A SYSTEMATIC APPROACH TO WATER RESOURCES DEVELOPMENT

By: P. Widmoser*

1. Water resources development (w.r.d.) as part of overall development

In order to achieve nation-wide targets like, let's say self-reliance in food supply, apart from mobilising capital and manpower, various fields of know-how, skill and technology have to be combined. As a matter of fact, specialisation has become one of the prerequisites of today's technological standards. As to how the various fields of specialisation have split off, no general rules are valid. Quite often even, there are no clear-cut borderlines existing between them. A hydraulic engineer, for example, who may well know how to construct a dam out of different materials will be dependent on further information for the necessary dam height. On the other hand, an agronomist can estimate the storage required for irrigation, but his technical knowledge may be limited to small earthen dam-design.

Whilst in industrialized countries specialisation has mostly developed along historical lines (sometimes without fitting any more into nowadays' exigency), developing countries are more or less still free to accommodate administration, budgeting, economic and technical training, standards, etc. according to up-to-date knowledge and to the specific regional demands, thus avoiding waste of know-how and money.

The following compilation may be helpful in doing so in the field of w.r.d., keeping in mind that this again is but one speficied way of development being related to many other branches. Another point should be mentioned here which is characteristic for w.r.d.: there is also a territorial interdependency in the downstream direction in the way that upstream works may considerably influence the downstream situation. New land use practices in the uplands may be the cause for the apparent decreasing trend in water storage of Nyumba ya Mungu dam since 1969.

2. The objectives of water resources development

The measures to be taken in w.r.d. may be

- protective: erosion control in catchment areas including mechanical and biological methods; flood control; water treatment for domestic and industrial use; waste water and waste disposal etc.
- corrective: river and canal navigation; harbours; recharging ground water; etc.
- utilising : water supply, irrigation, power generating;

or a combination of these.

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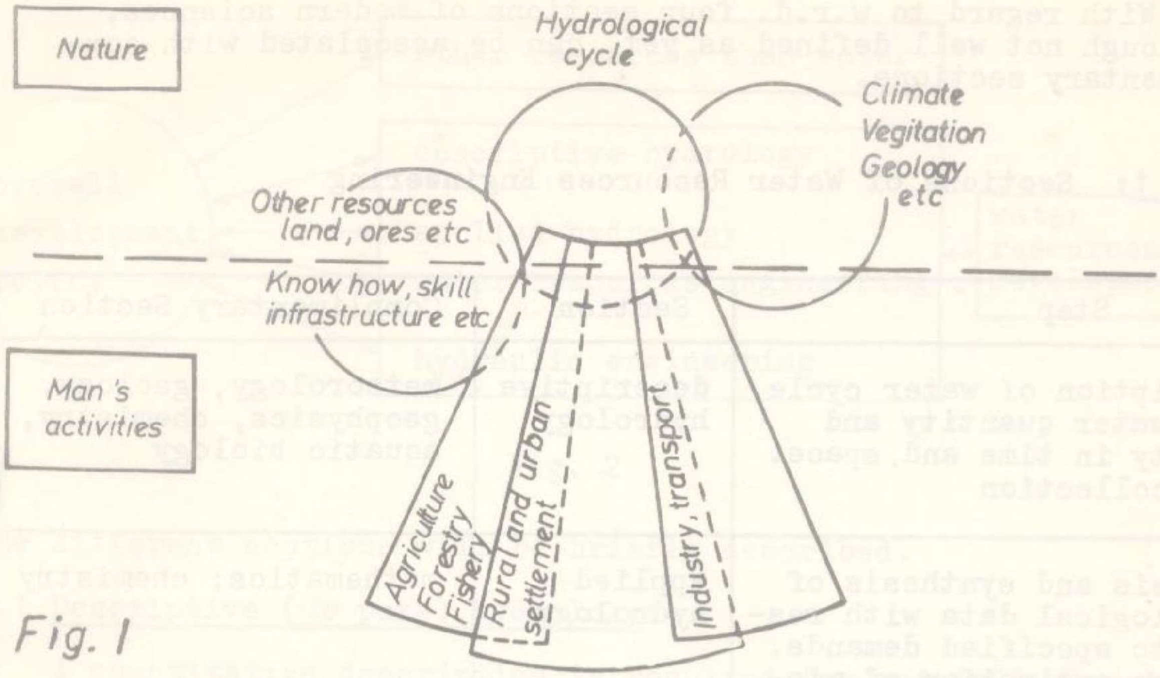

Fig. 1

Broadly spoken, w.r.d. is involved in (see fig. 1):

- agriculture, forestry, fishery and gam reserves;
- development of rural and urban settlements, including tourism and recreation;
- industry and transport.

One of the examples demonstrating how w.r.d. is determined by different factors outside its own technologies is erosion control: not only water management and hydraulic designs but also population pressure, land use, cropping systems, exploitation of woodlands etc. considerably determine the extent of erosion for a given region.

3. The four steps of developing water resources

In controlling and using natural resources men have

- to know the resources, their quantitative and qualitative appearance in regard to time and space;
- to specify their demands with respect to these resources within a region;
- to set rules how to exploit the resources in order to avoid clashes with overlapping interests;
- to cope with them technologically.

These four steps are already existent in non-industrialized societies. In that case, however, they are bound to mythology, religious and social controls and rites. An interesting description on this can be found for water supply and irrigation systems of the Wachagga on the foothills of Kilimanjaro mountains.**

** F.T. Masao: The irrigation system in Uchagga. Tanzania Notes and Records, No. 75 (1974).

With regard to w.r.d. four sections of modern sciences, although not well defined as yet, can be associated with complementary sections.

Table 1: Sections of Water Resources Engineering

Step	Section	Complimentary Section
Description of water cycle, i.e. water quantity and quality in time and space. Data collection	descriptive hydrology	meteorology, geology, geophysics, chemistry, aquatic biology
Analysis and synthesis of hydrological data with respect to specified demands. Optiman estimation of missing data, forecasting, analysing probabilistic and deterministic behaviour of w.r.	applied hydrology	mathematics; chemistry
Concepts and plans for w.r. development; setting standards, control lines, regulations; taxation; administering, hydraulic schemes and catchment areas.	water resources management (prescriptive)	land management, agriculture, forestry, fishery, mining, social medicine, sociology, economics, land use and industrial planning, policy.
Techniques of water use, conservation and control on the basis of hydromechanics, aquatic chemistry and bacteriology; design, operation and maintenance of hydraulic structures and tools.	hydraulic engineering	mechanics, material technology; chemistry, aquatic biology.

Overall development policy enters mainly in w.r. planning and management (step 3), but may also affect techniques (step 4) of water use and control (choice of materials, centralized or decentralized operation and maintenance, labor or capital intensive construction site etc.), see fig. 2.

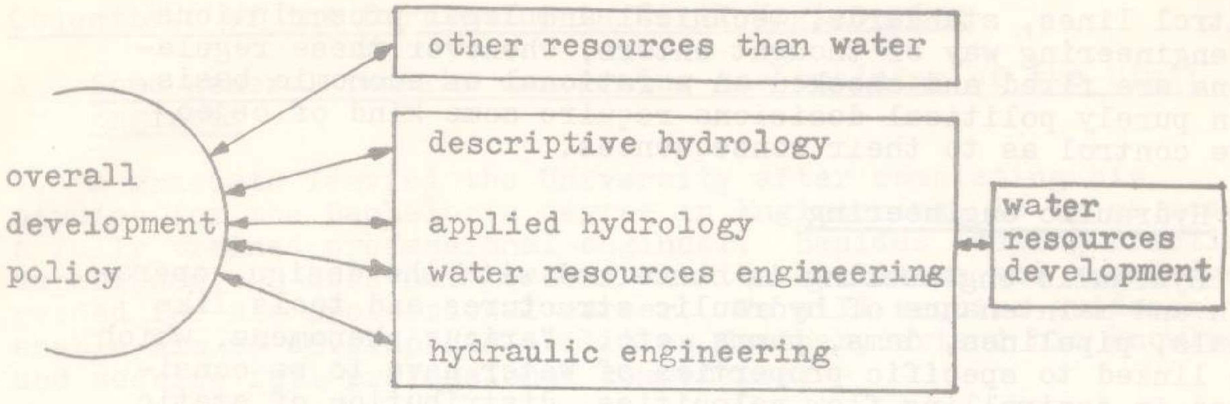

Fig. 2

The different sections will be briefly described.

3.1 Descriptive (or pure) hydrology:

A quantitative description is required for rainfall, levels of rivers, lakes and groundwater; discharges, interception, infiltration and evaporation.

For rivers, lakes, groundwater and oceans also qualitative information (temperatures, chemicals dissolved, disease carriers etc.) may be relevant. All data have to be collected and registered in a suitable form (hydrological year books, magnetic tapes, maps, etc.).

3.2 Applied hydrology:

Hydrological data have to be analysed and interpreted with regard to specified demands. Frequently, no long-term observations are available. So the vast field of the optimal estimation of required data as well as forecasting (correlation techniques, generating data, rainfall-flow models, etc.) enters into this item. An analysis of the probabilistic and deterministic behaviour (purely random, periodicities, trends, internal dependency) is often useful. As planning aims at a change of present stage, all possible consequences on the existing hydrology cycle have to be assessed with respect to the intended changes. Synthesing of data for these cases may quite often be a useful tool for applied hydrology.

3.3 Water resources engineering:

Just as traffic engineering is not only concerned with the actual construction of vehicles, w.r. engineering here will not only be associated with merely hydraulic structures. It is rather supposed to be related to the engineering aspects of planning, managing and operating water resources projects. Utilisation, conservation and control of complex water schemes or natural catchment areas are in need of operating rules, control lines, standards, technical and legal prescriptions. An engineering way of thought enters, whenever these regulations are fixed and checked on a rational or economic basis. Even purely political decisions require some kind of objective control as to their consequences.

3.4 Hydraulic engineering

Hydraulic engineering is concerned with the design, operation and maintenance of hydraulic structures and tools like canals, pipelines, dams, pumps, etc. Various phenomena, which are linked to specific properties of water have to be considered in controlling flow velocities, distribution of static and dynamic pressures as well as some aspects of water quality. Studies on flood waves and wave forms, turbulences, scour, sediment transport and ground water seepage, to quote only a few examples, require considerable engineering know-how and can be highly fascinating. Boundary conditions for a spillway discharge may be so complicated that even computer solutions won't cope with them and the engineer has to rely on hydraulic models. But even for such simple structures as small irrigation channels or diversion boxes a basic understanding of flow phenomena is essential for proper design.

All that, although related to purely technical aspects should nevertheless also include awareness of the needs and capabilities of those for whose benefit these structures are being built.

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CURRICULUM IN CIVIL ENGINEERING AT THE UNIVERSITY OF DAR ES SALAAM

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After two years experience with the curriculum in Civil Engineering, and after arrival of new staff members with new ideas, it was realized that there was room for improvement of the teaching programme. It was also necessary to develop the final concepts for the 3rd and 4th year, since only very rough outlines existed for this part of the course.

After a series of three seminars the "Objectives" given below were arrived at. They will serve as a basis for redrafting the curriculum and syllabi, presently in discussion.

It may appear that quite a number of trivialities are listed and that not every statement represents a fundamental new finding. However, it is important to include these points in order to be able to draw all the necessary conclusions and consequences for the teaching programme and methods.

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