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ANNUAL TECHNICAL REPORT 211(d) PROJECT
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UNIVERSITY OF ARIZONA

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SUMMARY OF CONTRIBUTIONS TO THE UNIVERSITY CAPABILITY

GENERAL

Strengthening the University of Arizona's competency in the area of watershed management utilizing systems analysis techniques applied to problems of less developed countries has taken several forms. The addition and revision of pertinent course curricula, the analyses of research programs and the addition of new faculty are items that occurred in the early stages of the 211 (d) Grant. The improvements in teaching facilities, the accomplishments in the research program and the rendering of service that occurred during the second year of the Grant will be briefly reviewed under the headings of teaching, research and consulting.

Teaching

The efforts for increasing the University's competency in teaching has been directed so that a lasting benefit will be available to the less developed countries after expiration of the 211 (d) Grant. Thus, a major activity has been the development of a computer-oriented instruction program given the name CARES - Computer-Assisted Resource Educational System. The heart of this facility is a small, inexpensive computer, a high-speed paper tape reader and teleprinter, together with a

programming language, the necessary models, relationships, etc., and the dialogue between student and "instructor". As an aid in visualizing the hydrologic response of watersheds, treated or untreated to precipitation inputs, a Passive Electronic Watershed Model is being developed.

Not to be overlooked is the continuing efforts of various University departments to revise its teaching program in keeping with the Grant's objectives. Although a major effort was made in this direction during the first year, the departments of Watershed Management, Agricultural Engineering and Agronomy continue to revise some of their water-related courses.

Research

Increasing the University's research capability has been mainly concerned with the development and modification of the various hydrologic models, the decision-making models and the procedures that will be utilized by CARES, the teaching facility. Several hydrologic models are nearing completion such as a stochastic precipitation model and a resource management decision-making model. The development of a programming language and the required dialogue for CARES has been initiated. Under preparation is a computer-oriented instruction for a course in basic forest hydrology.

An electronic circuit analysis program has been adapted for rapid numerical analysis of the Passive Electronic Watershed Analog Model. This will allow the model to be used for quantitative purposes as well as for visual observation of the hydrologic response of a watershed.

Consulting and Services

Encouraged by the University, several of the staff made consulting trips, primarily to Latin American countries. In one instance, a trip to Northwestern Mexico for the purpose of discussing the possibility of Mexico becoming a training center for Latin America on certain range management and water-related areas was favorably received. Another trip was used to determine the nature of watershed management problems in the Far East. Representatives from Pakistan, Indonesia and India expressed a deep concern for these problems in their respective countries.

OBJECTIVES AND SCOPE

Under the 211(d) Grant, the University of Arizona's assignment of responsibility is in the area of watershed management with special emphasis on the science and methodology of applying systems analysis techniques to problems of less developed countries. The specific technical topics involved include:

1. Economic evaluation of land management practices for optimal use of water and land.
2. Analysis of hydrologic regimes.
3. Simulation models for predicting water supply.

A more detailed description of the objectives and scope of the University of Arizona program was presented in the first annual (1969-70) report submitted by CUSUSWASH.

MAJOR ACCOMPLISHMENTS

Accomplishments during the second year of the Grant have followed along the lines initiated the preceeding year. Coordinating on-going teaching, research and service programs with objectives related to the 211(d) program involves interdisciplinary ties with such departments as Agricultural Engineering, Agronomy, and Water Resources and Systems Engineering.

Development of Teaching Competence

A major effort in strengthening the teaching capability of the University is in the continuing development of a computer-orineted system for instruction in resource management. The acronym CARES -- Computer-Assisted Resource Educational System-- has been applied to this procedure. It utilizes a teaching-research facility, the core of which is a small, relatively portable and inexpensive 8K to 32K computer with magentic tape transport, a high-speed paper tape reader and teleprinter, all of which should be readily available to emerging nations. The facility is a completely interfaced hydrologic data acquisition-analysis system. In addition to the computer it includes software and hardware for working with live-telemetered

data.

Financial support from the International Biological Program, Analysis of Ecosystems funded by the National Science Foundation is directed mainly towards the data acquisition aspects of the facility. The use of 211(d) funds has been in connection with the instructional program of the facility (CARES).

To instruct in the area of watershed management utilizing systems analysis techniques, computer program's are essential in developing the components or sub-routines such as stochastic models of precipitation which are inputs to watershed models used to predict hydrologic products, water and sediment, resulting from various land treatment practices. Superimposing decision-making models on the above physical models makes the use of computers an absolute necessity in analyzing the hydrologic potential of a watershed. Going one step further the computer can also be used as an instructional tool.

While not a new concept, computer assisted instruction (CAI) is currently being practiced at a growing number of institutions for a variety of subjects, one of which may very well be watershed management. In a 1968 report on an Office of Naval Research Contract (N00014-68-C0236) it was stated that there are at least three educational requirements which make CAI inevitable. These are: (1) the trend to individualize instruction, (2) the growth and complexity in information to be acquired, and (3) the shortage of qualified instructors.

Instruction in watershed management, a relatively new science, utilizing systems analysis, a relatively new set of techniques, is an area where all three requirements are met.

Students in resource management, upon graduation, will have to wrestle with problems of quantification in the real world. They will be obliged to face problems having complex physical, biological, sociological and economic attributes. They will have to synthesize information from many areas of knowledge, apply the information to solving problems, and adapt to change.

This will require a basic understanding of the physical, biotic and human environment and most important, a capability of translating this understanding into planning and decision-making. Simple answers to the complex problems facing managers today are, increasingly, less possible. The applied utility of computers often provides the only approach to obtaining workable solutions.

Computer-oriented instruction permits the student resource manager to be trained by the very system that will become one of his most important tools when he graduates. By compressing time and eliminating tedium with the computer, the student can be exposed to a greater number of more complicated and more realistic situations. The instructor, freed from routine and time-consuming functions can devote more of his attention to student needs, course content and course structure. He is moved into the more demanding dual role of

tutor and lecturer.

A computer-oriented instructional program for a course in basic forest hydrology is currently being prepared, a major portion of which will deal with the various processes and their interactions that influence the movement of water through a watershed. A special programming language is being developed concurrently. It is intended that the required dialogue between student and the "instructor" will be available in several languages.

Continued activity occurred in the development of the Passive Electronic Watershed Analog Model discussed in the initial report. An electronic circuit analysis program has been adapted for rapid numerical analysis of the analog. This will allow the model to be used for quantitative purposes. Thus, not only will students be able to visualize the effects of a given watershed treatment on the model, it may be possible to quantify the results. The mathematical description of the analog is readily amenable to computer assisted instruction techniques. Efforts have just been started towards packaging the electronic equipment into a portable field unit and developing descriptive material that describes the relationships between the electronic response and the behavior of the physical system. With this accomplished, the dialogue for a CARES program can be prepared.

The Department of Agricultural Engineering completed the revision of Agriculture 190, International Agriculture. A new course was added to the Watershed Management curriculum, WSM 305, Modeling of Small Watershed Hydrology. This allows WSM 345, Advanced Watershed Management, to concentrate on the use of systems analysis techniques for optimizing the management of watersheds. Watershed Management personnel assisting in the instruction of Hydrology 214S, Field Hydrology (Summer Camp), stressed the need for more effective planning, development and utilization of water resources in less developed countries.

Library acquisitions in the pertinent subject matter areas were continued. In addition, a bibliography on snow hydrology was compiled.

Development of Research Competence

Strengthening the research capability of the University of Arizona in the area of systems analyses in watershed management is tied to the procedures used to increase its teaching competency. To utilize the computer-oriented instructional program, CARES, necessitates the simultaneous development, modification and evaluation of models and procedures employed in this subject matter area. Research projects in progress within the Department of Watershed Management that relate to this area are as follows:

1. Development of stochastic models of precipitation.
2. Computer simulation of the hydrologic response of watersheds to precipitation inputs.
3. Prediction of snowpack water balance by means of a seasonal energy balance.
4. A decision-making model for optional resource development.
5. Development and testing of transpiration retardants.
6. Climatological patterns and their effects on agriculture and forestry.
7. Development of electrical analog models in watershed hydrology.
8. Development of computer language to be used with CARES.

The Department of Agricultural Engineering continued its efforts in its rainfall multiplication experiment. The digital computer model which was developed to predict the success of modified dry-farming through rainfall multiplication was extensively revised. Subroutines were added to permit faster program analyses and more flexible operations. An iterative solution for several crops and area ratios is now possible. The Department of Agronomy continued its cooperation on the above project and in the area of water-use efficiency.

Development of Competence for Consultation and Service

The University has continued to encourage staff members to offer consultation in watershed management. Closer cooperation in research and training in certain aspects of range management and water utilization between Northwestern Mexico and Arizona was the prime motive of a trip to Hermosilla, Sonora by Professors M. M. Fogel and E. L. Smith and Extension Specialist, B. N. Freeman. A leading proponent of this endeavor is a former Department of Watershed Management now working in Mexico. The possibility of using the research and training facilities currently being constructed as a Latin American training center was also discussed. The Mexican federal government, the State of Sonora and private individuals are cooperating in this investigation center.

During a trip to New Zealand to present a research paper at a meeting jointly sponsored by UNESCO and the International Association of Scientific Hydrology, Dr. Fogel discussed watershed management problems with many of the participants from the less developed countries. In general countries with large populations, such as Indonesia, Pakistan and India could readily identify their watershed management problems as being associated with increasing and regulating streamflow and conservation in the water-source areas. They differentiated between these problems, which they believed to be in large part population induced, and their irrigation problems.

As part of the USAID/Brazil Contract, Drs. Barnes and Matlock of the Department of Agricultural Engineering visited Brazil on consulting assignments.

Twenty-four University of Ceara' faculty and Peace Corps--Columbia participants such as Tom Skinner have trained at the University of Arizona and taken work developed by the 211 (d) program. Several people from LDCS such as Zere Gebrehewit of the Ethiopian Ministry of Agriculture from the AID missions are working directly in the 211 (d) program area.

Universities Contribution and Entrainment

With the added competency gained by the University through the 211 (d) Grant, the entrainment effect of other resources towards the support of related studies continues. Taking advantage of this increased capability to obtain other grants and research contracts the University contributes by normally being required to support the research on some kind of matching basis. During the past year, grants or contracts have been awarded from NSF, OWRR, USDA and several private companies to do research in areas closely related to the objectives of the 211 (d) Grant. Additional support is also being sought from NASA, OWRR AND BLM AND HGW.

A more direct involvement concerns the time of the Project Director and other closely associated personnel which have been paid from University funds. Additional

spaces and related facilities have also been provided for use by the Watershed Management Department in carrying out its 211 (d) functions.

The development of the instruction program for CARE is a tedious process and must go through a number of iterations of the sequence--program evaluate, de-bug and validate. Because of their interest in the CARE program the University Computer Center is donating as much free time on their terminal as needed for developing the programs.

Four faculty received partial funding of their salaries from 211 (d) with the University contributing most of the salaries. Three other faculty who receive no support from 211 (d) are also devoting the bulk of their efforts to the to the 211 (d) project.

The Desert Biome portion of the International Biological Program, analysis of ecosystems, whose objective is to develop computer models of desert ecosystems, plans to concentrate their watershed modeling efforts at Tucson. Primarily, this is due to the impact 211 (d) has given the Universities watershed modeling efforts.

The University of Arizona has contributed space, remodeling expenses and equipment to facilitate work under 211 (d). Actually, over \$20,000 of capital equipment (over a period of 4 to 5 years) has been committed to the project from State and other funds.

WORK PLAN

Many of the activities initiated during the first two years will be continued in the next year. As before, major emphasis will be placed on the development of CARES-the computer-oriented instruction program. The less developed countries will derive a lasting benefit with the realization of this system. The research program will continue its efforts to provide much of the inputs that will be needed for such a system.

Recognizing that perhaps the University's weakest phase of the 211 (d) Grant is its consulting activities, the University intends to become more familiar with the programs of the other CUSUSWASH members. In this way, consultation may be accomplished on a team basis rather than on an individual University basis. Solution to watershed management problems requires knowledge of the entire system including the delivery of water and on-farm irrigation practices.

Table I. Expenditures for Fiscal Years 1969-71 and Anticipated Expenditures through 1973-74.

	<u>69-70</u>	<u>70-71</u>	<u>71-72</u>	<u>72-73</u>	<u>73-74</u>	<u>Total</u>
Salaries	38,113	48,221	40,000	35,000	30,000	191,334
Wages	9,430	4,015	5,000	4,000	2,000	24,445
Fringe Benefits	<u>3,771</u>	<u>4,892</u>	<u>4,100</u>	<u>3,700</u>	<u>3,400</u>	<u>19,863</u>
Sub Total	51,314	57,128	49,100	42,700	35,400	235,642
Stipends	6,213	9,640	14,000	10,000	8,000	47,853
Travel						
Foreign	--	2,620	4,000	4,500	3,500	14,620
Domestic	3,368	3,253	2,000	2,000	1,000	11,621
Equipment	2,694	3,985	3,500	3,500	3,500	17,179
Computer	1,348	100	1,400	2,000	2,000	6,848
Operations	<u>2,993</u>	<u>4,864</u>	<u>4,000</u>	<u>2,300</u>	<u>2,080</u>	<u>16,237</u>
TOTALS	67,930	81,590	78,000	67,000	55,480	350,000