THE EFFECTS OF WATER RESOURCE DEVELOPMENT ON REGIONAL GROWTH: FACTORS AFFECTING THE RELATION AND INSIGHTS FROM CASE STUDIES

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TABLE OF CONTENTS

Preface

It was the original intent of this paper to isolate the conditions which would, in a particular regional setting, make water development both necessary and sufficient for the initiation of a self-sustaining regional growth process. The paper ends up arguing that very seldom can we expect water development to be either necessary or sufficient, once growth has moved beyond its earliest stages. Growth and its economic organization are much more complicated and yet more flexible and resilient than that.

The conclusions may be useful guidelines to future regional planning activities. At a minimum, the paper may stimulate further discussion of the Water Project's role in the Integrated Regional Development Project.

The Effects of Water Resource Development on Regional Growth: Factors Affecting the Relation and Insights from Case Studies

The general question is, "How important is water in the regional growth process?" A second question often asked implicitly is, "Shouldn't water development be given some special priority going beyond that which would emerge from the usual economic ranking of development projects?" This feeling is called the "water is different" syndrome.

It is clear that some investments in water have been successful not only in terms of net benefits directly generated but in terms of setting off a self-generating growth process generating activities far beyond those tied directly to water. Far more projects have been singularly unsuccessful at both levels.

In nearly all the cases which we might study to find the conditions for the success of water resource investments, we fail to find well recorded ex ante and ex post analyses of project performance. Thus it is difficult to tell whether what we now perceive as success or failure was correctly anticipated by appropriate ex ante studies (thus confirming or failing to contradict the theoretical structure incorporated in the ex ante study), or whether actual performance has deviated from predicted conditions because of inadequacies of the predictive theory.

Projects judged to be successes or failures ex post may also fall into a particular category because of a difference in definition of "success or failure" between the technician carrying out the analysis and the decision-maker who accepted the project. An irrigation project which today produces unneeded products and requires continuing subsidy may have been the initial seed of growth for the opening of a region, or it may have prevented strife and rebellion. These things will never all be known to the technical specialist who must strive to provide the decision-maker with the best information possible on those dimensions of impact which are understood and can be measured.

WATER RESOURCES AS A BOTTLENECK TO REGIONAL GROWTH

Four conditions, separately or in combination, can make water a unique bottleneck to regional growth:

1. when water input coefficients (for production and consumption processes) are unchangeable;

2. when water supplies are fixed or subject only to very costly expansion;

3. when existing (and possibly potential) supplies are rigidly allocated among existing uses over long periods of time;

4. when water is the controlling factor in human health and productivity.

The simplest bottleneck is the fixed (water input) production coefficient of the sort expressed in an input-output model. The implication is that nothing can be substituted for water nor can increases in efficiency be found to permit production to proceed with less water. Naturally, if such fixed proportion production technologies exist and are confronted with a fixed or sharply increasing-cost water supply, production possibilities are limited. The importance of such situations must not be exaggerated, however, for in nearly every production process other inputs can be substituted for water. Examples from agriculture would include substitution of labor for water through more frequent and better controlled application; substituting capital for water by lining canals, by using sprinklers, or changing cropping patterns to less water-intensive crops.

A rigid allocation of water among uses is in effect a bottleneck of an institutional nature. This becomes especially serious when raw water supplies are also fixed or show high marginal development costs. The difficulty stems from the fact that economic growth typically changes the relative importance of different types of economic activity, usually by reducing the relative importance of agriculture, forestry, mining, and fisheries (primary industries) and increasing the relative importance of manufacturing and transportation (secondary industry), and services (tertiary industry). An inability to reallocate water to the emerging higher-valued uses then forces either costly new source development or precludes further growth. A highly relevant study is that of Kelso, Martin, and Mack (1973) which analyzes the process of rapid economic growth in a water-short region.

Finally, water relates directly to human well being and productivity through its impacts on health and the effects of its availability on human energy and time required for water gathering.

The extraordinary time and energy expenditures required of some remote peoples have been well documented by the Whites and Bradley (1972). Provision of nearby supplies would clearly free much time and energy, although it is not clear that these resources would be devoted to "growth".

The health impacts of potable water relate both to quantity and quality. There is little doubt that increases in supply up to, say, 50 litres per day will improve health through increased consumption, bathing, and improved food preparation. A new pathogen and parasite-free potable supply will be effective, however, only if:

1. the supply is reliable;

2. people are conditioned to use only the new supply;

3. other sources of exposure to the same pathogens do not exist or can be eliminated (e.g. in irrigation canals or fields, or in washing water).

A SKETCH OF DIRECT GROWTH IMPACTS

There is a large literature on industrial, agricultural, and residential water use technology which attempts to quantify the "importance" of water to particular classes of economic activity (e.g. Bower, 1964, 1966, 1968; Garrison and Paulson, 1972; Howe, 1968; White et al, 1972). An attempt at summarizing this literature is given in the following Table 1. An entry of X means general importance of an abundant low-cost supply of the water service to primary, secondary or tertiary industry or to the attractiveness of a region to population. The term "macro" refers to the basic economic viability of an activity in a region and to industry's choice of major regional location. "Micro" refers to industry's intra-regional location decision (e.g. in or out of the flood plain, in a particular city, etc.). Thus an X across from navigation and under agriculture...(micro) means that low-cost availability of water transportation will, with high probability, affect agriculture's micro choice of location. A brief rationale of some of the X's is given below.

Reliable and well-controlled water is important to irrigated agriculture, although there is no fixed requirement for a given crop. Greater care in application can greatly reduce the gross amount of water needed to obtain a particular relative yield (i.e. relative to complete freedom from moisture tension). This is to say that labor and capital can, in most circumstances, be substituted for water.

Drainage is listed with irrigation because of the need for adequate drainage of the root zone for the maintenance of viable agriculture. Many of the problems commonly perceived as "water shortage" are in fact the result of poor drainage caused either by inappropriate soil types, lack of natural or man-made drainage,

TABLE 1

The Direct Importance of Water Services to the Support of Primary, Secondary, and Tertiary Economic Activities and Population

Water Service	Agriculture, Forestry, Fisheries, Mining		Manufacturing & Transportation		Services[1]		Population	
	macro	micro	macro	micro	macro	micro	macro	micro
irrigation/drainage	X	X						
navigation		X		X				
hydro-electric power			X					
waste disposal		X	X	X				
water quality						X		X
municipal supply				X		X	X	X
flood control		X		X		X		X

[1] Including recreation.

or poor leaching practices. For example, Clawson, Landsberg, and Alexander (1971) conclude that it is not water which is preventing agricultural self-sufficiency of the Middle East but the poor practices followed regarding erosion, overgrazing, and (especially) drainage.

Navigation, especially inland transport which relies upon or competes with river control for other purposes, typically has many substitutes. With modern alternative technologies, inland navigation transport is usually not considered vital to any economic activity. However, it can provide very low-cost transport for bulky commodities where river conditions permit navigation without serious interference with other water services (especially electricity generation, irrigation, and water quality management).

Waste disposal is a valuable service provided by rivers, lakes, bays and estuaries. The water environment has an assimilative capacity for various types of wastes which can beneficially be utilized, although this is not a fixed quantity since it depends upon the other uses of water. The chemical, food processing, and paper industries historically have been heavy producers of pollution, so their location decisions have been heavily influenced by adequacy of intake water and availability of adequate receiving waters for waste discharge. This situation has been changed by developments in technology which have greatly reduced the waste loads of these industries. These technological developments have, in past, been induced by the imposition of higher water quality standards and by the recognition that many "wastes" have value when recovered. Nonetheless, it remains true that costs of industrial waste reduction increase sharply as the percentage reduction becomes high. Thus, the assimilative capacities of water bodies remain valuable resources.

Agriculture has been recognized in recent years as an important source of pollution. In some irrigated areas, nitrate pollution of groundwater supplies has made the groundwater unusable for human consumption. Nutrients contained in runoff from fields and (especially) feedlots have accelerated eutrophication of streams and lakes. Restrictions are increasingly being placed on agricultural waste loads, thus affecting location decisions.

The other side of this waste disposal coin is water quality. Degradation of water quality can actively affect various water uses, especially fisheries, recreation, and general esthetic values. Economical water quality management thus becomes a matter of finding the appropriate trade-offs between water treatment, waste disposal, and these other valuable water services.

The provision of central municipal supplies can be important to manufacturing, services, and the capability of supporting population. Heavy water using industries often find it worthwhile to develop their own water supplies, but when the size of the plant is not large or when the development of water supply requires very large-scale projects to be economical, the availability of sufficient water from municipal systems can determine the feasibility of a particular industrial location.

The availability of municipal supplies at reasonable costs certainly can determine the population carrying capacity of a region. While the quantities of water needed for human existence are small, the levels desired as living standards rise become much greater: for sanitation, bathing, laundry, and garden uses. Very high water costs can, therefore, impair the attractiveness of a region.

At the micro-level, the municipal provision of water (and sewerage) can be used to shape patterns of urban growth. When costs of private water supply development and sewage disposal are high, homes and businesses will be built only where these services are provided by a central agency. Some regional planners have recommended that water and sewerage services be used as an important growth control tool. The need for such tools depends, of course, on the type of economic system. (In the United States, recent court decisions have ruled that such uses of water services are illegal.)

The difficulties of technology transfer to developing countries has nowhere been better illustrated than in village water supply programs. The World Health Organization and various national aid agencies have traditionally required high technical and sanitary standards for village supply systems to which they have contributed. As a result, overly capital-intensive technologies which cannot be properly operated in a remote village setting have failed to develop reliable supplies and, through the capital constraint, have deprived other villages of water supply improvement. These problems are clearly illustrated by Frankel (1975).

Finally, flooding is a major problem in some regions. The presence of topographic variation and the feasibility of local flood control measures (e.g. levies, flood-proofing of buildings) make it unlikely for most regions that the macro-location of agriculture, industry, and services will be strongly affected. However, micro-location decisions and the composition of agriculture are affected by flood risks. Field crops are grown in the flood plain, but a reduction of flood risk frequently leads to more valuable crops being grown there (e.g. fruits). It remains true, however, that human reaction to flood risk contains a great deal of irrationality so that public programs of information, zoning, etc. are called for.

INDIRECT REGIONAL GROWTH IMPACTS OF WATER RESOURCES

A large water project undoubtedly will set off a chain of events extending beyond the immediate project in time and space. It is obviously desirable from a planning viewpoint to be able to predict these events and to be able to evaluate them from national and regional benefit-cost viewpoints.

Two basic benefit-cost questions should first be asked about secondary developments:

1. Do they represent benefits and/or costs beyond what would have been generated in the absence of the project?

2. Do secondary activities which arise in the project area represent new activity from a national viewpoint or are they merely transfers from other areas?

The reason for asking question (1) is that in a development situation where capital and recurrent budgets are stretched tight, other projects or expenditures would take place in the absence of the project being analyzed. Such alternative expenditures would also have secondary or indirect impacts. Do we have any basis for expecting the present project to have significantly greater indirect impacts (beneficial or detrimental) than projects alternative to it? If not, then secondary effects cancel out when we perform a "with-without" analysis of the project's impacts.

The purpose of question (2) is to raise the question of the "accounting stance" or the area being covered in the analysis. Water projects often induce other activities to come into the project area: farm product processing, transportation services, banking and other commercial services, and consumer oriented services. Do these activities represent new, more highly productive uses of their resources or are they merely transfers of activities from other areas which find it marginally advantageous to move because of the project? The greater the extent of underemployment of resources in the economy, the greater the economies of scale among the activities induced to expand by the project, and the lesser the scale economies among activities contracting elsewhere, the higher the probability that new regional secondary activities will generate net benefits to the nation as a whole.

Of course, these questions assume that there exists a technical capability of tracing secondary impacts. Existing capability for doing this is much greater in the case of a relatively small-investment in a well established area than where a large new type of investment is introduced in an underdeveloped area. Available techniques range from estimating a multiplier value for secondary income and/or employment (e.g. see Crosson, 1972) to a detailed inter-industry accounting of forward and backward linkages through input-output model techniques. An example of the latter can be found in Howe and Easter (1971, pp. 61-77).

Construction Period Impacts versus Continuing Impact During Project Operating Life

A distinction needs to be made between construction period and operating lifetime. The construction period usually means: (1) a temporary boom in employment; (2) sharply increased demands for social services and infrastructure; (3) disruption of traditional economic activity, especially agriculture, as workers

turn to paid construction work; (4) rapid depreciation of existing infrastructure. Unless careful plans are made both to assemble and dis-assemble the construction effort in orderly fashion, social disruption can take extreme forms and large costs can be pushed off on local government and private parties. For these reasons plus the generally inflationary tendencies of many economies, the construction period often generates secondary costs far in excess of any secondary benefits.

CASE STUDY SUMMARIES

This section gives brief sketches of water development projects which can be broadly classified as successful or unsuccessful in terms of their own productivity or in terms of desirable secondary effects. The few cases presented are meant to illustrate some of the situations presented in Table 1. For each case, one or more tentative conclusions will be presented. The cases themselves are drawn from countries at all stages of economic development. Further expansion of these and other cases can be found in Howe (1975).

Irrigation Projects

The Mwea Irrigation Settlement, Kenya[1]

This is a highly successful rice irrigation scheme, located about 60 miles northeast of Nairobi at an altitude of 3800 feet and just south of the equator. Annual rainfall varies from 23 to 64 inches per year. Soils consist of freely draining red lateritic clay loams and impervious black cotton clays, underlain by murram and volcanic tuff. Only the black cotton soils are now being irrigated. A small pilot plot was started in 1951 and the decision to construct the main scheme was precipitated in 1954 partly by a desire to settle detainees during the "Mau Mau" emergency.

The settlement has a potential of about 13,000 irrigated acres which has been developed since 1954 in stages of 2000 to 3000 acres. Emphasis has been given to bringing each stage up to full production potential before initiating further expansion. In addition to irrigated rice, tenants grow about 800 acres of cotton and subsistence crops. Most tenants come from nearby Kirinyaga District from closely knit Kikuyu society. Approximately 30,000 persons occupy the 32 settlement villages which were built to house the tenants. The only requirement for admission was landlessness and the only requirement for remaining is satisfactory performance. Only 110 tenants were evicted during 1961-70, a small number relative to the 2600 current tenants.

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[1]The basic source of the information on Mwea is a mimeographed paper (undated) by J.J. Veen who was, in January 1972, resident Manager of the Mwea Project for the National Irrigation Board. Personal visits over the period 1964-1972 provided additional insights.

No tenants had any previous experience in rice growing. Each tenant has a basic plot of 4 acres, 1/8 acre of which is permanent nursery, all rice being transplanted. The land is cultivated mechanically by tractors provided by the Scheme. Transplanting, weeding, reaping, threshing, and winnowing are carried out by the tenants, often supplemented by hired labor. The Scheme collects the bagged paddy, dries it, and mills it.

Tenants are charged a water rate of about $28 per acre to cover maintenance of structures and works. Mechanical cultivation, spraying teams, fertilizer, seed, and bags are available and charged against the value of the tenant's crop which is sold only to the Scheme, with the exception of small quantities retained for home use. Housing loans are provided for repayment over 5 years, and the Scheme has successfully controlled malaria and bilharzia.

The distribution of tenant net cash earnings in 1971 was as follows:

Kenya Shillings:	0-1000	($ 0-$140)	1.8%
Kenya Shillings:	1000-2000	($140-$280)	15.9%
Kenya Shillings:	2000-3000	($280-$420)	42.5%
Kenya Shillings:	3000-4000	($420-$560)	30.2%
Kenya Shillings:	4000 +		9.6%
Mean Net Income:	2800 ($392)		

Mwea clearly has been highly successful. The success can be attributed in part to the following features of the project: (a) development of previously unoccupied land; (b) recruitment from tribally related peoples; (c) strict discipline over inputs, cultivation, pest control, timing of irrigation and harvest, etc.; (d) excellent water control because of centralized, well engineered land leveling and building of bunds, canals, drains, etc.; (e) (in recent years) protection of the domestic market for rice.

The Rio Fuerte River Basin Commission, Mexico[2]

The progress of irrigated agriculture in Northwestern Mexico constitutes what is probably the greatest achievement in Mexican agriculture since 1945. The Fuerte Commission was established in 1951 along the same lines as the other Commissions, charged with integrated basin development. The river is the largest in the Northwest (4.5 million acre-feet per year) but one of the most variable, draining an area of about 12,000 square miles. The commission has confined itself to irrigation development and flood control in the lower parts of the basin in contrast to the widely varied activities of the other Commissions.

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[2]Source: Barkin and King (1970).

The originally irrigated lands were expropriated from the United Sugar Company in 1938 when the land was turned over to small holder collectives (ejidal lands). The Commission has expanded the irrigated acreage to 230,000 hectares, about half of which is ejidal land and half privately owned. The Miguel Hidalgo Dam provides water and power, and the area around the chief town of Los Mochis has attracted cotton ginneries and other processing and service industries. A railroad to the area from the north has promoted the export of winter vegetables to the United States. These valuable but risky export crops are grown by the larger private land owners because of the risk averting behavior of the small farmers.

The program of the Rio Fuerte Commission has clearly been highly successful. A major reason for success is that the Commission took the initiative to provide a package of needed inputs: water, water delivery systems, land leveling, roads, marketing facilities, etc. If any national ministry failed to perform its tasks, the Commission was able to do the work itself. This high degree of coordination among inputs has been a major contributing factor to success.

The Impact of Irrigation on Regional Growth, Sonora, Mexico[3]

Crosson has studied the relationship between the growth of agriculture and that of urban activities in the Yaqui and Mayo Valleys and Cuidad Obregon, Sonora, Mexico. In his theoretical formulation of the relationship, Crosson isolates four effects of expanded irrigation: a productivity effect which, by making new technologies possible, increases the potential productivity of local resources; an input-output effect of generating more varied and extensive demands for agricultural inputs; an income effect as recipients of increased income demand more consumer goods and services; a potential processing effect or forward-linkage which may attract firms to the area to process the primary products of agriculture. Crosson points out that these effects will not develop fully unless the right resources are free to flow into the area. For mixed economies, this emphasizes the importance of the responsiveness of private investment to public investment undertakings.

Agriculture in the State of Sonora expanded rapidly from 1940 to 1970. In 1940, population was 364,000, the only town of size being Hermosillo at 18,600. Agriculture covered 260,000 hectares of which 140,000 were irrigated by private wells or unregulated streamflow. By 1950, population was 510,000 with 43,500 in Hermosillo and 31,000 in Ciudad Obregon. Total agricultural land had increased to 800,000 hectares, 280,000 being irrigated from wells and stream diversions. By 1950, most opportunities for expansion of private irrigation had been exhausted. Two very large public irrigation districts were formed

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[3]Source: Crosson's chapter in Cummings (1975)

in the Yaqui and Mayo Rivers and came into operation in 1951. A third district was established in 1953 to control the use of groundwater around Hermosillo.

These districts increased irrigated land to 544,000 hectares by 1960. Agricultural technology continued to advance rapidly, with heavy technical service inputs from the United States and extensive public investments in rail, highway, and port facilities. The introduction of high yielding varieties of maize and wheat played an important role. Furthermore, farm price, credit, and foreign trade policies were used to reinforce the favorable climate. The completeness of the package of public, private, and policy inputs was unusual and resulted in rapid expansion of agriculture and directly related enterprises. Crosson found that one peso of net agricultural income in the Yaqui-Mayo Districts was associated with 2.75 pesos of factor income in Ciudad Obregon.

Howe and Oyarzabal, in a private report to the World Bank, note the frequency with which strong risk-averting behavior is observed in the Rio Mayo District of Mexico, a factor which water planning must take into account. Farmers in the District have an option of growing one cotton crop per year or a two-crop soya-wheat rotation. The average profit (over time) per hectare of cotton is 6000 pesos, while the average for soya-wheat is 4000 pesos. Many of the farmers choose the latter because of the risk which arises with cotton's long maturation period which sometimes carries the harvest over into the rainy season with possible loss of part of the crop. Thus, both the farmers and society give up a very substantial value to avoid the volatility of private incomes from cotton.

Water Management in a Rapidly Growing Arid Region, Central Arizona, U.S.A.

Kelso, Martin, and Mack (1973) have carefully studied the extent to which water constrains the continued growth of the economy of the State of Arizona. That State has been one of the most rapidly growing ones in the U.S., with government, finance, insurance, public utilities, wholesale and retail trade, and services leading the growth. Farms and mining have fallen from 28.4% of personal income in 1929 to 6.7% in 1970, although the absolute volumes have risen slightly. All surface water supplies available to the State are over-committed with the exception of one million acre-feet of Colorado River water which is being developed through joint federal-state projects. Underground water is being used at a rate far in excess of recharge and water tables have fallen as much as 125 feet from pre-World War II levels.

The analysis was carried out using a sophisticated set of alternative economic projections, input-output models, and linear programming representations of the agricultural sector. The major findings of the study are (pp. 26-27): (a) water is an economically scarce commodity but not so physically scarce as to

threaten the State's economy; (b) much of the scarce water supply is, through water law and location, locked into uses of very low marginal value in terms of incomes directly and indirectly generated; (c) curtailment of these low-valued uses would have very modest negative effects on the state's economy; (d) the reallocation of existing water supplies from such uses to the emerging higher valued uses would release the growth of the Arizona economy from all restraints by water well into the next century. This provides an excellent example of the importance of the reallocation of water over time in water short regions.

Drainage

The Middle East

Clawson, Landsberg, and Alexander (1971) have studied the factors constraining agricultural output in Egypt, Lebanon, Jordan, Syria, Iraq, and Saudi Arabia. They concluded that the potential of the agricultural resources of the region is such as to permit these countries in one generation to escape the circle of rural poverty. Major parts of the region, the Nile Valley, the Mesopotamian Plain, and the hill country, were all garden spots historically. Much of the area is now decayed from soil erosion, overgrazing, poor drainage, and incredible accumulations of soluble salts. Yields are meagre (10 bushels per acre in alternate years) at best in much of the area. Areas of similar climate and soil characteristics in other parts of the world have yields many times higher. Livestock, too, is very unproductive through disease and overgrazing.

Clawson points to two popularly held opinions about the area: (1) that the agricultural productivity of the area has been forever lost or, in Egypt, has reached its limits; (2) that water is the factor which is missing and which could restore the productivity of the area and expand its boundaries. Clawson and his colleagues find both to be myths. They estimate that, with appropriate farm technology and freed from institutional rigidities, in 20 to 30 years agricultural outputs could be doubled in Egypt, increased tenfold in Iraq, and expanded significantly in the other parts of the region other than Israel.

With respect to water, they find that it alone is not the key to this expansion, but that, again, a package of inputs and programs must be supplied. Among the inputs are appropriate soils, and the investigators find that soils are scarcer than water. Drainage is basic, especially for Iraq and Egypt. Programs of laying drains and flushing out the soils are critical, and disposal of the resulting brines and maintenance of the drains pose problems. In Egypt, they find that yields could be increased 50% and that shifting to underground drains from currently used ditches would free enough land surface to pay for the drainage program over time.

Overall, they find that drainage, land levelling, moisture conservation on rainfed lands, crop rotation, fertilizer, improved crop varieties, and weed control are more important factors than water. Water appears not to be the bottleneck to agricultural production. Increased water supply is neither necessary nor sufficient for further agricultural growth in the particular setting.

River Navigation

The Arkansas River, U.S.A.

The McClellan-Kerr Arkansas River Navigation System is one of the largest public water system developments in the United States. The navigation features of the project have cost $1.2 billion ($10^9$) and involve a canalized passage 10 miles up the White River from the Mississippi, 9 miles through a canal to the Arkansas River, 280 miles of channel up the Arkansas to Muskogee, Oklahoma, and 50 miles up the Verdigris River to the outskirts of Tulsa. There are many locks and dams. Belzung and Sonstegaard (1973) have studied the impact of this huge navigation investment on the region through which it passes. They point out that benefits of the project in this mixed-economy case depend entirely on private sector responses in providing transport facilities, ports, and the establishment of new types of waterway using activities. The authors of that study conclude (pp. 1 and 48):

> At this point, there does not appear to be any indication that the Region is on the threshold of a substantial surge of development; but the Waterway provides a significant improvement in the Region's transportation system which may, in the future, be the focal point of economic expansion in the Arkansas-Verdigris Region.
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> . . .
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> Three score (60) or more new--or relatively new--facilities have been constructed in and around the port areas; but the point to be emphasized here is that these new developments are mostly changes in location of existing plants, they are relatively small by most standards, and very few of the new plants are really water transportation oriented.[4]
> ...Unquestionably, there is reason at this time for some degree of pessimism for the long run...

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[4] Emphasis added

Hydro-Electric Generation

The Owen Falls Hydro-Electric Project, Uganda[5]

The Owen Falls Dam is a single-purpose hydro-electric project built across the Nile at Jinja, just a few miles from Lake Victoria which acts as the dam's reservoir. Currently installed capacity is 150 MW. Interestingly, the idea of the dam was initiated by Churchill after an African journey in 1905, but the years through World War II saw practically no capital expenditures except for the railroad extension in Uganda from Kenya.

When the decision to build the Dam was taken (1947), it was thought that an enhanced supply of electricity would be a sufficient condition to bring rapid industrial development. The press spoke of Jinja's becoming "the Detroit of Central Africa," and the postwar development plan (the Worthington Plan) noted that "experience with electricity in other parts of the world has nearly always shown that the most optimistic estimates of consumption have been greatly exceeded soon after the provision of a reliable and cheap supply."[6]

Electricity demand grew, but not nearly as rapidly as expected, and new customers were not of the types nor in the locations expected. Industry in Jinja and Kampala never materialized, while small scattered consumers predominated. The settlement pattern in Uganda caused problems because of the absence of nucleated villages, and a much more extensive distribution network had to be built.

Other steps to encourage industrial development were not included in the 1947 Development Plan, and several years passed before the Uganda Development Corporation was set up to co-sponsor projects with private firms. The efforts of the Corporation were not very successful, and it wasn't until 1956 that the first major industrial customer--a textile mill--came on line. A copper smelter was extablished in Jinja in 1957 and remains the largest single customer.

A further step to promote industrial development was the creation of an industrial estate in Jinja. Rail sidings, access roads, offices, shops, and flats were provided. At the height of the construction phase, the labor force reached 2500 Africans, 200 Europeans, and 123 Asians, and future prosperity was assumed to be assured. Once construction of the dam and industrial estate were completed in 1954, however, the labor force fell rapidly, the buildings were left empty or leased for storage rather than manufacturing, and the roads deteriorated.

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[5]Primary source Elkan and Wilson in (Eds.) Rubin and Warren (1968, pp. 90-105).

[6]E.B. Worthington, A Development Plan for Uganda, Government Printer, Entebbe, 1947.

The small industries which did comprise the bulk of Uganda's growth were not power oriented and were widely dispersed, partly because the Electricity Board's uniform tariff provided no incentive to locate in groups or near the source of supply. When consumption failed to grow as expected, the Electricity Board entered into a 50 year supply agreement with Kenya on terms extremely favorable to Kenya.

It is clear from this experience that hydro-electric power is not a sufficient condition for inducing industrial development. Elkan and Wilson (1968, p. 104) conclude:

> The trouble has been that the decisions to create users for its output were not taken quickly enough.... it does seem that if a major electricity project in a small economy is not to be more of a burden than an asset, the decision to go ahead needs to be closely geared to specific proposals for the use to be made of its product.

The Grijalva River Basin Commission, Mexico

In 1951, a Commission for the integrated development of the Grijalva and Usamacinta River Basins in Southeastern Mexico was created. The combined runoffs of the rivers of the basin constitute nearly a third of Mexico's total runoff. The area is still extremely isolated, the first railroad crossing the basin in 1950, and the capitol city, Villahermosa, being connected by land transport with the rest of the country for the first time in 1958.

The Commission started planning and road building in 1953, deciding to build the very large Malpaso Dam. Work started in 1958. The main activities have been to promote extensive resettlement from the central highlands as part of an overall government attack on the increasing concentration of population around Mexico City and other urban centers. The Chontalpa project was begun in 1966 and involves drainage and irrigation for 350,000 acres. A later stage is to double this. The colonization schemes are experiencing difficulties in transplanting people from highland areas to tropical Gulf Coast. The scheme aims at settling 1000 families per year at a cost of about $75,000 per family.

Overall, 15 years of heavy expenditure have had limited effects both on the region and on the national objective of decentralizing economic activity and population. Aluminum and petro-chemical industries have been established along the coast, attracted by ocean transport and cheap power, but no labor intensive industry has been established and little in-migration has been induced. Barkin and King (1970) conclude that there has been a great deal of waste of resources from an economic viewpoint.

Hydro-Electric Power and Industrial Location, Canada

Schramm (1969) has studied the effects of low-cost hydro-power on industrial locations in British Columbia. He states:

> Past experience shows that the availability of low-cost hydro-power can significantly affect the locational decisions of power intensive industries. In the United States, the developments of the Tennessee Valley Authority in the southeast and the Bonneville Power Administration in the northwest have led to large-scale settlements of such industries in areas which, with the exception of low-cost energy, generally offered neither suitable local raw material sources nor nearby markets....The almost exclusive raison d'etre for Canada's and Norway's large, export oriented electro-metallurgical and chemical industries are favorable hydro-power sources in close vicinity to tidewater locations.

Again as in the preceding case, we observe the importance of power and ocean transport together. In attempting to answer the question of whether or not such relationships can be counted on to obtain in the future, Schramm's analysis has become somewhat outdated by events, for atomic energy reliability and costs have failed to improve as was then predicted, and the costs of fossil fuels have escalated rapidly. We must now qualify Schramm's conclusions by indicating that hydropower again has a cost advantage over thermal plants, both in terms of fossil fuel costs and, for some locations, in terms of independence from foreign fuel supplies.

Large-Scale Multiple Purpose Projects

The Lake Volta Project, Ghana[7]

In the late 1940's, Britain sought a source of aluminum within the sterling area. Gold Coast, with bauxite and excellent sites for hydro-electric and port development, seemed a good candidate. The development would entail a major dam, the lake of which would cover 3275 square miles or 1/30 of the surface of the country; the largest new port in Africa; an alumina factory and aluminum smelter; a major new township; extensive extensive infrastructure; and the resettlement of approximately 80,000 persons.

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[7] A major source was Chambers (1968)

In 1952, a Preparatory Commission was set up for very careful planning of the project, with heavy emphasis on the human factor.[8] The guiding principles of the Commission were (1) to prevent any in-migration to the areas to be innundated; (2) that all displaced persons should be made as well off as they were before; and (3) that resettlement should be accomplished through self-help after compensation for properties lost.

The Commission's planning work was completed in 1955, but financing negotiations stalled, partly because of political complications surrounding independence. The momentum of coordinated planning was lost. In 1961 when construction finally began, engineering work proceeded splendidly, being completed in 3-1/4 years instead of the planned 4-1/2 at a cost saving of $40 million.

The resettlement program, however, was never fully pulled together and had to undertake a crash program to handle 80,000 people. Under the heady atmosphere of the Nkruma Government, sights were raised and self-help forgotten: houses and villages were to be planned and modern; agriculture was to be cooperative, intensive, and mechanized; and intensive animal culture was to be introduced.

In spite of the rush, quite amazing feats had been accomplished by the end of 1964: 2000 miles of lake boundary had been marked; a rough social survey of 80,000 persons had been carried out; 14,000 acres of land had been cleared; 52 settlement sites had been negotiated; 500 miles of laterite road had been placed; 11,000 core houses had been built; and 10,000 families had been peacefully evacuated.

Equally impressive problems were created: resettlement sites had been poorly selected and were resisted by traditional occupants of the areas after the more liberal military government assumed power; housing styles were not liked by many people (too hot, too cold, and too few rooms for polygamous families); water supplies were notoriously bad; the agricultural program fell far behind schedule, so that land was not available for most of the people; mechanization proved impossible because of lack of upkeep and trained personnel; the concept of cooperative agriculture was foreign, and when the mechanical cooperatives started to charge farmers for their services, most farmers opted out; and the livestock programs ran into terrible disease problems.

The total resettlement costs through 1971 totalled a very approximate $40 million.

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[8]The world was nervous about big projects at that time because of the disasterous results of the ground nut scheme in Tanganyika.

Some major lessons from the Volta experience are:

1. The welfare approach to resettlement which replaced the self-help approach diverted resources into housing and infrastructure which could have been provided by the people themselves at much lower cost. The emphasis should have been on provision of more directly productive assets. "Economic success makes welfare possible, possible, not the other way round."

2. Too much new development and economic change were attempted under the strain of relocation.

3. Under the enthusiasm for broad economic and social change, objective economic and social analyses of agriculture and infrastructure were not undertaken. Partly as a result, totally non-viable sub-schemes were undertaken.

The Volta project showed not only the importance of detailed pre-investment planning, but subsequent events have shown that the human, ecological, and physical dynamics of a large project are partly unpredictable, suggesting that resources must be provided for continuing monitoring and research on the project after it is in place.

The Mexican Integrated River Basin Experience, A Summary

In summing up the river basin experience of Mexico, it can be said that the attempts at integrated basin development in the isolated tropical basins (Papaloapan and Grijalvas) have largely been failures, while the more specialized development efforts in the arid areas (Tepalcatepec-Balsas and Fuerte) have been moderately to highly successful when judged from the multiple-objective viewpoint of Mexico's development policy.

An interesting aspect of the integrated river basin development strategy is that it has centered solely on the development of the natural resources of each basin. Government has not provided incentives for other types of enterprise to locate there. As a result, few activities other than those processing the agricultural outputs have settled in the basins. Private sector resources have not been attracted to the areas. When private response is low, the returns to public investment in terms of national objectives are greatly reduced.

CONCLUSIONS

The preceding conceptual and empirical materials have not led us to any final understanding of the water development-economic growth relationship, but some observations have reappeared in the analyses of quite different settings, giving some hope that they might be used as guidelines in future policy formulation. These recurrent observations are now summarized.

1. The relative importance of the various services provided by water will change as regional economic growth takes place. (This changing role of water is clearly depicted for Arizona in Kelso's study.) A changing role for water implies that economic growth can frequently be accommodated by a reallocation of existing water supplies. The other side of this coin is that institutional arrangements (water laws, absence of regular transfer mechanisms, etc.) can stifle growth by locking existing water supplies into uses of diminishing value.

2. Water development has its greatest impact in earlier stages of regional economic growth by establishing a minimum basis for human subsistance and because irrigated agriculture and mining (both water intensive uses) often play dominant roles in these early stages. These tendencies are increasing functions of the aridity of the area.

3. Irrigation is clearly a necessary but not sufficient condition for the initiation of growth of arid and semi-arid zone agriculture. The provision of a "whole package" of the requisite complementary inputs, while rarely observed in practice, can result in high productivity and growth effects.

4. The availability of lower cost hydro-electric power is a strong attraction to the power intensive metallurgical and chemical industries, especially in combination with tidewater location. While undeveloped hydro-electric sites are increasingly scarce and remote, this advantage is likely to increase in the future. Past examples of successful development include Ghana, Canada, Norway, and the Papaloapan and Balsas Basins in Mexico, the Columbia, Ohio, and Tennessee River Basins in the United States.

5. In mixed economies, private sector investment response to public water project investment is a critical factor in determining total social returns. Most of the Mexican river basin developments failed to generate self-sustaining growth because of a failure to attract any but the most basic processing industries.

6. In more advanced economies, water development is likely to affect the micro-location decisions of non-agricultural economic activities but not the macro-location decisions. This is partly due to the small proportion of total production costs usually represented by water.

7. Even with the best predictions which can be made of large water projects' impacts on the economy and society, there remains sufficient uncertainty about ensuing events as to warrant provision of resources for continued

monitoring and ex post assessments of such large projects, both so that lessons can be learned from the experience and so that adverse developments can be corrected early.

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