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**Scientific and
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Washington, D.C.

Land Use and Conservation Treatment, Flood Control, River Basin Planning, Interbasin Transfer of Water, and Micro-Hydroelectric Generation

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LAND USE AND CONSERVATION TREATMENT, FLOOD CONTROL, RIVER BASIN PLANNING, INTERBASIN TRANSFER OF WATER, AND MICRO-HYDROELECTRIC GENERATION

by

Buell M. Ferguson
Sheldon G. Boone
E. B. Dyer
Vujica Yevjevich

All comments, opinions, and recommendations in this report are those of the team members and not necessarily those of the sponsoring institutions. The study tour was jointly sponsored by the USDA Office of International Cooperation and Development and the Ministry of Water Resources and Electrical Power in the People's Republic of China.

Contents

EXECUTIVE SUMMARY

A USDA Science and Technology Exchange Team, sponsored by the Office of International Cooperation and Development, visited the People's Republic of China from April 12 to May 12, 1982. The purpose of the visit was to study China's land use and conservation treatment program, flood control projects, river basin planning, interbasin transfer of water, and micro-hydroelectric generation. The Ministry of Water Conservancy hosted the team of three Soil Conservation Service employees and a professor from the George Washington University.

Land use and conservation treatments for erosion control and water management have been practiced in China for over 2000 years. But the problem of adequately feeding a one-billion population on a usable land area slightly less than the United States is a constant challenge. Much of the current conservation efforts are as much to shape land areas to gain cultivatable land as they are to allow for a distribution of water for irrigation by gravity.

There is a change going on in China, but it is a slow change. The first task is to feed and house the population. This is being accomplished by diversifying the economy when possible, setting production quotas, and multi-utilization of flood control projects for power, irrigation, and sediment movement. China has an acute awareness of its population and land use problems.

Even with its past history and technical knowledge of erosion control, severe erosion and land use problems continue to exist in China. This is true especially in the loessial plains area of the Huang He (Yellow River)--an area that was of special interest to the team.

Observations were made of several exceptional water control projects and developments. The Chinese seem to have the engineering technology and concerns for adequate design of small reservoirs. Laboratories exist in several locations to test models of dams and channels. Opportunities exist for coordination of improved engineering and soil and water conservation technology with long-range conservation planning and application. Both the United States and China will be better off with a continuation of the exchange of technical data and professional exchange teams.

Recommendations

1. China and the United States jointly continue to explore procedures for comprehensive planning of water and related land resources in selected river basins in each country.

2. Any existing comprehensive plans on these selected basins be exchanged between the Ministry of Water Conservancy and Electric Power* and the Soil Conservation Service, USDA.

3. An exchange program be established to explore in depth the principles and techniques of small watershed planning, with emphasis on land treatment measures for erosion control and onfarm water management measures for water conservation.

*This ministry was renamed the Ministry of Water Resources and Electrical Power in the latter part of 1982.

4. China further develop technologies for storing and conveying water on terraced lands; establishment of vegetation, grasses and trees on active eroding lands and consolidation of vertical banks and gully sides, and protection from earth slides into reservoirs built in gullied areas.

5. A systematic exchange of technical data and trained personnel be continued between China and USDA, especially in watershed stabilization with soil conservation practices.

6. China continue to strengthen its soil and water conservation efforts to help reduce the tremendous problem of erosion and sedimentation.

7. The United States and China continue to exchange technologies on micro-hydroelectric developments.

LAND USE AND CONSERVATION TREATMENT, FLOOD CONTROL, RIVER BASIN PLANNING, INTERBASIN TRANSFER OF WATER, AND MICRO-HYDROELECTRIC GENERATION

INTRODUCTION

Technical cooperation between countries is an activity which is beneficial to both. The United States with its high degree of advanced technology and China with its long history of experience and technology are sharing approaches to solving common problems and are learning from one another.

This sharing is partially a result of the science and technology exchange program sponsored by USDA's Office of International Cooperation and Development (OICD) and the People's Republic of China (PRC). In April and May 1982, a delegation of four water resource specialists, by invitation of the Ministry of Water Conservancy, visited the PRC to review flood control and river basin planning activities and techniques. It was felt that knowledge from the PRC's long history of land use and conservation treatment, and flood control and water utilization, with emphasis on small upstream activities, would be beneficial to the U.S. to further develop its techniques and methods.

The team consisted of a team leader, Buell M. Ferguson, Director of Engineering for the Soil Conservation Service (SCS), USDA, Washington, D.C.; E. B. Dyer, Assistant State Conservationist, SCS, USDA, Nashville, Tennessee; Sheldon G. Boone, State Conservationist, SCS, USDA, Denver, Colorado; and Dr. Vujica Yevjevich, Research Professor and Director of International Water Resources Institute, School of Engineering and Applied Sciences, George Washington University, Washington, D.C. Travel in China began 11 April 1982 when the team arrived in Beijing and ended 11 May 1982 when the team left Guangzhou.

At the request of the Ministry of Water Conservancy, the team made suggestions to China on how it might benefit from techniques being used in the U.S. and gave short seminars on U.S. techniques and experiences. Open discussions were held at all locations with many questions from both sides.

Specific objectives of the visit included investigation of China's (1) river basin planning techniques, including the use and interbasin exchange of water; (2) flood control techniques, both planning and operations; (3) land treatment problems and corrective techniques in high sediment producing upstream watersheds; and (4) use of small watersheds for development of micro-hydroelectric facilities.

This report addresses each of the four main objectives. Each area is written by one of the team members and agreed to by all to be our best impression of activities in that objective area.

The team utilized information and data that were prepared by other scientific and technology teams prior to the exchange visit. They were:

(1) Soil and Water Management in the People's Republic of China, October-November 1980, Paul Howard, SCS, Team Leader

(2) Soil Management and Productivity, June-July 1981, Dr. Ralph McCracken, SCS, Team Leader

(3) U.S. Report of Technical Exchange with PRC on Soil and Water Conservation, November 1981, Benny Martin, SCS, Team Leader

(4) Water Spectrum, Winter 1981-82

(5) <u>China- Journal</u> - <u>The Longtan Project</u> by Richard Galster and Edward C. Pritchett

Study materials also used were:

(1) Wan Young-Yan and Ahany Zong-Hu, <u>Loess in China</u>, 1980, Shanxi, People's Art Publishing House; Beijing, China

(2) <u>China: A General Survey</u>, 1979

(3) <u>Beijing Review</u>, several issues, February to May 1982

RIVER BASIN PLANNING AND INTERBASIN TRANSFERS

by

Sheldon G. Boone

Tours and discussions of river basin planning activities in China indicate (1) a very general level of planning, and (2) a very detailed analysis and study of specific basin projects and operation strategy. None of the planning materials supplied for review supported the idea of comprehensive water and related resources planning of large and intermediate sized basins as practiced in the U.S. during the period 1962-1978. This is not to say that strategies for comprehensive development of water resources do not exist in China. They appear to exist principally as single-purpose plans for flood control, hydropower development, sediment control, transfer of water north to Beijing, and so forth for individual basins. Long-range and comprehensive plans for the development of China's water and related land resources to meet the needs of the people of China for the next 25, 50 or 100 years were not presented to the team.

General Aspects of Water and Related Land Resources

The area of China is 9.6 million square kilometers (3.7 million square miles) and is more rugged than the U.S. Mountains and plateaus cover 59 percent; low basins, 19 percent; plains, 12 percent; and hilly areas, 10 percent. The two largest rivers, Chang Jiang (Yangtze River) and Huang He (Yellow River), drain generally west to east from the Qinghai-Tibet Plateau to the Yellow and East China Seas. While these two river basins contribute only 39 percent of the Nation's water supply, they seem to dominate water resources discussions and literature.

Water resources generally are abundant in China. There are 1,500 rivers which have drainage areas exceeding 1,000 square kilometers (roughly the maximum size of a PL-566 watershed project in the U.S.). The normal yearly runoff is 2,600 billion cubic meters, an average depth of 11 inches. This runoff is produced from precipitation of 6,000 billion cubic meters averaging 25 inches for the Nation. However, China's climate is influenced strongly by the monsoons. Precipitation in June, July, August and September is often 70-80 percent of the total year's supply. The monsoons come from a southwesterly flow of air. The summer weather is also influenced by typhoons from the Northwest Pacific. These hit the Eastern China coast on the order of 7 times per year, and about one-third of the time, move inland, sometimes giving rise to extraordinary storms. The winters are dry and under the influence of cold continental currents from the Northwest.

In addition to the seasonal variability, precipitation also varies in quantity greatly from year to year. These variations give rise to periods of flood and drought which have plagued the people of China for thousands of years. Historical records show that 1,092 big floods and 1,056 severe droughts occurred from 206 B.C. to 1949 A.D.--a period of 2,155 years. This averages about one major disaster per year.

A total of 100 million hectares (250,000,000 ac) of land are under cultivation in China--only 11 percent of the country. The rugged terrain and severe climatic condition probably account for this. However, in the order to produce enough food for the population, some of the earliest water resource developments were for irrigation and for flood control. Evidence of a number of such projects dates back to 500 B.C. At present, 48 percent of all farmland is irrigated. Since 1949, 84,000 reservoirs have been built, primarily to supply water for irrigation. In addition, many wells have been drilled to make use of the groundwater, particularly in North China. In total, there are 2.1 million power-operated wells for agriculture in the country.

Employment of these land and water resources for agriculture made possible a production of 332 million metric tons of grain in 1979.

Chang Jiang Basin

The Chang Jiang is one of the largest river basins in the world and a dominating resource in China in many regards. It drains from the Himilayas and provides the major transportation route linking the country east and west. It outlets into the East China Sea at Shanghai. The river is 6,300 kilometers (3,900 miles) long, draining 1.8 million square kilometers (0.7 million square miles), and has a total runoff of 1,000 billion cubic meters (650,000 acre-feet). The population of the basin is 342 million, or about 34 percent of the Nation's total. There are 25 million hectares of cultivated land, producing 40 percent of the Nation's grain, including 70 percent of the Nation's rice. Cotton production is one-third of the total. Industrial output is 40 percent of the national output.

Since 1949, 926 large- and medium-sized reservoirs and 45,000 small ones have been built in the basin, with a total storage capacity of 110 billion cubic meters. There are 1,800 miles of navigable main river due to better water regulations.

Commitments have been made to build the Sanxia (the Three Gorges) Project just upstream from Yichang, Hubei Province. While a number of problems must be solved, the project would serve flood control, power generation, navigation and irrigation. It is the major control reservoir that would increase the effectiveness of the dikes and levees downstream from a once-in-20-year protection to once in 80 years. Such a feat alone would materially improve the well being and productive capacity of millions of agricultural people in the Chang Jiang valley.

Also, the Gezhouba Project located 40 kilometers downstream from the Sanxia Project is under construction and is primarily a power-generating dam. It may also be a diversion point for water to be diverted to the North China plain. A major interbasin water transfer project is under consideration.

Huang He Basin

The Huang He, the second largest river in China from the standpoint of drainage area, is also an historic and well-known river in the world. Although the runoff from this basin is less than 5 percent of that of the Chang Jiang, its fame results from the color of the water caused by high sediment transport. Every year, 1.6 billion tons of sediment are brought to the lower reaches of the river, causing channel aggradation of 10 centimeters per year.

The central reaches of the basin drain the largest loess deposit in the world. This wind-blown soil is deep and very erosive, both by sheet and gully erosion. The vegetation has been destroyed in the past, and only in the past 30 or 40 years has there been much accomplished in erosion control work. This area of loess soils covers 430,000 square kilometers and produces 91 percent of the sediment delivery to the river. As a result of this heavy sediment load, work in this river basin has been primarily for flood control and sediment transport in the lower reaches. Also, irrigation storage reservoirs help supply the 4.3 million hectares of irrigated land in the basin.

The Huang He area, known as the cradle of Chinese civilization, has a history of 2,000 years of water and related land resource work, and yet remains the single greatest challenge in the country as far as improvement in resource use is concerned. Besides the obvious need to get better soil control in the loess area, the use of water for (1) sediment transport, (2) irrigation and (3) transfer to the North China plain creates severe complications for the 48 billion cubic meters of runoff annually.

Tributaries or Small River Basins

We visited small river basin activities in the municipal district of Shanghai and in Enping County southwest of Guangzhou. In addition, there were discussions about water resource development in tributary streams in the Chang Jiang Basin such as on the Hau River. A major reservoir has been built on the Hau River, along with protective dikes, as a part of the flood control program of the Chang Jiang. It was also stated that many small reservoirs have been built to meet the needs of the local areas.

The flat coastal area around Shanghai has typical protective works found in other well-developed coastal areas. Multi-purpose channel and structural works were visited. The improvements provided flood protection against internal runoff as well as against high tides. Navigation, irrigation, drainage, and saline soil improvements were also major purposes. On the navigable streams and channels, a system of locks and control gates was installed to permit boating at all times. Waterway traffic is the most important means of moving farm produce in the Shanghai municipal area.

In Enping County, we visited multi-purpose water resource developments on the small coastal basin of the Gin Jou River. This is a hilly or mountainous area where most cultivated land was used for growing rice. However, many other crops were also grown, including vegetables, tobacco and peanuts. Even though this area, as well as Shanghai, gets high annual precipitation (up to 3,500 mm), irrigation is necessary for rice production and to assure high yield of other crops.

However, the major purpose of reservoirs and onstream developments on the Gin Jou River is for hydropower. Many plants have been built and were found in operation ranging from micro to much larger facilities. One development we visited had a 22-square-kilometer drainage area reservoir with 8.46 million cubic meters of storage. The average flow was 2.5 cubic meters per second. Six power stations (5 micro and 1 larger) were built at the dam and in a short stretch below. They have a generating capacity of 4,560. At the time of our visit, the release from the reservoir was 1.3 cms, and the plant's output was about one-half of its maximum capacity.

Even though we saw much work in place, we never succeeded in reviewing a planning document or report, or learned how this planning was being carried out. However, it was evident that local and provincial needs and desires were the major driving force in these smaller basins. Also, it was evident that there is cooperation between counties and provinces, and with the Ministry of Water Conservancy and Electric Power at the national level. Just how all these developments received funding was not clarified.

Approaches to River Basin Planning in China

There is little question that PRC is giving high priority to development and management of water and related land resources. While no figures were given, it is obvious that as a percent of national annual budget or as a percent of GNP, the figures for China would exceed similar figures for the U.S. many times. Of course, the single highest priority in PRC is to feed its people more adequately in the future than they are today. This effort alone will cause continued pressure to (1) improve management of land and water resources now dedicated to agriculture; (2) develop additional resources to expand food and fiber production; and (3) through better control of these resources, bring a reduction in the frequency of devastating floods and droughts.

As mentioned previously, PRC has done much to mobilize its resources to accomplish these objectives. However, it was not made clear how national and regional water and related land resource plans are being developed, although it is clear that the "river basin" is the principal planning area. This probably results from an emphasis on the physical and engineering aspects of water plans and shortage of economic, demographic, social and environmental data and objectives. Much information was presented to us on present and potential reservoir storage capacity and hydroelectric power capacity, length and adequacy of channel and levee systems, number of hydrological stations, and capacity of flood diversion works.

They also explained briefly their organization for planning and implementation. In addition to the Ministry of Water Conservancy and Electric Power, there exist several River Basin Commisions that appear to do the major planning and implementation. There also exist at the provincial and local levels some planning and significant construction and operation authority. There does not appear to be a direct organizational link between the Ministry of Water Conservancy and Electric Power and the provinces or the local (commune) levels. While there are other ministries at the national level with some agricultural and natural resource responsibilities, it appears that the Ministry of Water Conservancy and Electric Power carries out most of the functions in PRC that are carried out in the U.S. by the Soil Conservation Service, the civil works of the Corps of Engineers, the Bureau of Reclamation, the water branches of the U.S. Geological Survey, the Federal Power Commission, Tennessee Valley Authority, and water research activities of a number of U.S. research agencies.

The team visited two river commission offices: Huang He Conservancy Commission and the Chang Jiang Conservancy Commision. The Chang Jiang Valley Planning Office has a total of 11,000 employees, of which 3,000 are college graduates. Included in this number are 2,000 engineers and 4,000 technicians. Departments under this office include a hydrology bureau, geological bureau, environmental protection bureau, research institute, and planning and design bureau (the largest).

Even though the offices we visited were well staffed with knowledgeable and capable engineers and other scientists, there appeared to be too much attention given to design, construction, and operation of individual projects as compared with planning and evaluation of comprehensive regional or basin water and related land resources to meet future as well as present needs of the Chinese society. In this regard, it appears that the Ministry of Water Conservancy and Electric Power could justify undertaking a program for updating regional or river basin comprehensive water and related resource plans. Such plans could bring together all pertinent information on current and projected population, needs for all goods and services, income levels, resource problem areas, development potentials, interbasin water transfer potential and needs, transportation demands, alternative plans and evaluations, benefit-cost analyses, and environmental impact assessments. These plans could undergo review within the Central Government as well as within the provinces to improve understanding and acceptance by the people.

Problems of Interbasin Transfers

The team received only very general information about interbasin water transfers and the need for such transfers. The North China plain appears to be the most water-short area in the country. Beijing, the capital, is located here as well, as is much developed agricultural land. The

last 2 or 3 years have been drought years for this area. Beijing is very short of water for municipal use. We visited one reservoir in the Ming Tomb area that was essentially empty, and it was still 2 months away from the rainy season. While there has been much development on the Hau River and other streams in this region, there is insufficient carryover storage to meet the needs of the region. Water has been diverted north from both the Huang He and Chang Jiang, but apparently no adequate satisfactory facilities are available.

Until the sediment delivery problem is solved through soil erosion control in the Huang He, there is not enough water available in this basin to meet the growing needs of the North China plain. Although ample water is available in the Chang Jiang, it must be delivered to or through the Huang He system. Before major works for interbasin transfers are undertaken, it appears highly desirable to carry out comprehensive long-range water related land resource plans for North China. This, together with the study of alternative water transfer schemes, should facilitate decisionmaking.

Impressions for Strengthening River Basin Planning in China and the United States

The river basin actions taking place in the two countries in the last 20 years are almost directly opposite. In the United States, many comprehensive plans have been developed with very little implementing of projects from these plans. In China, the emphasis seems to have been on building many projects based on general plans developed in the 1950's in some cases. There does not appear to be an effort toward developing comprehensive water and related land resource plans on a basin or regional basis. A better balance between planning and implementation seems to be in order for both countries.

Certainly, for any major investment in water and related land resource developments, it must be clearly shown through adequate study and analyses that there is both a social and economic need, as well as feasible solution: Today in the United States, public involvement in decisionmaking is necessa:

Environmental impact assessments are necessary. People want to know if they are going to be better or worse off if a public expenditure is undertaken. Hopefully, in water and related land resource planning, we can provide the kind of information that will lead to sound and lasting decisions.

Recommendations

1. The PRC and the United States jointly continue to explore procedures for comprehensive planning of water and related land resources in selected river basins in each country.

2. Any existing comprehensive plans on thse selected basins be exchanged between the Ministry of Water Conservancy and Electric Power and the Soil Conservation Service, USDA.

3. An exchange program be established to explore in depth the principles and techniques of small watershed planning, with emphasis on land treatment measures for erosion control and onfarm water management measures for water conservation.

FLOOD CONTROL AND OPERATION

by
Vujica Yevjevich

Most of the flood control measures in the PRC are of the structural type, at least in the areas--Huang He, Chang Jiang, Shanghai sea defense, and others--visited by the team. If the structural measures are divided into extensive measures (those spread over the large areas and of various soil and water conservation types), and intensive measures (those line or area measures such as reservoirs, levees, detention or release basins, diversion channels, and so forth), the general impression is that the intensive measures have traditionally received much more attention than the extensive measures. The reason for this is that the impacts of the extensive measures are of a long-range nature, while the intensive measures become effective as soon as they are completed. Before these measures are discussed in some detail, it is necessary to describe the basic characteristics of floods of the two rivers (Huang He and Chang Jiang) and the interactions under their specific conditions, of the movement of floods, the transport of sediment, and the meandering and capacity of the river channel.

Floods, Sediments, and Channels of the Huang He

The Huang He Basin is considered as the cradle of the Chinese (Han) people and their civilization. It is already widely known in professional circles as the river that carries more sediment per unit volume of runoff than any other river in the world of similar size. The reasons are basically the high erodibility and the extensive ongoing erosion of the Huang He's loess plateau, which covers an area of approximately 250,000 square kilometers located in the middle course of the river (around and inside the big bend that the river makes in the area east, north, and west of the city of Xi'an).

From the viewpoint of sediment supply and transport, the Huang He has three well-distinguished sections: the Upper Huang He, where sediment transport is relatively modest; the middle course in the area of the loess plateau, where the sediment supply rate is disproportionately high in comparison with the runoff from that area; and the lower course which transports a large amount of sediment with a relatively modest amount of water and which is basically in the continuing aggradation state.

The approximate quantities of water and sediment, as annual averages, are about 50 billion cubic meters of water and about 1.6 billion tons of sediment. Most of the sediment is generated by the erosion of the loess plateau. About 15 billion cubic meters of water are diverted from the river for various uses--basically irrigation, and municipal and industrial water supplies. The remaining 35 billion cubic meters of the water budget of the Huang He are used to transport (flush) the sediment into the sea. Out of the 1.6 billion tons of average annual

sediment supply into the river at the location of Zhengzhou (or more precisely at the outlet of the river from a narrow river valley into the large plain upstream of Zhengzhou), 400 million tons are deposited into the downstream channel of the lower course, 200 million tons are diverted from the river by irrigation and other water needs, and about 1 billion tons are deposited into the sea. The aggradation of the channel of this lower course is relatively fast, ranging from about 12 cubic meters per year on the average in the upper part of this lower course to about 4 - 6 cubic meters per year on the average in its lowest parts.

After the Huang He leaves the narrow valley confined by the loess plateau and some rock formations, it starts to braid widely in the upper part of the plain of the lower course. This braiding ("the wandering river"--according to a Chinese translation of the corresponding Russian term) is confined at present to a channel width of about 10-12 kilometers situated between the two large, parallel flood control levees. Then, in the middle and lower parts of the lower course, the channel passes from a braided river to a meandering river. The braided river sections have a slope of about 1:2000, while the slopes of the meandering sections are 1:5000 to 1:10,000. The river's mean slope in the middle course is about 1:1000.

The frequent and rapid shifts of braided and/or meandering channels often bring the major low flow channels to the two large dikes (levees), thus posing the serious problem of scour, with the potential of collapse of levees. This phenomenon requires special defense of large levees by using rock material for protecting the riverside of levees by masonary rock cover (wall), by rock-covered spur-dikes, or by rock rip-raps.

The heavy aggradation of the lower river course has required several raisings of the levees on both river sides for a total length of about 1350 kilometers (except for a section about midway down on the right side of the river along which there are no levees because of the hilly terrain). This raising of dikes (levees) must continue in the future if the problem of aggradation is not resolved. The level of the river bottom (talweg) is already several meters above the level of the adjacent plains.

The conveyance of floods, the safe flushing of the sediment, and the defense of levees from the scour and breaks by the highly braiding and meandering channels are interconnected, and are the greatest problems of the lower course of the Huang He. They must be resolved if the general plan of water resources development, conservation, protection and control of the Huang He is to produce the fullest benefits.

The loess plateau of the Huang He basin supplies very fine material. Only 1.5 percent of the sediment is sand. Silt is much more abundant. However, the very large quantity of fine suspended material significantly increases the specific weight of the "water-sediment mixture," so that larger particles of silt and sand move in suspension and saltation for the same velocities in rivers with much lower sediment concentrations. These are some of the specific sediment transport characteristics of the Huang He, especially in floods.

Floods, Sediments, and Channels of the Chang Jiang

The Chang Jiang has much less sediments, especially suspended sediment, than the Huang He. The trinity problem of flood flow, sediment transport, and channel meanderings is mainly related to the movement of the bedload material of sand and silt. The two major historical problems of the Chang Jiang were flood protection and insurance of the navigation. Due to very large water quantities of the river (the annual average flow is about 1,000 billion cubic meters), no problem exists in the supply of water for irrigation, and municipal and industrial use beyond the classical diversion (pumping, treatment, or drainage) problems. The Chang Jiang carries, on the average, about 500 million tons of sediment per year. Therefore, it has 50 times more water than the Huang He but only about one-third of the sediment. This simple comparison of average annual budgets of water and sediment of the two rivers obviously implies the significant differences in water resource planning problems in general, and the solutions of their flood control problems in particular.

The Chang Jiang has very large flood peak flows and very large total flood water volumes. Flood peaks ranged historically from 50,000 to 110,000 cubic meters per second. Flood volumes reached historically up to 185 billion cubic meters. Very good general data on flood damages exist in written documents for about 2000 years. Though these data do not permit an estimate of the 2000-year flood frequency, at least they permit an insight into the flood problems. Flood control is still the major water resource problem of the Chang Jiang. The planning of water resources of this third largest river (by flow) in the world (after the Amazon and the Congo) is highly dominated by the flood control problems, requirements, and flood safety standards.

The bedload is highly movable, at least one could judge that by the many longitudinal sand bars that change significantly from flood to flood. Two conditions make the Chang Jiang meander heavily in its lower section between Yichang and the sea. First, most of the fertile soils in the plain are deposited on the layers of permeable and erodible sand-silt layers, and second, large bedload movement enables a rapid fillup of channels and the scour of new ones. The first condition seems to explain the large width of the river at many sections, while both conditions explain jointly the present problems of the bank erosion and scour along the river. This latter consequence requires very careful defense of levees along the river, usually by using rock rip-raps at the riverside levee toes and the construction of rock (masonary) spur-dikes at the sharp interior banks of the river meanders. The pervious base of the plain soils poses some important questions about flood control, namely the seepage of water under the levees in floods and the corresponding danger of piping, scour, and levee breaks.

Both the Huang He and the Chang Jiang have a common feature. As soon as they leave the gorges or narrow valleys (confined by mountains and hills), the fan-type deposition of sediments occurs in the upper

sections of the plains. This classical problem is best illustrated using the Huang He as an example. The hilly and mountaineous area at or around the loess plateau is being lifted by earth crust movement at present. Therefore, the differences in head between the raising lands and the downstream plains increase with time so the fan-type braiding channels are continuously maintained. This factor also promises to maintain the aggradation of the channel in the plains of the Huang He.

The problems posed on the Chang Jiang will be quite the opposite. The construction of dams upstream of Yichang will represent a retention of most of the present bedload discharge of sediment along the Chang Jiang. This phenomenon will definitely lead to a continuing degradation of the channel of this river downstream of Yichang. The construction of dams and reservoirs on the tributaries of the Chang Jiang downstream of Yichang will further reinforce this future expected degradation.

Degradation of the long reach of the Chang Jiang downstream of Yichang may eventually increase the capacity of the channel to convey the flood peaks. However, it may also seriously affect the stability of banks (with reinforced meandering), the stability of river ports and harbors, and expose more of the levee sections to greater scour undercutting than that at present. This simply means that the present defense of levees, banks, ports, harbors and eventually bridge piers and abutements, must be reinforced by an additional amount of work than that required at present.

Flood Control and Operation of Flood Control Measures on the Huang He

Flood control and operation of flood control structures and measures on the Huang He are divided into three basic methods: (1) classical and modern intensive flood control measures with their specific techniques; (2) soil and water conservation measures that simultaneously control the sediment supply and flood peak flows and volumes; and (3) forecast, warning, evacuation and levee defense measures.

Intensive flood control measures. The present intensive flood control measures consist of the three types given here in order of priority: (1) levees along the major plains and the lower course of the Huang He, on both sides of the river, except along the topographically elevated banks (the total levee length is about 1350 kms); (2) flood water or release detention basins implemented from place to place on the plain along the 800-900 kms lower course of the river; and (3) upstream reservoirs already constructed or under construction that are either on the main stem of the Huang He or on its tributaries.

Levees are flood control techniques that have been developed and practiced by Chinese specialists and built by the Chinese people through many centuries. It may be postulated that the big levees (also with the big irrigation and/or navigation canals) requiring concentrated resources, labor discipline and hard work, have

represented some of the important conditions that have led to the formation of the central power, either of individual states or of the unified Chinese empire. Regardless of these monumental efforts and fine technologies, Chinese history is full of flood disasters due to the failure of levees, mostly during the exceptionally high floods. This history underlines and supports a modern concept--that it is nearly impossible, economically or by the people's consent, to produce a total flood control by using levees because either a much greater flood will occur from time to time than the one the levee is designed for, or the internal weakness of levees will lead to their local failures during floods, regardless of flood forecast, warning, defense efforts, and levee maintenance.

The difficulties of continuously providing safe levels of protective levees and safe performance of levees along their enormous lengths have led the Chinese specialists and decisionmakers to supplement the levee measure of flood control by other intensive measures. Basically, these additional measures are: diversion channels, retention basins, and reservoirs.

Levees are basically built from the local soils, often reinforced by rock material placed by two distinctive methods: (1) rip-rap stones, at the banks of rivers and the toes of a levee close to the river channel, and (2) by the masonary stone structures (revetment, walls, surface stone-protected spur-dikes, and so forth). The amounts of soil and rock materials used in the levees along the Huang He are very impressive, representing significant efforts of the past and present Chinese generations. The three major problems of the Huang He levees are (1) need to increase the height of their levels from time to time in order to compensate for the aggrading river bottoms; (2) continuing improvement in their resistance to flood effects (undercutting, erosion, piping, and so forth); and (3) needs for the increase in preparedness for flood defense and increased standards of levee protection because of a continuing increase of wealth in protected plains.

Release (detention) basins are used to help manage the flood volumes which occur beyond the capacity of flood conveying channels at the levee safe water levels. Parts of the plains, those at the crucial river sections which will suffer the minimum damage by flooding, are assigned to accept the surplus water of flood hydrograph. Diversion structures (with control gates) are provided. A channel system is developed for water to flow along the release basin, usually coinciding with the water drainage network of the channels. Controlled outlet(s) for the return of water from the release basins to the river and the drainage network of channels with pumping stations for a relatively complete removal of detained flood waters are also part of the system. Refuge (safety) areas protected by dikes or earth platforms are constructed for the people, livestock, and goods to be evacuated along with some measures of housing. The flood detention basins represent a transition between the classical structural measures and the contemporaneous nonstructural measures that are intended to minimize the overall flood damage along the lower Huang He.

Reservoirs on the Huang He and its major tributaries represent the third leg of the triad. It is expected that reservoirs built throughout the river basin of the Huang He will attain one or more of the following general goals with time:

(1) They will increase the protection from floods and decrease the average annual damage caused by floods in the Huang He valleys and plains;

(2) They will retain enough coarse sediments (silt and sand) of the loess, at least temporarily, until the soil conservation measures decrease significantly the sediment supply i.e., for the aggradation of the channel along the lower course either to be greatly reduced or basically eliminated; and

(3) They will serve as the major transitional measure of the flood control-to-sediment flushing dilemma until the soil conservation measures become effective in stopping the major sediment supply. Then conservation storage can be increased in the reservoirs by changing them to multipurpose structures rather than primarily being sediment detention and flood control measures.

By reducing the sediment input to the Huang He, the need for large amounts of flood waters to flush the sediment through to the sea will be also reduced. Then these waters may be stored in reservoirs for their best uses in dry seasons and dry years for irrigation, water supply to municipalities and industries, and for a more regular production of hydroelectric power.

Soil and water conservation measures

The soil and water conservation measures of the lands in the Huang He basin in general, and especially in the famous loess plateau are, in the long-run, likely the most crucial flood control measures of the river basin in the long run. The retention of sediments of the loess plateau within the area of this plateau is inseparable from the long-range flood control problems of the Huang He. They are the prerequisite for the best future solutions of the multipurpose water resources problems. Planning the future comprehensive solutions of water resources development, conservation, protection, and control depends on the outcome of the long-range effects of extensive structural and nonstructural measures of soil and water conservation. The proper zoning of the plateau into five types of land--namely (1) arable (or land to be transformed into arable or agricultural land), (2) range grazing, (3) range forest, (4) gully control, and (5) small river valley lands for sediment retention--is likely the prerequisite for the success of soil and water conservation measures on the loess plateau.

It is feasible to treat separately soil conservation and the water conservation problems in some river basins because although the two interconnect, they are still separate individual types of conservation problems. At the loess plateau of the Huang He, this

distinction seems somewhat less clear, or at least it is blurred. Heavy intensity of short rainfall bursts, mainly during the July-September wet season, provides both the erosion energy and high water runoff needed for carrying away the large quantities of eroded loess materials. Relatively short gullies of large longitudinal slopes, as well as nearly vertical gully sides, provide both a tremendous source of sediment and a large water-carrying capacity for sediments. Therefore, both sediment and water need to be retained, sediment permanently and water temporarily, for a lower rate runoff in floods. Soil properties of the loess favor such a joint conservation of soil and water. The loess materials have a much greater vertical permeability than lateral water transmissivity. Therefore, any induced vertical infiltration into the loess of depths 50-200 meters will increase the storage of water with a slow outflow from the loess. It seems that the water springs along the gullies will significantly increase in flow discharge in post-wet season as the intensity of soil conservation measures over the plateau increases.

Remarkable gullies all over the loess plateau seem to be a recent geologic phenomenon, mostly man-induced. If the present progress of the heads of gullies at the plateau levels ranges 1-3 meters per year, the longest gullies of 3-5 kilometers may have been created in the last 3000-4000 years. Lots of factors speak for the fact that the denudation of trees from the plateau was produced by the population of the region in the last several thousand years. One is intrigued by the question of how the advanced agricultural and artisanship societies of the Chinese states that built large canals for irrigation and long levees for flood defense could not have recognized the long-range impacts of the soil destruction on the loess plateau and sediment movement via the Huang He. One might also speculate that during the past 4000 years, the thinkers of the early dynasties may have balanced in their minds the three benefits of the erosion of the loess plateau against the negative aspects. These benefits may have been the distribution and deposition of fine sediments and nutrients originated at the plateau, over the land; the increase of fertile coastal lands by deposition in the sea (several dozen square kilometers per year, on the average); and the supply of important nutrients brought into the sea by the Huang He for an intensive plant and animal growth in the sea. Those combined with the classical difficulties of controlling the biological cover of erodible lands under pressure by the population for fire wood, construction timber, feeding of animals (goats particularly), and some food-containing plants needed by the continuously expanding population helped accelerate the problems. Likely, this expanding population caused, in the final count, the negative aspects of the plateau denudation to have outweighed long ago the above three benefits of the loess plateau erosion. The sediment erosion and heavy loading of the Huang He and its tributaries of the plateau with the sediments, the loss of arable land at the plateau, the loss of vegetation, and an increase of flood runoff rates from the plateau all increased the problems of flood inudations of the fertile plains.

One easily gets two fundamental impressions in listening to Chinese colleagues explain the problems of the erosion of the loess plateau and the consequences along the lower course of the Huang He:

(1) The planning of water resources development and control of the Huang He seem to be overwhelmed by the sediment problems and, in a way, the planners seem mesmerized by the difficulties of the resulting problems; and

(2) Regardless of the enthusiasm of the initial success of many experimental soil conservation efforts on the small demonstration catchments (watersheds), two factors still seem to cast some doubts about the final outcome of those efforts and their success: (a) The immensity of the area, with the very large resources needed for the final solution of the complete control of soil and water at the plateau being enormous and (b) the low rainfall in the northern regions of this vast plateau which slows down the recovery process.

There will be a long professional battle between those who would like to give prominence to the flushing of sediments in floods--first through mud flow (density currents) along the reservoirs and then regular flows along the long channel of the lower course of the Huang He--and those who would like to reclaim the plateau for intensive economic production of timber, grazing animals, and agriculture through the necessary large efforts of full soil and water conservation. This dilemma and a possible slow transition from one basic strategy to another will probably produce a lot of headaches for present and future decisionmakers, planners, technologists, scientists, and in the final count, for the people who live in the Huang He Basin.

Ongoing soil and water conservation measures on the loess plateau, at least in those areas that were visited by the team, are very impressive. They consist of three groups of measures: (1) conservation of range surfaces of grazing and forested lands that exceed some critical slopes of the terrain; (2) terracing of the plateau lands where their present slopes indicate both the relative feasibility of terracing and the fertility of terraced soils; and (3) control of gully erosion by check dams, gully slope consolidations, and sediment and water retention in gully reservoirs (this latter measure usually by evacuating the sediment in flood seasons through mud flow along the reservoir bottom).

Regardless of significant successes in all of these three conservational areas, some weak points will require the development of future technologies Examples are:

(1) better protection of stored water inside a terrace by building better rims as well as devices designed to carry along a minimum of sediment from upper to lower terraces;

(2) better solution for conveyance of surplus water from one terrace to the next terrace or to conveyance ditches;

(3) better protection of check dams along the gullies from undercutting by a proper and rapid sequence of construction of all planned check dams;

(4) contour planting of trees and shrubs along the steeper slopes following row plantings through the active erosion zones, which are the major sediment supply areas;

(5) proper inspection of check dams for any remedial work;

(6) consolidation of vertical slopes on highly inclined gully sides. Vertical or very steep gully sides of the loess plateau tend to separate the material in vertical blocks along the vertical fissures that peel off easily, likely under water pressure or frost effects, thus supplying a lot of material into gullies;

(7) prevention of earth slides into reservoirs. Gully reservoirs seem to have the following priorities: (a) raise the water level for an easier and cheaper water pumping onto the plateau, basically for irrigation; (b) store water for irrigation; (c) control the erosion of gully sides along the reservoir surface as a soil conservation measure; (d) some flood control; (e) mud bottom flow and its evacuation in floods; and (f) some sediment retention. Slides of side gully material may create water spillovers at dams even during the flood season.

<u>Flood forecast and warning, evacuation of flood plains, levee protection, and defense measures</u>

The flood forecast, especially when based on the upstream observations of progressing flood waves, seems to be adequate for warning purposes--either for the evacuation of people, livestock, and goods or for the preparation of flood defense organizations for levee protection as well as the other improvised flood defenses. No information was available in the briefings and discussions on flood control operations on how accurate the forecasts have been in the past for given lead times of forecast. Information was not given or discussed on how beneficial the forecasts have been in the past.

Flood control operations through defense of levees seem well organized, starting from the levee tenders (a person assigned a length of levee to tend) and the hierarchically building up of this defense organization with the provincial governor usually being the final decisionmaker on these defenses within the boundaries of each province.

Flood defense is important for a river like the Huang He with the flow rates ranging from over 22,000 cms during the largest historical floods to zero flow during the driest season of the driest years. However, the drying up of the river results mainly from various irrigational or municipal water supply uses upstream of the great plains of the Huang He. Regardless of the effect of irrigation

diversions on low flows, the very large variation between the low and high flows of the Huang He makes it one of the most variable rivers, by flow fluctuations, in the world. Therefore, forecast, warning, evacuation, and the defense of major flood control structures will remain important measures in the operation of flood control structures and flood control planning in China for some time to come.

Flood Control and Operation of Flood Control Measures on the Chang Jiang

Major intensive flood control structures

In some aspects, the basic intensive flood control structures on the Chang Jiang are similar to those described for the Huang He. The intensive structures are levees, retention basins, diversion channels, and reservoirs. However, the difference between rivers is substantial in one aspect. The future large reservoirs on the Chang Jiang and the present and future reservoirs on its major tributaries will have the same importance as the levees for flood protection, with priority of use before the flood retention basins. However, in the future, the retention (release) basins will be replaced in importance more and more by the reservoirs used for flood control, especially after the large Three-Gorge Dam with its reservoir is completed. Release basins will then serve mainly as the flood control measure to be used in extremely large floods, thus raising significantly the flood control standards to higher return period floods than the levees and reservoirs alone could provide.

Soil and water conservation measures

Many tributaries of the Chang Jiang that reach the river downstream of Yichang have a high degree of soil conservation and water retention. Terracing makes the soil less erodible and water is retained in many ponds (rice water supply ponds or fishing ponds) and many small irrigation water reservoirs which simultaneously serve as sediment traps and small flood control storages. Definitely, the soil and water conservation measures that serve to increase the arable lands and soil productivity one way or another will lead to further mitigation of runoff peaks from these lands.

Renovation and maintenance of levees

Many levees are relatively old. The Jingzhou levee near Shashi, west of Wuhan, on the Chang Jiang left bank, is 1600 years old. The ongoing renovation, maintenance, and improvement works are of three types:

(1) increasing the safety of levees from the river undercutting with stone rip-raps, especially along the convex river bends close to levees, with rock-masonary covered spur dikes along the most scour prone river bends, and reinforcement of stone rip-raps along the levee toes on the riverside;

(2) decreasing the piping dangers by reinforcing levees on their interior side. Fine river materials are dredged and deposited on the backside of levees, thus increasing the percolation length for given water level heads at the levees with the corresponding decrease of filtration velocities; and

(3) consolidating the levees by closing the white ant's nests and corridors with the injection (grouting) of mud, a mixture of clay and water.

Previous attempts of using wells on the side of the levee opposite from the river and by pumping water during floods from the wells to decrease the water table of infiltrating waters are now abandoned since the pumping has led to a rapid clogging of wells.

Shanghai Sea Defense

Flood problems in the Shanghai municipality occur mainly from high tides and lack of internal drainage. Even though the Huang Po River, which flows through Shanghai, is a tributary of the Chang Jiang, flooding from the Chang Jiang is not a severe problem. The reason for this is that the Chang Jiang is several miles wide at the point where it meets the Huang Po River and is emptying into the East China Sea. Most flooding occurs during the monsoon season which occurs from mid-May until the last of September. Shanghai proper is located on the highest ground in the municipality. Therefore, most farmland is flooded before the city.

The entire municipality is protected by dikes and a system of diversion rivers and flood gates. The dikes are built to protect the agricultural area from 12-foot tides and the city proper from the worst storm predicted to occur in 100 years.

Since drainage is a severe problem along with flooding, a system of channels has been constructed throughout the municipality to serve both purposes. Many products are also transported by boat on this network of channels. The largest river diversions also have ship locks which allow the Chinese to move boats and barges up to 300 tons in both directions depending on the levels of the rivers. Two such installations were under construction and one was functional. The Dah-Zhi River diversion is 38 kilometers long and serves two counties. The channel is 102 meters wide at the top with a 1:3 back slope. The west flood gate is 64 meters wide at the bottom. At the west flood gate, a ship lock was constructed which has a 300-ton capacity.

Overall, the network of rivers and canals, along with the flood gates and dikes, offers good protection from flooding in this low municipality.

Conclusions

1. The most basic flood control measure in the People's Republic of China still remains the levee; however, both its level and its safety have often been increased in recent times.

2. The breaks or overtopping of levees by exceptional floods have recently led to the development of flood release (detention) basins as structural measure to control flooding of assigned parts of flood plains, along with some flood diversion channels.

3. Recently, say in the last 20-30 years, the large reservoirs have joined the other basic structural measures (levees, release basins, and diversion channels) as the fourth leg of structural measures of levee-reservoir-detention basins diversion channels.

4. Sediments, both suspended and bedload, play a very important role in any structural flood control measure on Chinese rivers.

5. Soil and water conservation measures are of two types:

(a) Accidental measures via the terracing of land for agriculture and ponding water for irrigation; and

(b) Planned measures in the fight to reduce sheet and gully erosion via sediment retention, water retention, and infiltration.

6. The problems of heavy erosion and sediment production at the loess plateau of the Huang He have received in recent years special attention although the enormity of areal and conservation problems may require a long period of time and a large amount of resources to significantly reduce the sediment problems of the Huang He.

7. Maintenance and improvement of levees with the outlook for a successful defense in large floods remain the continuing concern of responsible governmental agencies of the People's Republic of China.

8. The sea defense system at the Shanghai municipality is doing an effective job. It is being improved to provide drainage as well as flood protection to the low lying areas. When completed, it should provide a satisfactory level of benefits.

LAND USE AND CONSERVATION TREATMENT

by

E. B. Dyer

In land use, especially agriculture, the major Chinese policy of the Central Government is to uphold the public ownership of land. Although this policy is relaxing somewhat to allow a Chinese farmer and family to own and cultivate small plots of 0.2 mu per person (one mu is one-fifteenth of a hectare or one-sixth of an acre, thus 0.1 acre per family of three) as an incentive for increasing food production, public ownership of land remains a strong policy. The means of organizing production is by provinces, counties, communes, work brigades, and production teams. The means of accomplishing production are by assigned output quotas, remuneration on work done, and bonuses for overfulfilling quotas. Production is accomplished by hand labor and human strength with little or no mechanical equipment. The use of donkeys, small horses, water buffalos, oxen, and humans on small assigned plots is the major energy source in agricultural production.

According to a recent issue of the Beijing Review, the responsibility system "to each according to his work" has been modified since 1979 to place the production responsibility system at the production team level. Production quotas are set for a group of individuals along specialized lines and remuneration is based on work done. The responsibility system has as its salient features:

(1) production teams, which are the rural area's basic accounting unit with 20-30 households divided into smaller groups along specialized lines;

(2) groups of households formed on a voluntary basis (or individual households and peasants) contract with the production team to do production tasks within a specified period of time. If the tasks involve major farm and conservation activities, they must be in line with relevant state production and purchasing quotas;

(3) contracts define the rights and obligations for the peasants, who are committed to fulfill the tasks on schedule and who get paid according to actual output, get bonuses for overfulfilling quotas, and pay for any losses themselves;

(4) peasants have the right to arrange as they see fit their own farm work and sideline occupations;

(5) public ownership of the means of production remains intact. The peasants have the right to use the state-owned land, collectively-owned farm machinery and water conservancy facilities, but are not allowed to sell or transfer them to others.

As an economic entity, the production team continues to manage production in a planned way. Every year it puts aside a certain amount of money from the collective that is used to expand production, improve public welfare, implement conservation works, and subsidize those in financial difficulties.

The Chinese Government finds it is necessary to uphold the policy of actively diversifying the economy with major attention to grain production while giving due consideraton to the interests of the collective and the individual. Many rural communes operate factories in addition to being engaged in agricultural production, thus providing diversification and extra income for the rural area.

The main task of economic works--soil conservation, flood control, irrigation, drainage, inland navigation, and so forth--is to keep China's population of nearly one billion people well fed and to enable the state to have the capability to undertake economic construction. Based on the major tasks for the current 5-year plan as outlined by China's Central Government, both the people's consumption and the country's construction should proceed according to the national plan and priorities. This requires planning and guidance to strengthen agricultural production through soil conservation, improved water management, and changes in the production responsibility system.

In the past, day-to-day farm chores were arranged by the team leader singlehandedly and the members got paid according to work hours regardless of the results of labor. The new responsibility system has done away with blind commanding and gives more scope to the peasants' talents and initiative according to the Chinese. In the past, it was "everybody eating out of the same pot," today, those who work more get paid more.

A recent Chinese publication stated, "An analysis shows that soil and water conservation is the foundation for the development of agricultural production and the harnessing of the rivers." A major task faced by the Chinese is to increase the production of grain and other food items in order to increase the daily intake per person from 1200 calories to 2000 calories. Currently, only a small proportion of the food intake is protein. In order for the Chinese people to have a modernized life by 2080, according to Li Shiyi writing for the Beijing Review, agriculture and animal husbandry must grow three and a half times larger than the present level. Even with a strict population control program, it is estimated that China's population will reach 1.1 billion people by the year 2000.

A concept of "suitable population size" has been developed by several studies -- one of which dates back 2000 years ago by Shang Yang of the Qin Dynasty. The term "suitable" means the growth of population would coincide with the growth of land resources and economic development so that the people could lead a prosperous life. Several population models developed in the last few years by a population research group headed by the scientists Song Jian and Hum Baosheng indicate that the most suitable

population would be 650-700 million people. A larger population would force people to lead a poorer life. They also estimated that such an adjustment process will require at least 70 years to accomplish. (NOTE: Half of China's population is under 20 years of age, and 65 percent of the total population is under 30. Only 5 percent are people older than 65. With an average age of 26, China has the youngest population composition in the world.)

Even though China has had since 1978 a strict population control program of one child per family, the growing population has literally eaten up expanded agricultural production. Grain production has more than doubled in the past 30 years without the aid of mechanization. But in the same period, the population nearly doubled from 500 million to one billion. The net increase of population in 1980 was 8.97 million, with 14.99 million births and 6.02 million deaths.

Today, the cultivated land per capita is 1.5 mu whereas in the early 60's, China averaged 2.5 mu of cultivated land per capita. Only an estimated 500 million mu of reclaimable land is potentially available for production. Reclaiming this land is problematic and costly; thus, the emphasis on soil conservation and food control.

Based on observations during the team's travels in Hebei, Shaanxi, Hubei, and Guangdong Provinces, and the Shanghai municipal areas, many conclusions were reached. In order to enlarge cultivated land, forests and grasslands have been destroyed, lakes and estuaries filled, land shaped and reshaped to form small fields, soil moved and mixed many times, and fields terraced to flatten the slopes. Nearly every usable mu of land and some mu's not so usable have been dedicated to food production. All of this has been accomplished basically by hand labor and toil of the Chinese peasants.

While conservation management such as terracing, use of green manure crops, organic matter, and rotations has been utilized for over 2000 years, land and water management today is dominated by the need to have maximum management plots for food production and accountability of the production teams. This philosophy has, in some cases, encouraged an overuse of the land and thus created additional erosion, intensified the pollution in sediment laden streams, deteriorated ecological balance, and aggravated destruction caused by natural disasters.

Observations made in the Shaanxi Providence near Xi'an (middle reaches of the Huang He where erosion on the loessial plateau is reported to be the highest in the world) indicate an excessive amount of bare earth throughout the province. Earth moving through massive land reclamation projects, utilizing bench terraces to reform the landscape and clean till cultivation where crop residues are removed for field or animal fodder, is practiced extensively in the uplands. Back slopes of the small plot terrace systems are often straight up and down with little or no berm and no vegetation. Numerous pits, earth fences, and bare earth around living and livestock quarters are prevalent.

Large ravines and deep gullies in various stages of severe dissection were observed in the loessial plateau. Erosion by water, wind, and gravitational action is very severe, the principal form being that of gully erosion on side laterals with deep grooves and sheer side slopes. This has caused a continuous "head-cutting" problem which is dissecting much of the loessial plateau. All of the erosion problems are aggravated by 65 percent of the annual rainfall concentrating in the months of July, August, and September. The rainfall is characterized by storms of high intensity which may be 1-3 millimeters per minute in 5 to 10 minute periods. In July 1971, one storm was reported as being 226 millimeters in 6 hours and 25 minutes which was 43 percent of the rainfall of the whole year.

The exchange team failed to see any small watershed plans although we did visit extremely large gullies in Chunhua County (Saanxi Province) which the Chinese technicians identified as small watersheds. Extremely good work of terraces on one meter by one meter with forestry restoration practices was observed on the steep canyon side of the gullies. Head-cutting was being treated with grade stabilization structures although there were no outlet structures other than an emergency spillway. The team expressed concern about the safety and capability of the structures to meet their purposes.

In the bottom of the deep ravines, flood control structures (earth and rock dams) had been constructed in series. Even though we were informed that these structures were for flood control, much emphasis was placed on the use of the water for irrigation of the loessial plateau some 90 to 150 meters above the reservoirs. There were no apparent assigned purposes or management built into the reservoirs to assure their use for flood control.

Observations indicated well-designed and constructed dams, especially a larger earth-rock dam near Beijing. Even though water levels were low due to a seasonal drought, the structure had high utility for irrigation of food groups, especially vegetables.

In evaluating the overall river basin and watershed planning and management objectives, the need and use of a more coordinated planning approach with land treatment for erosion and water management in small watersheds, coupled with a vigorous delivery system for technical assistance at the commune, brigade, and production team level are apparent. Opportunities exist for coordination of improved engineering and soil and water conservation technology, long-range conservation planning and application on individual communes, watersheds and small river projects to supplement the work of large river basin commissions. Emphasis should be placed on conservation land use and treatment at the top of small watersheds (gully area plus drainage area) and continued practice installation into the lower parts of the watershed and river basin through a coordinated and correct consequential basis.

Conclusions

1. There is a continuing need for a systematic exchange of technical data and trained personnel between the PRC and USDA, especially in watershed planning and soil conservation application. This is especially needed in specific geographic problem areas for erosion control, water management, and flood prevention.

There is a potential for significantly improving food and fiber production through a strengthened soil and water conservation program that is coordinated at all levels of government with adequate planning and technical assistance to the "grass roots" level.

2. There is mutually beneficial potential for exchanges of soil conservationists, engineers, watershed planners, biologists, and other interdisciplinary team members between China and the United States. China, in its efforts to stabilize gullies and slides, its use of land through multiple cropping and interplantings, and its management of sediment and use of organic matter has much to offer the United States. We can in turn offer technical improvement in layout, design, and installation of erosion, control structures, soil management and vegetation improvement, water control both for irrigation and flood control.

3. A closer coordinated and planning effort for future exchange teams should be made between the United States and China and would provide more benefits. This includes being more specific as to problem areas that are to be examined. The Ministry of Agriculture, Ministry of Forestry, Academy of Agricultural Sciences, the agricultural colleges, the provincial bureaus of agricultural and soil conservation, and the county bureaus of conservation should be included with the Ministry of Water Conservancy and Electric Power divisions that are responsible for erosion control and flood prevention in the small watersheds.

4. We would encourage the Chinese Government to strengthen their soil and water conservation efforts, especially in the planning and technical aspects. A delivery system of well-qualified technical personnel, trained in the planning and application of soil and water conservation management systems at the commune, brigade, and/or production team level should be an area of high priority in China's effort to reduce soil erosion and increase the productive capacity of the land. Adoption of watershed and small river basin planning and implementation techniques used in the United States should prove of benefit to China. Emphasis should be placed on an integrated land treatment program beginning at the upper reaches of the small watershed and coordinated all the way to the end of the river basin.

5. We encourage the Ministry of Water Conservancy and Electrical Power to continue to seek out methods and materials to increase the amount of permanent vegetative cover and to return more crop residues to the soil. These two actions will enhance soil erosion control and will improve water mangaement.

6. The management of the soil should be based on soils maps in planning the production, conservation and land use programs of the watersheds. This will require the acceleration and development of a coordinated soil survey program which should be a part of a world-wide classification system.

MICRO-HYDROELECTRIC DEVELOPMENT

by
Buell M. Ferguson

China is recognized as a leader in micro-hydroelectric technology and in the number of operating systems. The team studied some small- and medium-size installations in Enping County in the Guangdong Province with the idea of applying China's technology to similar situations in the United States. Although the installations we viewed were not China's most modern, they were typical for small installations.

The climate of Enping County is semitropical with an annual rainfall of 2,400-2,600 millimeters (mm) per year. Rainfall varied from 1,450 mm during dry years to 3,600 mm during wet years.

Mountains cover 50 percent of Enping County and are the source of many small streams feeding into the Ginjou River. The micro-hydroelectric installations were located on many small streams as well as at dams built for navigation on the main rivers.

The small installations we viewed had generators ranging from 75 kw to 400 kw in capacity. There were smaller generators (2.5 kw) in some of the communes in the county, but we did not visit them. These smaller units were not connected to the national electrical grid. The 75 kw units were the smallest units connected to the grid.

Over 72 percent of the water resources in the county has been developed with a total power output of 131 million kwh in 1981. Forty-three small installations have a 43,400 kw generating capacity with the rest coming from larger hydro-electric installations.

The first installation visited was the Jing Jiang Dam, a medium-sized installation completed in July 1973. This impoundment provided flood control, water for irrigation, recreation, and commercial fish production, as well as hydro-electric power production.

The lake had a watershed of 362 square km and a storage capacity of 475 million cubic meters of water. The dam was 63 meters high and had a hydroelectric generation plant with a total capacity of 19,000 kw. The equipment, with the exception of the generators, was produced locally. An average of 11 cubic meters of water was consumed for each kwh of generating capacity.

After visiting the Jing Jiang installation, the largest in the country, we visited the Red Flag Power Plant. This installation consisted of six small stations in series. A small dam 30-feet high was located above the first station and provided both flood control and water storage for hydro-electric generation. The watershed consisted of 22 square kilometers. The elevation head for the six stations ranged from 6 meters at station 2 to 103 meters at station 3. Generators varied in size from 75 kw at stations 1, 4, and 6 to 1,600 kw at station 3.

The equipment had been in place several years and, with the exception of the generator and electrical controls, was locally manufactured. The stations were not all developed at the same time and were not designed for the most efficient use of water and the elevation head. It was noted that some stations did not use all the elevation head available at their particular location. Operation of the six stations required up to 200 people.

Modern equipment, efficient use of the water, and elevation head could increase the capacity of 4,560 kw (15.5 million kwh per year) by 20 to 50 percent and reduce the labor requirement to that of a few individuals.

China has modern self-contained equipment which they plan to install in locations such as this one sometime in the future. This will increase the electric power from installations such as the Red Flag.

The Red Flag installation produces $700-800 thousand yuan per year in revenue for Enping County. This revenue is being used to improve the hydrologic condition of the watershed. The main effort is aimed at a reforestation program. At present, they are planting over 100,000 mu (16,666 acre) of trees each year.

Eight dams have been built in series on the Jing Jiang for the purposes of drainage, irrigation, navigation, and electrical production. These installations consist of a low-gated dam with a bridge for highway transportation, a ship lock for boats and a generation plant for hydro-electric power production.

A typical unit was the Jiangzhou dam and hydro power station. The elevation head of this plant was 5 meters. Hydro-electric production came from 10-2000 kw units. The generators were powered by locally manufactured turbines connected by a direct drive shaft. Installations observed at other locations used propellers for power.

Even though these units are only 6 years old, the equipment is crude by modern Chinese standards. The Chinese were in the process of updating the power stations as modern equipment became available.

Conclusion

South China has ideal conditions for small hydro-electric installations. Although the equipment is crude, the government and the people are admired for their ingenuity in developing their water resources. It will take time to fully protect the watersheds and modernize their installations.

Some of the schemes and techniques used in China can be applied in the United States using the efficient, self-contained equipment being manufactured today. As electric power continues to rise in cost, more of these small installations will become cost efficient, particularly where there now exists a dam with a sufficient water supply to operate the power units.

Recommendations

1. The United States continue to study the techniques being used in China as they may be useful in may parts of the United States.

2. The United States develop a technology exchange program on micro-hydroelectric installations with the China.