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RICHARD L. MEIER

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Center for Planning & Development Research: Institute of Urban & Regional Development
University of California, Berkeley

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The Social Impact of a Nuplex

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There has been a great deal of discussion about the advantages of nuclear-powered, industrial complexes (or "Nuplexes") but comparatively little about the problems of establishing one or its cultural consequences. Prof. Richard L. Meier of the University of California, Berkeley, examines the social contributions and effects of a "Nuplex" from the viewpoint of an expert in social and economic planning. This material is from a working paper developed for the university's Center for Planning and Development Research.

The term *nuplex* was born in 1968. It labels a difficult-to-describe phenomenon that is expected to come into physical existence in the mid-1970s and become increasingly important thereafter. The nuplex is one of the consequences of the introduction of very large nuclear reactors for electrical power production. The AEC coined the term to encompass the anticipated complex of industrial, and even agricultural and marine, installations that will naturally cluster around a large nuclear reactor in order to exploit the unique opportunities it presents.

Long ago it became evident that nuclear technology had properties that would attract a considerable number of interdependent ancillary industries to the immediate neighborhood of a large reactor. The basic pattern of agglomeration had been presaged by the formation of of complexes around oil refineries, salf mines, and a few hydroelectric installations. The first diagrammatic representation of a nuplex appeared in 1956. (R. L. Meier, *Science and Economics Development*, Cambridge: MIT Press 1956.) However, the idea has assumed much greater significance recently; it could well be the first instance of the new and exciting tasks in the service of man to be taken up by existing large government laboratories for fundamental and applied research.

Two years earlier Alvin Weinberg had argued that an important share of the world's ills could be eradicated by massive research and development programs. (*Bulletin*, December, 1966.) He called the successful outcome of such a program a "quick technological fix." Most of the large laboratories created by the U.S. government, operated in many instances by academic and industrial contractors, would have a vital role to play in such programs. The national laboratories were visualized as instigators, coordinators, and, to a great extent, researchers.

The idea of a "fix" has many connotations, most of them dramatic; therefore, it was widely discussed. Many opinions were based upon speculative reinterpretations of historical cases. What if a crash program had made an obviously useful new technology, such as malaria prevention, synthetic rubber, or hybrid corn available a decade or more earlier than it actually arrived on the scene? How much distress would have been prevented?

What would the world be like now?

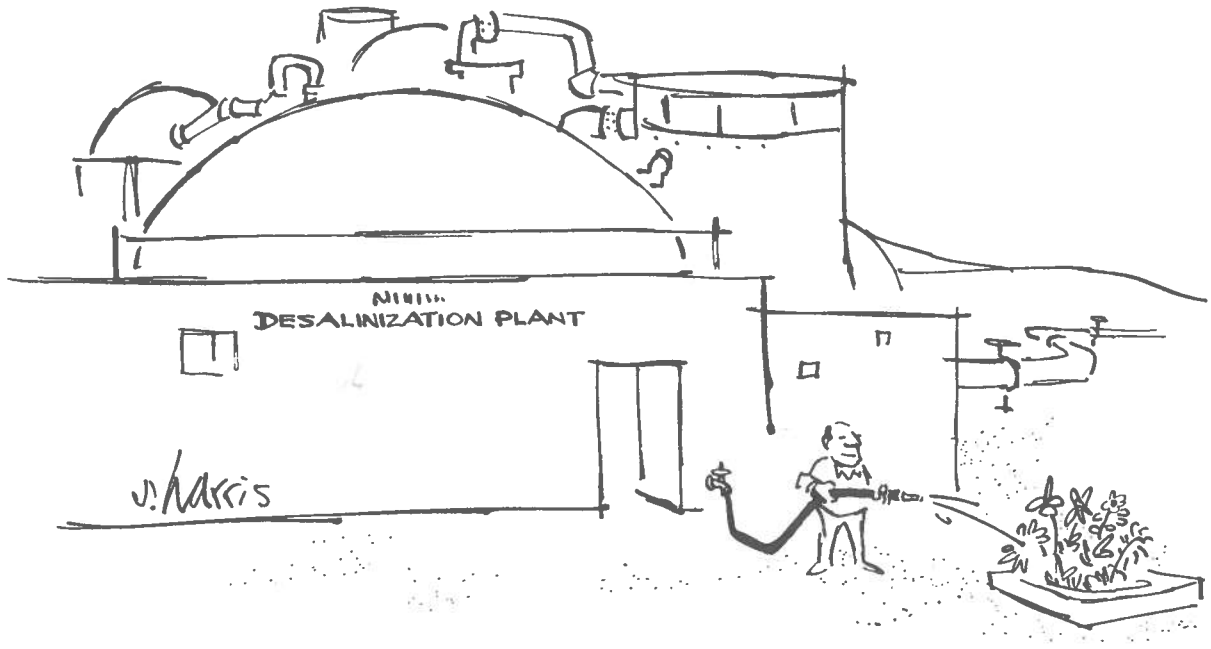
Logically, however, a "technological fix" can only solve critical problems already recognized by using ideas immediately at hand. In those instances the prior existence of the necessary knowledge was doubtful.

Examples for current applications were suggested, such as the intrauterine device for population control, and nuclear energy for Los Angeles water production, but subsequent assessment indicated that the programs for implementation were elusive—no straightforward path to the desired outcome could be found.

THE TECHNOLOGICAL FIX

Shortly thereafter, the threat of great famines affecting hundreds of millions of people presented a suitable opportunity for a technological fix. A series of crop failures in the Soviet Union and in Asia resulted in imports from North America so sizable that its large surpluses were drawn down to a normal carryover supply. Simultaneously, quite independently, the nuclear power reactor industry succeeded in underbidding coal as an energy source for a large power plant at a site immediately above a good quality coal seam. As a result, a series of nuclear plants of increasing size would be built in North America. Engineers at Oak Ridge had the vision to link the world food problem with this technological success.

The connection was made by means of a novel cluster of known technologies that, when combined, could unleash a substantial expansion in food output elsewhere in the world. Their scheme could produce staple crops only slightly differentiated from foodstuffs presently consumed by the poor, and therefore quite certain to be accepted. This is in contrast to repeated proposals to convert coal, oil, or natural gas into microbial protein, but do not explain how poor people can be induced to



eat the synthetic foodstuff. Thus the stage was set for a technological fix. The Oak Ridge idea took the shape of an agro-industrial nuclear complex that produced fertilizers and desalinated water on-site and then irrigated and fertilized an adjacent coastal desert seeded to staple crops. It seemed, after brief study, to be technically feasible, economically worthwhile, socially desirable, and politically strategic.

This opportunity was further explored by a summer study directed by Edward Mason, a professor of nuclear engineering at the Massachusetts Institute of Technology. The specifics of the proposal were roughed out between June and September, 1967, and a draft was shown to the press the following March, (*New York Times*, March 10, 1968, p. 73.)

The illustration of the completed agro-industrial complex indicates the present state of the study; it outlines a bio-technical automaton that spreads out to the horizon from an empty shoreline. Not a road, office building, worker, or evidence of human settlement is to be seen. Nevertheless, the text estimates that as many as 100,000 persons may be directly connected with the project before full capacity is reached.

This "food factory" closely resembles scores of large-scale irrigation projects based upon big dams and hydroelectric power. The mechanization aspects are paralleled by the Groundnuts Scheme concocted by the British immediately after World War II. *Virtually all of these large schemes have been dismal failures in the economic sense.* Among more than a score in Africa, for example, only the Gezira Project of Sudan stands out as a success. In South Asia, the returns have yet to come in on many big projects, but the majority of those that have gone into operation failed to produce food at costs low enough to compete on the market. The output has been only a fraction of what was planned. The problems that intervened so disastrously were rarely technological in origin. Mostly they could be called "people problems," originating with settlement procedures, laws, customs, education, marketing, management, and so forth.

Therefore, a very high priority must be given to testing the feasibility of proposals for organizing the human contribution to the nuclear agro-industrial complex. This is best done by fitting the building blocks of technology to some of the most applicable sites and then proceeding to plan as optimal a program for community development as is economic, legal, socially acceptable, and politic. This exercise should reveal a number of extra, unsuspected values inherent in the nuclear agro-industrial complex that were not envisaged by the technologists. The result should greatly increase the likelihood of success.

THE PEOPLE

Any nuplex with a large food-producing component will displace local people. Even the wastelands, the kind of territory preferred for such development, are loved by residents and nomads who will resent the intended transformation of their environment. Therefore, unless careful preparations for the introduction of a nuplex are made in advance, it will be greeted by bitter resistance, litigation, strikes, and even sabotage. These kinds of

conflicts are natural, and will certainly break out unless people become convinced that they will gain much more by co-operating with the new project. Once established, a major threat to successful operation remains in the form of a devastating malaise sometimes referred to as "the company town syndrome." It comprises the set of inbred conflicts that pit employees and local residents against the company and its managers.

These and other well-documented forms of trouble can be avoided in part by proper location of the nuplex. Common sense arguments suggest that the installations should be laid out so as to (1) disturb the lives of a minimum number of families, (2) open up a channel for personal growth that leads as easily into the metropolis as would a suburban location of the site, (3) settle every prior human claim to land and services early in the occupation, (4) provide a range of options for immigrants, including the freedom of changing their minds at low cost to themselves, and (5) yield a high payoff for collective self-help solutions to problems of getting settled. Too often engineering considerations, including transport costs, are the sole consideration in the choice of a site, and legal precedents the sole basis for settling claims. If that procedure is followed in newly developing countries, it is highly probable that the relatively sophisticated requirements of the nuplex would set the stage for a possible political and economic disaster.

IN THE BEGINNING

The Oak Ridge calculations indicate that it is highly unlikely any unsubsidized integrated nuplex producing fertilizer and food can come into existence with a total investment of less than a billion dollars. Economies of scale are needed to make the facility competitive.

The Mason report suggests that the following procedure be followed for starting a nuplex: Find a coastal desert not blessed with cheap oil or gas. Identify a sizable, and rapidly growing power grid within the range of high-tension transmission lines. Build a medium-size nuclear reactor (say 300 MWe) with a high efficiency desalination unit and an electrolysis plant for brine; sea water treatment to control scaling is accomplished with sodium hydroxide or hydrogen chloride, or both, depending upon local markets for chlorine and caustic soda. Build a fertilizer ammonia plant that is tied to a new kind of electrolytic hydrogen producer. Balance this with electric furnace phosphorus production. Build pipelines to hundreds of thousands of acres of low, gently sloping desert soils and sprinkle with distilled water until the salt is removed. Add part of the nitrogen and phosphate to the soil and grow wheat, maize, cotton, oil seeds, potatoes, and specialized crops. Export the extra fertilizers and crops through a sizable harbor that will probably also need construction. Incorporate as many electrochemical and electrometallurgical plants as possible. Add another power reactor with two or three times the capacity and repeat the previous steps where possible.

THE BERKELEY STUDY

The full task of growing a nuplex is far more complicated. A first attempt to uncover the associated organizational steps, such as building up the staff of an appropriate organization, the promotion of foreign and local financial support, and the identification of a political constituency to back the enterprise, showed that at least 40 steps or operations needed to be completed. When these steps were scheduled in proper order, taking into account reasonable time lags, it was discovered that the experiment station that developed the appropriate seed stock for the farms, started the trees for the townsites (a coastal desert without shade is a most unprepossessing place to live), and built up a breeding stock for the fisheries was very likely the critical first step. Some of the best talent in the world must be attracted to the project at this very early stage.

An exercise in programming these 40 steps indicates that if all political intervention favors the nuplex, it will still take seven to eight years after the finances are settled and the litigants' cases decided before full operation of the major components can begin, and another decade before systematic uses of byproducts are installed. Full profitability can be achieved only about two decades after initiation. The dimensions of a typical nuplex for an underdeveloped country when in full operation in a poor but developing country are supplied in Table One.

One of the most surprising outcomes of the calculation of social consequences was the size of the population of settlers likely to be attracted. Even allowing for the intensiveness of capital investment, and for marked productivity increases in the whole society, the range of 250,000–400,000 seems most probable for the scale of operations given. The poorest countries are on the high side of this spread. (See Table, page 19.)

The expected structure of the new settlement would include (1) a "harbor city" to conduct the manufacturing and shipping, with at least 100,000 population; (2) up to a score of "farm-factory villages" with populations of 5,000 to 12,000; (3) smaller villages for the settlement of the nomadic people of the region; and (4) several thousand independent farmsteads operating as "small-holders."

AN INDIAN EXAMPLE

Although 1968 has been a year of recovery for Indian agriculture, the vulnerability of the whole Indian economy to the failure of the monsoon remains. The large metropolises are most sensitive. With the anticipated lower levels of foreign aid an extended drought could be truly catastrophic, causing the loss of millions of lives and halving the growth of industrial production. Therefore, *the highest and best use of a nuplex in Indian economic development would be to guarantee the basic*

food rations adequate for a major metropolis.

Relatively empty coastal desert is found in India only in the extreme northwest, close to West Pakistan, in the state of Gujerat. The most promising sites, which would disturb no more than a handful of year-round residents, border the Gulf of Kutch. Social and political considerations point to the Little Rann of Kutch as a place to launch one of the first nuplexes. Its rich estuarine soils have been rendered sterile by deposits of sea salt. A trial layout of the major facilities, the most promising of a series of attempts, suggests that a causeway be laid across the shallow end of the Gulf of Kutch in order to cut off a portion that could be used for fisheries. A drainage canal system would carry away the leached salt from the silt, along with the runoff from occasional heavy rains. Fertilizer dissolved in the drainage from polder-type fields would be transformed by sunlight into algae, and this by-product material would feed most of the fish. One of the advantages of such an approach is that two stub ends of the Indian Railways could be connected, thus integrating a fractured group of districts in western Gujerat.

The metropolis to be served by a nuplex in the vicinity of the Gulf of Kutch is the Bombay "conurbation." It has already six million urban residents while millions more in the hinterland are pressing for an opportunity to find employment and get established. If India continues to develop, Bombay must function as a pacemaking center and is likely to become one of the truly great cities of the world. By the time a nuplex could be in full production Bombay must have added five to ten millions more people and still be in the earlier stages of its growth curve. Thus the nutritional support of Bombay alone in the course of Indian development will require several nuplexes, or whatever monsoon-independent alternative may be found, before the end of the century. The other major metropolis within easy access is Ahmadabad, with an estimated million and a half population when settlements within commuter distance are counted. Produce from the Kutch site would naturally flow south to the major and minor harbors of Bombay via barge and ship, while fertilizers, cotton, and flour would move to Ahmadabad and the Indo-Gangetic plain beyond by broad-gauge rail line.

The social engineering required by the nuplex represents an enormous break with past procedure in India. Indians have built a number of new cities since achieving independence, mainly to serve as state capitals and industrial townsites, but all have been inconvenient to live in and extravagant in cost because Western standards for living space were used and almost all housing and facilities were contractor-built. Self-built homes and communities based on Indian standards will be much more satisfactory for the inhabitants and should reduce costs by half or more. However, management of the growth of self-help communities requires a flexible, opportunistic approach. Such administrators can be found in India but, as elsewhere, they are exceedingly scarce and in great demand.

TABLE ONE

NUPLEX OPERATIONS INTEGRATED WITH A GROWING METROPOLIS

(Ca. 1988)

Size:

1,000 million gallons per day distilled water
1,000 megawatts electrical power capacity (two reactors at 300 and 700 MWe)
320,000 acres of fully irrigated land
100,000 acres marginal lands (using rain and surplus water)
70,000 acres fisheries

Managerial Responsibility:

250,000 A.	Corporation-operated
50,000	Small holders (some under contract)
20,000	Subsistence plots, urban settlement, etc.
170,000	Peripheral farms, cooperatives, specialists, etc.

Crops:

200,000	Cotton (1750 lbs.)	
400,000	Wheat and Millet (6000 lbs.) or Maize	
120,000	Pulses (3000 lbs.)	
60,000	Safflower (4000 lbs.)	
60,000	Potatoes, Sweet Potatoes, and Yams (45,000 lbs.)	
40,000	Fish (1800 lbs.)	
100,000	Forage Crops (hay, pasture, silage, etc.)	
120,000	Vegetables and Fruit (30,000 lbs.)	
	onions	beets
	tomatoes	"bhutta"
	"brinjals"	citrus
	okra	papayas
	pumpkins	bananas
	cauliflower	strawberries
	peppers	

If the nuplex is to be a food-producing exurb of Bombay operating on a site in Gujerat, at least two language groups are necessarily involved. The Kutch peninsula contains a large number of people speaking a local idiom often described as a separate tongue. Experience indicates that Rajasthanis and Sikhs from the north will appear as soon as economic opportunities arise. The construction workers engaged to lay the foundations for the industries, the harbor, pipelines, and canals will include many members of the tribal groups, some of whom will try to stay on.

The precisely scheduled mechanized farming required to use the year-round production of distilled water seems to be ideally suited to the skills of retired military men, an element that is beginning to cause the Union government some concern because dissidents within that group can be a serious threat to law and order. Normally they retire shortly after age 40, so much of their productive life lies ahead of them.

Superimposed upon all of these considerations is the examination system so universally employed in India by government corporations. By this means the states most lacking in opportunity, such as Kerala, Madras, and Bihar, export their surplus school and college graduates to rapidly growing areas.

Very likely it would take a consortium to form the responsible corporation. It would be to the interest of Gujerat, Maharashtra, and the Union governments to participate, but special deals would have to be made to obtain the foreign exchange, so that outside interest groups may also be represented among the settlers. For example, many Indians have for generations built up the agricultural industries of Africa, Asia, and Polynesia, but are now under attack as an undesirable minority and may wish to buy into a project like this as a refuge from persecution.

Most of the extra value of a nuplex is traceable to the increased security of supplies. The amount could be established by carrying out an estimate of the cost of maintaining a buffer stock of grain and cotton equal to about two years of output—a task yet to be accomplished. These considerations suggest that the world market price assumptions imbedded in the Oak Ridge estimates may underestimate the value to India by 10–20 per cent. In addition, the political problems and the foreign exchange shortages appear to have a variety of solutions that are specifically suggested by the technologies to be used.

THE SINAI DESERT

The primary question regarding any resource development project proposed for the Near East today is whether it will contribute to peace in that area. The next is whether it will help in some way to alleviate the pressing food shortages anticipated there in the 1970s, particularly in Egypt. Doubts raised concerning potential return on investment for a nuplex are a minor matter compared to the costs of the war. Indirect costs to neutral bystanders, such as Japan and India, amount to hundreds of millions of dollars per year, so the economic incentive to increase the chances of peace is strong. The Soviet Union is similarly handicapped by the closing of the Suez Canal.

Human resource development appears to be the principal opportunity. Hundreds of thousands of Palestinian Arabs were pressed into the Gaza Strip and the Sinai desert as a consequence of the hostilities of 1956. Demoralized by the loss of their land, almost all would have perished but for the refugee assistance organized primarily through the United Nations. Most families live in tents and temporary quarters. The anticipated population in 1980 approaches 400,000, the bulk of them without productive employment. These Arabs could be taught to make the desert bloom.

The markets for food output are the growing metropolises of Egypt, particularly Cairo and Alexandria. The waters of the Nile must be used there to produce as much long-staple cotton and other high value crops as possible. Wheat and pulses will be in greatest demand, but extra potatoes, fish and milk would be greatly appreciated.

Industrial products from a Sinai desert nuplex would have more various destinations. Electric power can go to Egypt, Jordan, Syria, Lebanon, and Israel and save the construction of at least one power plant in each country. The fertilizer output could go almost anywhere in the Mediterranean basis, but electrometallurgicals and electrochemicals would require special promotion because they compete with hydroelectric and gas-based industries now under discussion or development in other Arab countries of the Near East.

HUMAN RESOURCES

The nuplex should be regarded as an educational enterprise that uses on-the-job training to produce biotechnical skills in dealing with the most efficient varieties of irrigated crop plants and their pests. The services of many of trained Arabs would be in great demand throughout the Muslim world, as well as in some parts of Latin America.

The present population of refugees would be offered a range of opportunities. They could become urban industrial employees with private holdings large enough to guarantee subsistence, They could accept farm labor jobs that enable them to specialize in double- and triple-cropping techniques, in aquaculture (mainly fisheries), and in animal husbandry. They could become small holders and sell through cooperatives. Or they could go into commerce and services (tourism would be one by-product of the nuplex) in the hope of starting their own businesses. These are attractive alternatives for a population with largely peasant origins.

All of the demands placed upon the site appear to be best met by the territory behind the existing town of El Arish, although other sites are close competitors. The industrial harbor city could be put down southwest of the settlement between it and a coastal lagoon. The lagoon itself could be converted into ponds for sea salt manufacture and aquaculture. Lower density urban villages that supply labor to the industries but also engage in extensive vegetable and fruit production would be served by roads, pipelines, and possibly a newly-laid railroad directed inland. A few miles back from the shoreline a series of "farm factory" villages, designed to expedite triple-crop agriculture, need to be built; they would be surrounded by gently rolling fields made up often of levelled dunes. The center of this doughnut-shaped area can be used for converting by-product materials into meat and milk, preferably to be done by sedentarized nomads who seem to have a knack for animal husbandry. In the palm groves of the coastal strip to the northeast of El Arish some good opportunities for tourism can be identified. Tourists can help support many of the services desirable to resident professional people but too expensive to provide solely for them. Thus a relatively urbane environment seems possible at an early stage in development—a condition that would make the locale attractive to the most creative biotechnologists.

A look at the full set of organizations and institutions with a strong interest in developing a Sinai desert nuplex will show a surprising number that have access to capital or to essential blocks of know-how. Thus the Arab development funds, supported most heavily by Kuwait and Libya, already have sufficient hard cash. A number of operating international organizations, such as CARE, have had experience working with Palestinian Arab refugees as well as with food distribution systems. American applied research findings from national laboratories would be available for the asking, as they would be for other hard-pressed societies. The American, Canadian, Italian, Mexican, German, Dutch, and Japanese industrial expertise imbedded in the sub-units of the nuplex is purchasable. Inability of the Soviets to meet the future food needs of Egypt from its own prospective supplies should encourage them to support the project. The outlook belies the headlines: a concert of favorable forces might well result in an operating nuplex in the Sinai desert before one could be completed in India!

Any review of the successes and failures in installing advanced technology in poorly industrialized countries uncovers another set of risks that design engineers rarely admit. Because some of my information is confidential I cannot go into detail here, but a significant chance exists that some sub-unit will work so badly it does not pay to try to operate it. In a complex, where one process may depend upon the operations of several others, we must worry about whether the failure of one unit will not cause the whole complex to fail. A careful review of the interrelations of various nuplex combinations suggests that the whole scheme is most vulnerable to reactor inadequacy and to failure of ammonia synthesis plants. Use of parallel ammonia production units of competing design will minimize chances of total failure.

Most of the uncertainty in obtaining calculated returns on investment will not be traceable to the choices of technology, but rather to the human factor of inexperience in the context of the demands of ultramodern technology. Means must be found for achieving continuous cooperation between different kinds of specialists and to react very quickly to emergencies.

THE SOCIAL PLANNING TASK

Governmental agencies and the social science professions have been building up experience relevant to the "people problems" inherent in building a nuplex and managing its operations. They recognize that the greatest skill must be applied in smoothing social relations between the respective ethnic, religious, and class-based communities. Plans must be designed to minimize the conflicts between existing life styles and the modern ones introduced by the nuplex.

Every sub-culture can be represented as a fabric made up of interdependent life styles. In each life style a few social roles will determine the color and texture of the unique pattern. A few of those unusual for Asia, yet essential to the achievement of effciency of a farm-factory project, are the agriculturist, the livestock raiser and fish breeder, the master mechanic, the process industries operator, and the organizer.

All of these life styles emphasize interests in organization—animate, inanimate, and human. Therefore, they are comparatively stimulating and satisfying, especially if the subregion progresses toward higher output and increased proliferation of social organization. The implications of this self-organization must be traced out as far as it is possible to do so.

In the Sinai the Arabs are expected to aggregate in a neighborhood according to community or province of origin. However, if they have acquired high school diplomas, they may instead choose neighborhoods that fit their income and education, as in Cairo and Alexandria.

The best strategy for social planning is not to depend upon theory for designs of neighborhoods and communities but only for suggestions what should be on the agenda. Thus social experiments in community building must be undertaken as early as the genetic experiments in adapting a crop strain to local conditions in the agricultural experiment station. Exercises in laying out the full development in advance need to be undertaken because they pinpoint places where forethought is necessary. For example, the livability of the coastal desert communities growing up with the nuplex would be greatly enhanced if a tree nursery is begun along with the first experiment station studies. The trees could then be ready for transplanting before the family builds its house.

Similarly, each job opening must be analyzed for its requisite skills and experience and the training program outlined. We know from experience that several people must be trained for each of the more responsible positions because many intervening opportunities are likely to deflect the candidate's interest. Experiments in training methods may need to be launched quite early.

THE PROGNOSIS

The nuplex can register a real success only if it becomes an institution with an image of its own for which it gains popular support. The TVA became a concept much greater than the embodiment of several dams, a power grid, and a large fertilizer plant within one administration. This popular support is generated by paying careful attention to the customer and his views. There will be 20 to 50 customers for each resident on the project; therefore the principal poliitcal constituency for the nuplex will be found among the consumers.

My conclusion is that we have a technological fix that is feasible and worthwhile. The risks of failure are serious, but they are worth taking. The solution is not as quick, sharp, and immediate, as the term "fix" suggests, but a long, slogging effort in a new direction. Taking it up would contribute a bit more hope in some of the most desperate parts of the world.