayed in that situation are interesting but not persuasive.

9. J.C. Beckett, The Making of Modern Ireland: 1603-1923 (New York: Knopf, 1966).
10. S.H. Cousins "Emigration and Demographic Change in Ireland, 1851-61," Economic History Review 14, 1961; Frances Morehouse, "The Irish Migrations of the Forties," American Historical Review 33, April 1928, 3.
11. G.T. Griffith, Population Problems in the Age of Malthus, 2nd Ed. (London: Cass, 1967); R.D. Edwards and T.D. Williams, The Great Famine: Studies in Irish History, 1845-52. (New York: New York University Press, 1957).
12. K.H. Connell, "Peasant Marriage in Ireland," Economic History Review 14, April 1962, 3; "Catholicism and Marriage in the Century after the Famine," in Irish Peasant Society. (Oxford: Clarendon, 1968).
13. Emmet Larkin, "Economic Growth, Capital Investment, and the Roman Catholic Church in Ireland in the 19th Century," American Historical Review 72, 1967, 3; Oliver MacDonagh, "The Irish Catholic Clergy and Emigration During the Great Famine," Irish Historical Studies, 5, September 1947, 20.
14. Cecil Woodham-Smith, The Great Hunger: Ireland 1845-9. (London: Hamish Hamilton, 1962).

15. Andrew M. Greeley, That Most Distressful Nation: The Taming of the American Irish. (Chicago: Quadrangle, 1972).
16. R.L. Meier and Gitta Meier, "New Directions: A Population Policy for the Future," in F.T. Brayer, ed. World Population Policy and U.S. Government Policy and Programs. (Washington: Georgetown University Press, 1968), pp. 103-16.
17. Ping-ti Ho presents a modern analysis of the statistical background to drought and famine in China in his Studies on the Population of China, 1386-1953, (Cambridge: Harvard, 1959), pp. 230-6. This territory was stricken 1876-9 when a responsible official estimated five to six million people were in desperate need of relief by 1877. The Foreign Relief Committee's estimate of loss of life was nine to thirteen million. Famine affected the same area in 1892-4, 1900, 1920-1, and 1927-8. In the introduction of railways greatly reduced the death toll in the last two of these, even though the severity of the last may have been greater than that of the late 1870s. Considerable loss of life was experienced in this area immediately before this series of catastrophes due to the annihilation of the Moslems and after this period during the Japanese wars.
18. Cheng-Sian Cheng, "Population Growth and Urbanization in China, 1953-1970" Geographical Review 63, January 1973, 55-72.

TABLE III—NUMBER OF DROUGHTS IN DIFFERENT PROVINCES OBSERVED DURING HISTORICAL TIMES IN CHINA*
(By Centuries)

A. D.	0 - 100	100 - 200	200 - 300	300 - 400	400 - 500	500 - 600	600 - 700	700 - 800	800 - 900	900 - 1000	1000 - 1100	1100 - 1200	1200 - 1300	1300 - 1400	1400 - 1500	1500 - 1600	1600 - 1700	1700 - 1800	1800 - 1900	Total
Chihli	—	—	2	1	—	1	3	2	1	6	14	3	23	16	7	5	13	8	47	152
Shangtung	1	—	1	1	—	—	5	1	3	5	2	4	8	6	5	4	11	8	30	95
Shansi	—	1	1	1	—	1	4	1	5	5	1	1	12	10	7	8	17	3	12	90
Honan	5	14	—	—	2	1	3	1	8	30	23	2	12	12	4	3	9	2	20	151
Kiangsu	—	1	—	3	6	1	1	2	9	4	2	17	10	6	3	4	11	5	24	100
Anhwei	—	—	—	—	—	—	1	2	10	5	7	18	2	4	3	2	9	5	22	90
Kiangsi	—	—	—	—	—	—	—	—	5	1	1	5	6	2	2	9	21	—	12	64
Chekiang	—	—	—	1	—	—	—	1	8	2	4	19	7	6	14	22	20	8	15	127
Fukien	—	—	—	—	—	—	—	1	3	—	—	6	6	4	4	13	6	5	2	50
Hupei	—	—	—	—	—	—	2	—	3	2	2	5	5	10	15	23	17	4	14	102
Hunan	—	—	—	—	—	—	—	1	4	2	2	7	2	5	9	4	11	—	11	58
Shensi	—	—	2	—	1	4	5	5	3	6	8	6	6	9	7	9	9	1	16	97
Kansu	—	—	—	1	—	—	—	1	—	—	—	4	—	5	1	1	1	6	9	20
Szechwan	—	—	2	—	—	—	5	—	—	—	2	10	4	2	2	2	—	1	—	30
Kwangtung	—	—	—	—	—	—	—	—	—	—	—	—	3	3	2	6	1	—	2	17
Kwangsi	—	—	—	—	—	—	—	—	1	—	—	—	—	5	2	7	3	1	4	23
Yunnan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	10	6	—	1	19
Kweichow	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	3
Fengtien	—	—	—	—	—	—	—	—	—	—	—	2	1	1	—	—	—	—	—	0
Kirin	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	4	—
Helungkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2
Sinkiang	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
Mongolia	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
Kokonor	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	2
All China	25	35	24	41	37	41	43	41	43	64	69	58	77	60	54	84	82	36	70	984

*In some cases the phenomenon covers more than one province, while there are a few cases where location is not given; hence the sum for the different provinces in a century is not identical with the number given for the entire country.

20. William Hinton, Fanshen: A Documentary of Revolution in a Chinese Village. (New York: Vintage, 1966).
21. Jan Myrdal and Gun Kessle, Report from a Chinese Village. (New York: Pantheon, 1965).

China: the Revolution Continued. (New York: Pantheon, 1970).
22. Walter H. Mallory, China: Land of Famine. (New York: American Geographical Society, 1926). The author was chairman of the China International Famine Relief Commission; he reports on the normal disappearance of livestock during famine.
23. Surprisingly, the data on buffer stocks held were among the first to be released when China renewed its earlier policy of publishing statistics.
24. The most famous of these classics is that of Sun Tzu, The Art of War, which has a multitude of commentaries continuing to the present. Translations have utterly different styles cf. Lionel Giles (London: Luzac, 1910); Samuel B. Griffith (London: Oxford, 1963).
25. Mongolia had been the locus for intense Russian-Chinese competition in the 1950s and 1960s, well before the ideological split between the two countries. It remains the key to military strategy for both armies.
26. Harrison Salisbury, The Coming War Between Russia and China. (New York: Norton, 1969). Seymour Topping in Report from Red China. (New York: Avon, 1971).
27. Charles H. Murphy, "Mainland China's Evolving Nuclear Deterrent," Bulletin of the Atomic Scientists 28, January 1972, 28-35.
28. In no society in the world today does the original cost of non-food energy consumed exceed 5% of total income. In many instances the cost of energy is, however, felt to be far more significant because quite considerable transport and distribution costs are added to minehead and wellhead prices, and governments then double or treble prices to consumers with excise and value added taxes.

Chapter Three

SURVIVING ALL CHALLENGES

Fourth Draft
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A very specialized method of argument has been employed throughout the discussion of urban crises. It traced out futures for cities if the poorest of a likely set of possibilities should happen. The method is often called "worst case" analysis; it provides the decision maker with some situations that should be avoided, if at all possible, because of the undesirable outcomes. At the same time inputs are being marshalled to maximize the value-added-by-joint-effort. If external forces had overwhelmed the defenses of the metropolis, however, and the worst happened, we imagined that subsidiary groups and individual actors would draw upon traditional routines of joint effort in order to cope with the uncertainty and stress. The simile that comes to mind is that of a skater on thin ice who crashes through the supporting surface and must discover how deep the water is as well as employ the standard life-saving techniques learned earlier, but if the ice only bends he makes almost as much progress as if the surface were secure.

Preoccupation with worst case analysis is not only morbid and defensive, it can be hurtful. Society cannot afford to become too concerned about all the unlikely sequences of events which might lead into unexpected and unwelcome futures. To be prepared for all of them would require infinite resources. Even the status quo could

not be maintained. Our procedure intends to be prudent; it sets aside relevant kinds of reserves for contingencies with precedents, corresponding in many ways to insurable risks, and some extra reserves for other contingencies. After that one hopes for the best; the stocks held in reserve may for the most part remain unspent. Beyond that, we must retain a streak of fatalism which recognizes all the while that cities may be long-lived but are not immortal.

Scores, if not hundreds, of large cities built up with generations of hard labor have disappeared altogether. Each encountered a crisis it could not survive. The lesson that might have been learned was usually lost because there have been few reasonably unbiased records of the events that led to their downfall; too often in the past the histories have been written by successors, usually conquerors, who consistently attributed the destruction of the city to the significance of the omens, valor of the heroes among the attackers, the strength of their prayers, or the rightness of their cause. Occasionally neutral third parties were on hand who did their best to render an objective account. More rarely still, teams of archeologists, which are now made up of a variety of specialists, have pieced together explanations centuries, often millennia, after the fact. Classical scholarship has been able to deduce something about the specific underlying stresses brought about by resource scarcity at the time of catastrophe, but this is a very tentative kind of analysis.

Thus it is not surprising that ancient history provides us with no satisfying statistics or generalizations on the causes of the apocalyptic deaths of great cities, such as Carthage, Babylon, Nineveh, Antioch, Pataliputra, Bagdad, Ch'ang An, Teotihuacan,

and the like. Nor is there an assessment of the reasons for abandoning such cities as Memphis, in the Nile Valley, Angkor Wat in the Mekong, the large Mayan centers in the Yucatan jungle, the ancient settlements in the Indo-Gangetic plain, or the early Yoruba aggregations in old Ghana, except that people appear to have become less numerous, less productive, and apparently disinterested in urban life. Partial explanations do exist -- quite frequently we can discover that a harbor was silted in, a water supply lost due to the changing course of a river, the soils of a vital hinterland were worn out and eroded away, an ore body was depleted, or the population was destroyed by a great epidemic -- but in few cases are they comprehensive enough to be persuasive.

In some instances, a chain of natural events may be triggered by customs and obsessions of the dominant classes. The patrician Romans in the villas of a reconstructed Olympia, site of the world-famous quadrennial games, could hardly anticipate that their baths would cause them to be buried in sixty feet of mud and sand. The wood to fuel the hypocausts for heating the water was cut on the hilly flanks of Arcadia much faster than the forest could renew itself, so a record rain set off a huge landslide, thus preserving much of its integument for posterity. Similarly, the Romans did not understand the risks involved in building Pompeii, which was buried by the same vulcanism that produced the hot springs channelled into its famous baths.

The continued existence of cities has depended upon the maintenance of unified corporate organization, originally in the form of temples and royal households, later associations of guilds of artisans and trading companies, and eventually representative

government.¹ When unity failed the city dissolved, or fell prey to the free-booters of the period. Factionalism in key sacred and political institutions sets loose the rumors that attract marauders the way that the odor of fresh meat draws hornets.

Recent history, however, has been very different. No large city has been extinguished by war, revolution or natural disaster. Over time national social institutions have learned to apply modern technology and have synthesized a most remarkable capability for healing urban wounds; the great destruction of World War II rarely required more than a decade to overcome. Even Hiroshima and Nagasaki are larger and much more prosperous than before. The statistics suggest we must be living in a fortunate era for cities because they not only survive but grow in number and size. Thirty or forty more urban centers are expected to move into the million size category over the next decade. Nevertheless, runs of good luck come to an end; we must seek cues or clues to the transition to some new state of danger well in advance.

One such set of disastrous futures which generate huge concern has arisen over the past several decades, but deliverance from them cannot be planned in detail. This set was encountered first in 1945 when the existence of nuclear weapons began to dominate action and reaction. Many major cities have their doom inscribed in the target setting of a multi-megaton bomb in a second strike. Weapons aimed at enemy weapons have higher priority, and they will be targeted in early flight by enemy anti-ballistic missiles (ABM) but fallout radiation from these explosions would rain down on most other cities in the Northern Hemisphere. Some cities might be rendered uninhabitable, but much more likely the

radiation would be distributed in some freakish way that would save a considerable number. Fallout over cities around the Equator and to the south would be more dilute. Nuclear warfare presents us with a discontinuous line into the future; all outlooks shrivel with the first release of nuclear weapons.

By my own calculations and estimates most cities would survive an initial upset in the balance of terror that the present global system of government based upon national sovereignty has created. Some leading metropolises might be totally destroyed, some abandoned, and the remnants of the citizenry in others might be impelled to set up on a new site. In most instances, though, the city would be reoccupied if the cancerous effects of lingering radiation were less than those of cigarette smoking, because the surviving urban infrastructure would be much too valuable to abandon. Moreover, the chances for survival in cities improve over time as the ability accumulates to detect mutations, accept high abortion rates, construct elaborately instrumented systems of monitors that pick up the effects of radiation early, and cope with early forms of cancer. The attitudes of the surviving population toward human reproduction, processed foods, water supply, human injury, risk, and governmental authority, however, would have been transformed by the struggle to adapt to post-holocaust conditions of life and the changes are not now readily imaginable.

The chances of large scale destruction are reduced even more because the controls over the weapons in the strike force are becoming more finely graduated, allowing last minute retractions. The agreement on strategic arms limitation (SALT) between the United States and U.S.S.R. markedly reduces the principal source

of risk buildup. Therefore the longer a breakdown of the balance is averted, the better are the overall chances of the survival of the urban resident.

Curiously, although it is theoretically possible to design civilian defense systems that would greatly reduce casualties in the event of nuclear warfare, the very exercise of facing such a catastrophe seems to induce paralysis and disinterest. Normal people cannot contemplate gloomy and dismal futures very long. When their attention is deflected to more immediate concerns, any system tuned to respond to disaster tends to lose track of reality, each successive test encountering a greater disparity between its mobilization program and the needs of the then existing world, so civil defense agencies become undependable and error prone as they sit and wait. Thus, for psychological reasons, an increase in the effort of nuclear disaster planning can no longer be viewed as productive.² Instead organizations should be created that can react quickly to the unexpected, drawing upon active inventories and reserves, ready for any kind of contingency and opportunity.

An example of what is meant regarding constructive approaches to disaster planning would be helpful at this point. After the Managua earthquake of December 1972 (10,000 people buried in the rubble, 300,000 homeless or displaced), American state planning officials flew down to fill in an important gap in their information. How did their counterparts in Nicaragua survive during the first chaotic three to seven days after the shock? What sources of drinking water did they find? When did they recover enough from the shock to get hungry? Did they feel they had to loot grocery stores? What demands were made upon them for help, and to

which did they respond? Knowing the confusion associated with the first twenty-four hours of relief operations, how did their counterparts find their way back into an organization with an integrated communications system? Personalized accounts of action at times of extraordinary stress are dramatic and much more easily recalled than the directions in a manual. Which of the individual histories would fit the requirements of a nuclear disaster?

Obviously the best hope for avoiding destruction lies in finding a way to disarm. A joint process must be installed that not only prevents any further buildup of destructive capability but converts bomb materials into fuel for nuclear power plants. (Then their fuel value would be of the order of a hundredth of the cost as a bomb but power production can nevertheless be a means of relatively safe disposal.)

This brief review of the very worst case for cities indicates that the need for unproductive contingency allocations is declining over time, and that they can gradually be replaced by support of those urban agencies and organizations with very short response times, such as police, fire, and medical emergency, linked with distributors of food, fuel, and other supplies by high capacity wireless equipment. As this happens, the responsibility for civil defense shifts from national concerns to metropolitan functions; cities must increasingly take care of their contingencies as well as their progress.

Grave Injury

Although experience with occasional catastrophic urban destruction has been lacking over the past two decades, one finds

that the great cities have been going through repeated small-scale crises. These trials are worth reviewing because a catalogue of "near misses" is as good a forecasting device as a series of well reported failures. They point to many of the greatest hazards that urbanization faces in the future.

The idea that cities are being tested continually by small-to-medium threats of catastrophe and that their responses to these emergencies set the precedents for the reaction to great catastrophes is an appealing one. Current world history might be assessed as if it were a gigantic natural experiment; great cities in various parts of the world must meet scores of threats that strike at essential operations over the course of only a decade. Information on the frequency and source of threat should enable city planners to prepare defenses against disasters that have yet to occur. Nevertheless, an attempt to carry out such a program of investigation of recent urban history very quickly reveals a number of inadequacies both in the concept and in the data.

It was thought, for example, that a list of potential urban catastrophes could be compiled in much the same way that the reports of wars and revolutions in the nineteenth and twentieth centuries have been identified and chronologically ordered. Human costs have also been quantitatively estimated in most instances.³ However, catastrophes for cities were revealed to be different than for nations, primarily because the latter have legally defined occasions for waging war and citations for rebellion, while cities have precisely identified very few of the threats to their existence. The first "catastrophe list" (Table III-1) that was compiled for world cities contained two classes of phenomena: one was a series

TABLE III-1

METROPOLITAN CRISES IN THE 1960s

A Classified List of Threats to Functions
(includes only million size metropolitan regions)

Water Hazards

Hong Kong, 1961; Cut off from reservoir in China
Hamburg, 1962; North Sea flood tides
Bombay, 1963; Drought
New York, 1963-5; Long drought
Madras, 1969; Reservoir failure
Calcutta, 1969; Works breakdown

Institutional Loss or Collapse

New Orleans, 1960; Schools shut down
Rio de Janeiro, 1960; Government moves out
Hong Kong, 1960; Refugees overwhelm housing
Hong Kong, 1962; Refugees overwhelm housing
Alexandria, 1962; Loss of summer capital
Atlanta, 1962; Elite die in air crash
St. Louis, 1962; Metro. government rejected
New York, 1966; Garbage and transit strike
Calcutta, 1966; University strikes
Singapore, 1966; U.K. Navy leaves
San Francisco, 1967; Council of governments funds stolen
Tokyo, 1968; Universities shut down
Rome, 1969; Strikes of service workers

Energy Failures

New York, 1965; Power blackout
Beograd, 1969; Hydroelectric shutdown threat

Accidents and Natural Events

Tashkent, 1966; Earthquake

TABLE III-1 (continued)

Revolution and Rebellion

Dallas, 1963; Kennedy assassination
Singapore, 1965; Separated from hinterland
Los Angeles, 1965; Watts "rebellion"
Jakarta, 1966; Assassination and genocide
Cleveland, 1966; Hough riots
Hong Kong, 1966; Maoist riots
Wuhan, 1968; Red Guard battles
Washington, 1968; Riots and looting
Paris, 1968; Student uprising and general strike

War

Berlin, 1961; A wall is built
Lahore, 1965; Tank invasion threat
Prague, 1967; Russian takeover
Saigon, 1968; Tet offensive

Note: The identifying descriptor serves only to focus attention on a complex set of events that is believed to have been associated with crisis behavior in million-size cities and has been reported in international news services to some degree.

of threats to survival which were completely averted (followed by sighs of relief), and the other designated events in which damages were sustained, but only by a dispensable precinct or ward. The final list resembled a batch of medical reports from a loosely inter-related population of patients, mentioning epidemic prevention, recommending antibiotic distribution and reporting broken bones, fevers, digestive upsets and expressions of pain, (but no deaths) in the same context. The insight is important because the welfare of a city has properties closely parallel to the concept of the health of a group. The latter is known on the basis of much study to be measurable in many of its multitudinous dimensions, but not quantifiable as a single index number, so the analog stimulates a comprehensive assessment. Employment of health-related terms is more descriptive than mere parable; it may well offer the most suitable paradigm.

News stories reveal great differences between cities. Some are loud hypochondriacs, while others are uncomplaining stoics. New York, for example, exhibits a long sequence of urban crisis headlines but Shanghai's complaints, reduced to a few strings of characters by the time they reach nearby Hong Kong, are restrained. News of impending crises may be selective, since reports that entail loss of face may not be reported at all in Asian and African countries. Thus we are forced to discriminate between tub-thumping promotional cities that demand attention and the poor, ailing, powerless, undefended cities that seem unable to express what is happening to them in a comprehensible way. The former is consistently a high level transformer of resources, while the latter consumes at a much lower intensity. Just as a doctor must appraise

the effect of an injury upon "normal" human development, we are forced to specify an orderly development of million size cities so as to amplify the laconic accounts of some cities, and discount the dramatics of others.

Note that the analogs employed have temporarily abandoned the ecological framework and have embraced the organismic. The reason for this is the slow response time inherent in the organization of the populations in a community. The design of a living system, possessing a heavy endowment of neural tissue inside of a skin is Nature's way of organizing biomass to get quick response in averting a variety of threats. Natural communities suffer their losses and stubbornly regain their original state, but organisms are artful dodgers and can learn new evasive tactics without incurring damage.

These qualms about drawing inferences regarding the vulnerability of cities from the series of critical incidents which the largest of them face are raised primarily because the method does not seem likely to become improved by the expenditure of more research effort. What risk minimizers would like to do eventually is make it possible to take out insurance with some gigantic successor to be Lloyds of London. The insurance firms, using actuarial data available to them, would insist that cities take certain prudent measures to reduce potential losses, otherwise their insurance rates would be raised. Elected officials in such cities would find it much easier to persuade a public to undertake disaster prevention measures if they are clearly means of reducing the insurance component in operating costs. However, a first inspection of the information available on world cities indicates that it is not

reported systematically enough to be subjected to actuarial analysis that will cover the full range of risks. Because the possibility of introducing the risk-reducing measures associated with insurance, along with the automatic provision of funds to restore normal conditions, seems not too workable, cities must depend instead upon altruism -- the scarifices people make to help others in distress. The technique of critical incidents remains nevertheless about the best available for balancing the attention paid to problems of prospective survival for cities.

Urban Water Hazards

Indubitably the most serious difficulties with natural resources experienced by large metropolitan areas are those with water supply. As the population and the industry of a city continue to expand, whole new watersheds need to be dammed up. Their normal flow is then pipelined to the smaller reservoirs in the metropolitan area and from these points distributed through the urban grid. To do this, water authorities are formed to reach far out into the hinterland and purchase the rights to the runoff. If this acquisition is not undertaken well in advance of need, the occasional droughts that affect virtually every urbanized region and its water catchment areas will bring industries and sanitary systems to a halt.

The sequestration of water is most difficult in densely populated regions where rural communities have already established claims. Since the cities in many of these regions are relatively poor and cannot afford to build up a strong safety factor in the form of up-country reservoirs, they are forced to find some way to

ration limited water supplies about once every decade or more often. When this happens, announcements are made through the newspapers, and over radio and television, that there will be no pressure in the pipes of the city water system except between specified hours. Meanwhile, water carriers and tank trucks ply the streets selling water just as they might otherwise sell milk, kerosene, or vegetables. A shortage of food, particularly the perishables that are usually grown close at hand, is likely to follow the onset of drought. The combined difficulties are often sufficient to scare off potential immigrants and keep them out of the metropolis. If the drought continues into a second or a third year, the parched metropolis is likely to experience an inflation in food staple prices as well, thus creating a condition that will drive poor people back to their villages.

Large cities that have grown up near the headwaters of river systems are most vulnerable. Examples are Mukden and Sian in China, Delhi and Hyderabad in India, Addis Ababa and Johannesburg in Africa, Bogota and Caracas in South America, Pittsburgh, Denver and Dallas-Fort Worth in North America. The upper watersheds they draw upon tend to have a greater year-to-year variation in precipitation than the full drainage basin. In dry years these cities are likely to use the total flow available, draw down the reservoirs and pump heavily from the aquifers underlying the city itself. Many such aquifers rest on a base of dense brine, so continued pumping from such strata results in increasingly saline water.

There may be adequate supplies of fresh water a few hundred miles downstream, but it does not pay to build an upslope pipeline, especially since it could be rendered useless for a decade or more

by ordinary rainstorms. Further, since at least two years would be required after the time of decision to put such an aqueduct into operation, the likelihood that the project would be regretted is exceedingly high.

It is not at all easy for a metropolis to go into the countryside and buy up water rights. Inevitably, the political leaders in the rural communities come to regard this action as one that robs them of their future. The repercussions in legislative assemblies and parliaments are highly undesirable. Whenever dams and reservoirs are built leaders at the state or province level hear repeated stories, some true and many false, illustrating the unfairness of the urban authorities to "ordinary people." Often sizable villages are displaced from their traditional sites. Naturally the rural representatives respond to the threat by forming coalitions to repel invasion from the metropolis, even if it is the dominant political center in their own state or province. Almost always the rural population is over-represented in the legislature; therefore it possesses an unusually strong veto power.

The typical solution available to the growing metropolis is to pay for the same water two or three times. It must of course provide the scarce leadership and the capital for a regional water authority that has the power to collect the water at convenient points. This authority will find its actions bound by compromises in its charter which provide water for people in the vicinity of a constructed facility at rates a third to a tenth of those charged in the metropolis. Moreover, to obtain passage of legislation for such an authority with broad powers for water resource development, the metropolis must "bargain" for votes from

smaller cities and some rural areas. It must promise to support independent legislation creating industrial estates, harbors, airports, technical colleges and other installations at uneconomic sites purely because they are desired by the provincial elites. The metropolis creates the bulk of the taxable income and property, so the taxes applied to such projects derive from metropolitan production, and a water authority becomes a device for redistributing the added value created by urbanization to people who have thus far remained away from the cities.⁴

Woe be unto the metropolis that finds its water in an adjoining state or nation, because it is then not in a position to bargain for it directly. It is likely to pay much more without being sure of delivery even then, because extraneous issues due to strains in the relations between large political units can always be interjected. Everywhere in the world the subject of long-term water supply seems to be synonymous with political intrigue. Fortunately, large cities do not grow up in true deserts because in places like Arabia, as in the old Wild West, the occupants of the land go one step further and enforce their claims to water with private armament.

The normal effect of a great drought, such as that experienced by New York City in 1963-65 and Hong Kong somewhat earlier, is to cause the water-using industries producing for customers outside the immediate region to locate their next plants in urban areas where water is more secure. For a river-based city, this is often downstream. Estuary-based cities with shortages find themselves pushed into a flurry of water supply expansion activities by these same industrial interest groups.

Often high-cost substitutes are installed so as to reduce future vulnerability to drought. Thus, bottle washing and sterilization for reuse in milk, soft drinks, and beer distribution is displaced by disposable steel and aluminum cans and by plastic-coated paper. The new containers greatly exacerbate the solid waste collection and disposal problems faced by these cities, but those costs are seldom borne by the producer.

The large modern cities located on estuaries and shorelines have one great advantage over those on rivers; they can draw upon the salt or brackish waters of the sea for the large-scale cooling requirements of power plants and energy-intensive manufacturing. If fresh water becomes dear enough, they are in the right position to fill a minor portion of their needs with desalinated water that can be produced as a by-product of these industries, though this is likely to happen only when the cost of adding extra water supply capacity equals the maximum experienced by a million size city in the world today.

Much loose talk is heard about the ease of sabotage of the water supply lines to a city, including the introduction of some toxin into the water that would make it unfit for use. This is far more difficult than it appears. Even in Bombay, whose inner four millions are supplied by two large pipes side-by-side running above the surface for many miles (because the city rests on a rather narrow peninsula and its sources are inland), it would take the authorities only a few hours to replace a length or two of pipe or a valve that might be destroyed. Water requirements for several days are held in tanks and reservoirs within the city. Moreover, many of the poor get their daily water from the barrelmen who draw

it from a few wells inside the city. The presence of contaminants would be detected hours or days before it reached the bulk of the city regardless of what point it was introduced. Most inorganic contaminants would be held back for a while by the sand filters that are routinely employed, while the biologically active materials are very likely to be fully inactivated by the chlorine that is routinely added. An extremely skilled and well-informed agent might overcome these difficulties, but such a person could probably have a greater impact by attempting to bring other departments of government to a halt, and it should take less physical effort as well.

It may seem bizarre to take up such eventualities but the list of rebellions, riots and strikes affecting great cities is longer than the "near misses" on water supply. Successful cities must be very open systems, so it is impossible for the city to prevent the entry of agents seeking their destruction. If the Bombay water system seems to be able to cope with foreseeable emergencies, then it must be possible for its counterparts elsewhere in the world.

Energy Crisis

A city that does not import energy sources for its internal operations is dead. It can be shown that even the efficient technologies for exploiting sunlight incident upon a city cannot support people at urban densities.⁵ A large natural gas field immediately underground could support a small to medium size city but it would be exhausted too quickly by a metropolis. Exploitation of a rich coal seam underneath the city is ruled out by the

combination of the heap of spoil that would be produced at pit heads and by the settling of the surface caused by underground cave-ins. Thus, the larger cities must universally be fuel importers on a huge scale. Normally they bring in more than 99 percent of the fuel or electric power that is needed for their operation.

No metropolis has experienced a really serious failure in the importation of energy since World War II, unless one wishes to include Seoul and Athens when ravaged by the Cold War in 1950-51. At that time neither maintained a population exceeding a million. In the 1940's coal was still the predominant fuel, though oil often played a significant role, so the bulk of the imports, even in a relatively poor metropolis, was very sizable as compared to building materials and food. This meant that every time the rail lines and harbor came under attack, the inflows of fuel, food and most reconstruction materials would be simultaneously cut off and the respective stocks on hand would need to be rationed. Energy shortages were always accompanied by a lack of adequate shelter and by hunger; therefore, energy shortages are not an easily isolated threat to cities.

Since the construction of the autobahns, threats of invasion have almost always resulted in a military takeover of road transport, in addition to rails and harbors, and civilian needs have consistently been assigned low priorities in the allocation of transport equipment. Actual occupation of a metropolis by the enemy during wartime did not immediately result in improved access to food or fuel. Therefore, the great cities of Tokyo, Berlin, Leningrad, Manila, Hong Kong, and Athens suffered grievously during the 1940's.

Several predictable consequences were identified following those breakdowns in energy supplies. The most observable effect was the reduction in activity of all kinds -- economic, cultural, physical. Another was emigration, since the population of all the cities mentioned above was reduced by more than half within one to two years after the onset of attacks, and only a minor fraction of that loss was due to war casualties. Urban families with relatives or some kind of property holdings in the countryside thronged the escape routes. These refugees were joined by citizens on day trips who went foraging throughout the city's outskirts for food or lower grade fuels. Bicycles became the most prized vehicles at such times. Thus the forests in the parks and the green belts were almost totally removed, and even some of the peat bogs were dug up. Damaged buildings were scavenged for edibles and combustibles. Materials like paper became extraordinarily scarce at the same time.

Once hostilities ceased, however, supplies of kerosene and wheat flour were quickly moved in; technicians patched up the electric power distribution grid within weeks, or at most, a few months; electric power generating stations were put into operation even more speedily. All during this accelerated reconstruction period people flowed back. Indeed, the pace of resettlement proceeded to such an extent that each of these cities passed its former peak size within a decade of its nadir, even though housing and office space remained desperately scarce for more than another decade thereafter.

Never before have large cities recuperated so rapidly from such extensive destruction. This resilience in the face of great

damage is attributed in part to the multipurpose diffusion of energy inherent in electrification, but the modern bureaucracies managing utilities and services in the metropolis should be given equal credit. In each case the organizational framework had not been totally destroyed and the surviving elements retained the capability for recruiting and training individuals to fill the gaps. Bureaucracies heal wounds more quickly than the guilds of artisans and merchants that preceded them, and energy utilities such as electric power, gas, petroleum products distribution, and railroads ranked among the most advanced bureaucracies in each of these cities.

The ability to recoup damages to energy supplies has advanced even further over the past thirty to forty years. Power plants can now shift quickly from one fuel to another. Essential intracity traffic could be maintained with propane or even methane. Elaborate power grids have been constructed to provide back-up power for cities in case of the shutdown or loss of a captive generator. Many of the networks linking up the buildings in the metropolis have now been placed under ground or under water and are therefore not easily severed. Telephones are increasingly independent of the availability of electric current from the regional grid, so that systems of exchanges can work even when all the lights are out.

Presence of regional grids has, however, introduced a new and unexpected vulnerability. The Great Blackout of 1967 affected almost twenty million urbanites in the New York, New Jersey, Pennsylvania and Ontario area for a whole night. Lesser failures have occurred since then in several metropolitan grids, and in some cases their origins remain totally inexplicable. Although in those

instances subways and elevators stopped, trapping thousands, most buses and cars remained operational. Henceforth, too, a number of back-up generator units will be on hand in headquarters areas, thus greatly reducing the vulnerability of the large city to electrical energy supply failure.⁶

No other experience with threats of energy cutoff has come to hand that suggests large cities would be exposed to new disasters due to the inadequacy of the energy distribution systems. The planners of their public utilities have worked out a number of strategies that allow big cities to become relatively autonomous in the short run. In the long run a number of fuel substitutes can be mobilized, particularly if the population served includes a body of high-quality technicians -- a condition that is at least 90% true for million-size cities today.

Breakdowns in Public Order

While strongly persuasive evidence can be assembled to show that the physical fabric of the city is now mended more rapidly than ever before, there are some doubts that damage to the socio-political system can be as speedily repaired. Recent widely publicized riots in American, French and other modern metropolitan areas caused much physical destruction, but they took an even greater toll from the amount of public cooperation that had been achieved outside of the firm and the workplace. Urban order is an ephemeral kind of human resource; it includes at least (1) tolerance of others different from one's ingroup, (2) consensus on the rules governing public behavior, (3) an acceptance of the legitimacy of the courts in the settlement of disputes, (4) admission that carefully constrained police powers are needed to enforce the

authority of the courts, and (5) willingness to follow a responsible body of leaders. The resource is depleted when divisive issues are allowed to expand, causing polarization and breaking down the trust which is the basis of cooperation.

The characteristics of the urban social process enumerated above are all needed to expedite bargaining between individuals and groups without a recourse to threat or the use of violence. Coercion-free bargaining is the basis for urban order. Informal arrangements for completing social, cultural and political transactions are almost always more efficient than the formal procedures, therefore the degree of utilization of informal social process appears to be an indicator of the order that has been achieved in that urban region. Among the great cities, Tokyo has organized itself most carefully to expedite visitation, consultation, negotiation, bargaining, and the closing of deals. Inside each organization, down to the smallest, is a formal visiting place, where each person sips tea at a low table and expresses subtle reactions produced by almost his whole body. The higher the status of the host, the higher the table and the stakes. Subsequent meetings are most often conducted on neutral ground in some restaurant, coffee house, bar, night club, golf course, resort, etc. The style of service of food and drink corresponds to the kind of arrangement to be produced from the meeting -- with a foreigner one might choose a steak house or Chinese restaurant, possibly an eating place dedicated to an exotic specialty. With a provincial one defers to his taste for the cuisine of his region, for a fellow professional a bar traditionally frequented by other members of the profession may be most suitable -- each place being

designed to fit the needs of the man with the expense account. Each great city is famed for its expense account entertainment spending, but Tokyo easily surpasses them. The most complicated arrangements between multiple parties of different status, strength, cultural origin, age, and physical prowess can be bargained and closed more quickly in Tokyo than elsewhere. Business activities run on a higher proportion of credit than in other cities, so assessments of character are more important. Crime is moderate to low, racketeering and extortion are kept under control, corruption is not blatant, street violence restricted to the university districts, and public officials pay respectful attention to complainants even if no action is likely to be taken. Reforms and improvements upon public image are present everywhere. Therefore ad hoc organization is quicker and easier in Tokyo -- if one starts with adequate cash and organizational connections, and can handle unlimited quantities of tea, coffee, beer, whiskey, Scotch, sake, and then still more tea. Public life is so extensive and demanding that private lives are often starved and strained.

Calcutta is perhaps the prime contemporary example of a metropolis that has not developed this kind of human resource in a way that will contribute to its progress. Calcutta has always been a city of many ethnic and religious communities and large numbers of unattached men whose allegiances remained tightly bound to family and village somewhere in the accessible hinterland. Its severest trials, however, began at the time of the formation of Pakistan from 1947-1951. In the huge population exchange that resulted, Calcutta saw its educated and organized Muslims depart, while those that remained were of the very poorest level. The

metropolis received many more Hindus than the Muslims it lost, so the majority of the refugees was forced to settle on the fringes of the existing metropolis outside of the Corporation boundaries. The international boundary laid down at that time sliced off almost half of Calcutta's hinterland just at a time it needed to support a big influx of settlers. The social fabric is only now, after the founding of Bangladesh, beginning to recover from these shocks.

The frustrations experienced by different elements in Calcutta's population led to strikes of several varieties, food riots, violent political demonstrations, local pogroms, student disturbances, and a sullen resistance to authority on issues that presented little difficulty elsewhere in India. Public life is normally dull, telephones work poorly, secretaries are inadequate, and expense accounts rare, so that much of the time on the job is spent on hobbies, family affairs, and gossip. Family life, when it is possible, is said to be rich and rewarding, or at least complex and puzzling.

Calcutta has only a handful of lunching places for businessmen or public officials to get together -- the old British clubs have been retained but the transactions carried out in them are desultory. Alcohol is exorbitant in price, poor in quality, and seems to be reserved for the military, who in turn are kept off center stage. There is a remarkably active world of make-believe -- theater, films, music, poetry, intellectual circles, ideological groups, and religious associations -- whose component parts interact on only rare occasions. The disinterest of most of these groups in British institutions and the architectural relics of that era is one of the reasons for the visible decay of the central

districts, but the real sources of present civic disorder are much deeper. An established profit-minded clique has maintained its hold over the Corporation and the Improvement Trust. Calcutta's businessmen have extracted every rupee of profit possible from the urban milieu without promoting the new public services required for growth and development over the long run. Other great cities in India have produced some of the cooperative effort that was needed but businessmen and other community leaders in Calcutta have not bothered to defend themselves against charges of neglect; they can only say that they have been compelled to play the game of survival in a different way. The heads of leading families have not been able to communicate with each other on development because each group, however it defined itself, aimed to obtain justice for itself first. Life has been conceived as a negative-sum game in Calcutta; a feeling of frustration and powerlessness has prevailed.

The concept of order in large cities is best visualized as a multi-dimensional web knit together in networks that have frequently reproduced distinctively patterned relationships. Under stress, the web is easily deformed, causing friction and perhaps even rupturing some bonds. In cities with gloomy prospects, bonds are being broken more rapidly than they are repaired or replaced, so that the overall order is dissipating.

New organization and activities must be stimulated to halt the slide toward dissolution. They introduce new knots into the web; after some lag they produce new bonds in the networks. Even Calcutta generates a wide range of new organizations each year, particularly around its periphery. These include a number

of new holding companies, small modern enterprises, still smaller traditional enterprises, private schools, governmental offices, political associations, sports clubs, dramatic societies, professional groups, religious missions, neighborhood organizations, cooperatives, etc. The difficulty is that more seem to become stultified, moribund, or pushed toward bankruptcy than are created. Therefore, on balance, Calcutta has not been producing the new organizations that are needed to mobilize its human resources and produce expanding loci of order in its metropolitan area. A highly developmental metropolis, such as Tokyo, may have as severe a mortality rate for organizations as Calcutta, but Tokyo maintains a kind of civil order that greatly eases the task of starting and building new organizations. When the birth rate of organizations is greater than the death rate, the metropolis moves ahead -- first in terms of increased social participation, then in economic efficiency, then in political stability and, finally, in externally recognized cultural achievement.

The creation of new organizations presupposes a capacity to communicate. The city must install a variety of media that transmit information, preferably in an unbiased form. Thus information regarding a new opportunity and justification for forming a new organization most often arrives in specialized journals and catalogs, but it is reinforced by word of mouth reporting and perhaps with snapshots. Consider, for example, the establishment of a technical library, an art center, a housing cooperative, a private school, or a new manufacturing enterprise. The initiative is taken by a promoter, who through a series of face-to-face encounters persuades others that this project offers a profitable use of their time.

He finds financial backing, chooses the operating site, and starts instructing others in the most efficient ways they can contribute. Then he must turn his attention to the consumer of the new goods or services he intends to supply. Potential users of the output must be found and then persuaded that this product is clearly superior to the existing alternatives. The most economic strategy for persuasion generally requires the use of several communications media in a way that allows them to reinforce each other.

When a formula for selling the product has been found, the organization must expand rapidly to fill the niche that it has created. In doing this the promoter must look for suitably educated or trained people in moribund or dying organizations and fit them into his organization. The dense settlement of a metropolis allows a promoter to draw from a large pool of potentially valuable pre-programmed (i.e., trained, educated, or experienced) individuals and in a matter of a few years construct a finely tuned and sensitive organization. The outcome for the metropolis is a new address where people have relatively stable long range expectations and engage in orderly, integrated, productive action while depending much more heavily than ever before upon various communications channels for continuing operations. As long as most individuals and groups among the populations of men and automata can communicate with each other the metropolis continues to be a self-repairing, self-renewing, ultra stable living system.

The kind of catastrophe a modern metropolis most worries about is the failure of the organizations responsible for its major source of livelihood -- the reason for its relatively elevated standing in the hierarchy of central places -- but now with the

advantage of hindsight we see that such fears are rarely justified. Thus Singapore imagined that it might lose its entrepot status in Southeast Asia when the British Navy abandoned its installations. The organized efforts to compensate for the loss, however, caused Singapore to reach new levels of civic achievement -- including, quite unexpectedly, full employment. Similarly, Glasgow experienced a series of bankruptcies in its shipbuilding and engineering industries, yet unemployment has not reached levels that are normal in Canada, because the civic order was eroded very slowly. Now the availability of labor could bring it large new enterprises adapted to the expanded European Common Markets. Bankruptcies of railroads and toll bridges, where complete shutdowns have frightening implications, almost always turn out to be more reorganizations than dissolutions, and the changes may show up in altered names, perhaps, but not in a significant loss of service. As a result of a wave of such crises, railroads all over the world have been nationalized, and the huge deficits are met out of the public funds. The precedent has now been extended, so that if a major organization, such as a Rolls Royce, Lockheed Aviation or a Pirelli, founders it is propped up by governments after minor slimming operations. Such transitions are agonizing; they reflect the collapse of a portion of the local leadership. Having paid much tribute to the national government to maintain the overhead costs of the nation, cities can put in claims for help in these times of emergency reorganization and they usually get what they need. Thus metropolises live through many headlined crises which bring about merely a loosening up of commitments, greater dependence upon outsiders, new methods of accounting, a redirection of public attention, new leadership, and opportunities for new growth.

Therefore, despite cartoons depicting the precarious plight of the metropolis, wry satire on the fallibility of public services, waves of rumors predicting the breakdown of essential institutions, and the round of strikes that halt apparently necessary services, urban citizens lead a remarkably secure life. Viewed in the aggregate, the struggling metropolis can now maintain a steady state with scarcely a wobble, given any exigency short of nuclear warfare. In normal times, but particularly the cautiously optimistic periods, the capacity to breed and import new highly productive organizations generates substantial growth. For world urbanism we can expect this growth to be relatively smooth, continuing over many decades.

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FOOTNOTES

1. E.A. Gutkind, International History of City Development, (Glencoe: Free Press, 1964); Gideon Sjoberg, "The Rise and Fall of Cities," in Nels Anderson, ed. Urbanism and Urbanization (Leiden, Brill, 1964). Actually the literature is vast, and features many viewpoints, but the line of development for city organization depicted briefly here is compatible with almost all of them.
2. Disaster studies received a fair amount of theoretical as well as practical attention in the decade after the first tests of hydrogen bombs. Interestingly, this interest fell off very rapidly and there were relatively few reports of studies conducted during the 1960s. Repeatedly it was found that panic very rarely occurs under conditions of great damage, and that instead social relationships among the survivors were strengthened, even to the extent of causing remission in mental illness. A large share of immediate assistance is given by strangers who were also victims, but medical help, shelter, fresh water, and regular food after the immediate emergency must be brought in by rescue teams coordinated by centralized ad hoc organization. Finally formal organizations complete the restoration of normal conditions through the payment of insurance claims, extension of loans, and restoration of services. Allen H. Barton, Communities in Disaster, (Garden City, N.J.: Doubleday, 1969). The most impressive performance recorded thus far was for the coastal city of Niigata, where despite huge destruction due to earthquake and tsunami the loss of life was held to a very low level, and the city came back into operation with rapidity. R.R. Dynes, J.E. Haas, and E.L. Quarantelli, Research Report #11, Disaster Research Center, Ohio State University, Columbus, December 1964.
3. Joel David Singer and Melvin Small, The Wages of War, (New York: Wiley, 1972).
4. The political economy of water is very nicely handled by Bain et al. In their instance most of the water was to be used for export agriculture but the innovating institutional elements were backed by metropolitan water authorities. Joe S. Bain, Richard E. Caves, and Julius Margolis, Northern California's Water Industry, (Baltimore: Johns Hopkins, 1966). For the more technical aspects of metropolitan water planning see M.L. Albertson, L.A. Tucker, and D.C. Taylor, eds. Treatise on Urban Water Systems (Fort Collins, Colorado: Colorado State, 1971).

5. The calculations are made as follows: A hectare can produce under optimal conditions no more than ten tons of food and fiber, dry weight, per year. Some energy is needed for fertilizer and food processing, so the net yield is no more than eight tons. Each urban resident needs a million kilogram calories per year (250 kg.) for food and about three times that much at a minimum to support transport, manufacturing, lighting, and other energy-using urban activities. With ideal technology that assumes the highest conversions and trivial amounts of waste, about one ton of organic matter could be converted into these requirements. Thus no more than eight urban people could be supported by a hectare of rich land and they would still need about a tenth of an acre or so for strictly urban activities not related to extraction of solar energy. The resulting density (maximally seven persons per hectare or 1800 per square mile) is still too thin to be called urban. The typical conditions are, of course, more nearly half as productive or less, and the densities supportable thus become average rural densities. In the long run future, however, the energy imports need not come along the surface -- they could be concentrated by satellites and beamed downwards.

6. The Northeast Power Failure, as it came to be called, led to a worldwide review of power grid design. In the United States the Federal Power Commission made a special report to the President of the United States: Prevention of Power Failures (Washington: Government Printing Office, July 1967, Lee C. White, Chairman). The occasion was marred somewhat by a similar failure covering an equally large region, in part overlapping the former one, with outages of one to ten hours, while the report was in press. Nevertheless in 1966 an equally large failure around Los Angeles had minimal effect because the Southern California Edison Company had installed automatic loadshedding triggered by relays that detected a reduction in the number of cycles per second of alternation in the current. The experience led to much more comprehensive planning at every level of service, apparently to the point where the irritation of the customer upon experiencing a failure is valued at many times more than the total economic loss. The unavailability of power to a customer is rated at less than one hour in about 20,000. The strategy now is to prevent cascading of failures in a network by isolating an increasingly small "island" which may require repair while the load is met by the extra capacity in the remainder of the network.

In developing countries lightning competes with human error and sabotage as a cause of failure. The reliability that is economic may well be in the 99.8 to 99.9% range. Cf. Proceedings of a conference on The Economics of the Reliability Supply held by the Institution of Electrical Engineers, London, October 1967, particularly papers by (a) G.G.R. Argent, M.W. Kennedy, and A.B. Wood, (b) H.J. Sheppard, and (c) M.W. Gangel and R.J. Ringlee.

A standard procedure henceforth is the computer simulation of a network, subjecting it to all known forms of failure, so as to produce decision rules for power system managers.

