MAINTENANCE OF IRRIGATION AND DRAINAGE SYSTEMS

1. INTRODUCTION

The issue of maintenance is directly related to a man-made environment, consisting of artificial elements. Natural things develop and maintain themselves. Everybody knows that every tool or equipment need some kind of maintenance. Without that, it will ultimately loose its functions and utility, and it has to be replaced. Yet, one can observe quite different maintenance practices: from very frequent and intense to nearly absent, from expensive to cheap, from complicated to simple, etc. Apparently, the intensity or neglect of maintenance, depends on several factors:

- The nature of the tool: some tools do not need much maintenance, others are vulnerable and need frequent maintenance: a car engine is essential and needs frequent maintenance, the engine of a kitchen mixer usually cannot be maintained and does not need much maintenance till it brakes down after a (hopefully) long life.
- The importance of the tool, in view of its functions: an ashtray in a car does not effect the essential function of the car; a car keeps going with a broke ashtray, non-smoking car owners do not even need it.

Similar examples can be found for various other factors such as:

- The speed of deterioration and loss of functions; some things deteriorate very slowly, others more rapidly, but they can deteriorate quite far without loosing their functions.
- The cause and type of deterioration;
- The cost of repair in case of deferred maintenance;
- The cost of replacement or rehabilitation if it can no longer be repaired;
- The cost of regular routine maintenance itself;
- The available finances;
- etc, etc.

Everybody knows that some degree of maintenance is usually necessary, but problems and differences of opinion occur when further questions arise, questions which are basically coming down to:

- **Why and when is maintenance necessary;**
- **Who is responsible;**
- **How is it to be done and by whom;**
- **And how are the costs to be financed.**

These questions will be briefly discussed in this paper, as far as related to irrigation and drainage systems. The first question depends on:
- aspects of functions (Section 3),
- costs and benefits (Section 4),
- and resulting frequencies (Section 5).

The institutional aspects are discussed in Section 6 and the last two questions in Sections 7 and 8. But first some reflections will be given on the "maintenance environment": conditions which affect all considerations on maintenance, irrespective of technical or financial factors.

2. THE ENVIRONMENT OF MAINTENANCE ACTIVITIES

Apart from the above mentioned factors, a number of less concrete factors certainly can play a role in the maintenance policies and discussions:
- does anybody feel responsible or is anybody made responsible for maintenance;
- the culture: it is common to maintain things;
- does it have status to be involved in maintenance work;
- is it a private or a public good to be maintained;
- are their personal benefits to be expected?

As a result of all these factors sometimes important things are hardly maintained, while for other things one wonders why so much money and effort is automatically spent on seemingly useless maintenance activities. All factors together may explain seemingly simple questions as for instance "Why does a country maintain its roads?." Can the road no longer be used if it is not maintained, is it so cheap to do that the question is not important, does it cost too much fuel if it is not done, is it prescribed in a law, whether useful or not, does it create employment or is there a well development economic sector working specialized in maintenance, is it the peoples nature to be neat and clean, is it too expensive to let it come to substantial repairs, etc.

Similar principles and questions of course apply to the maintenance of irrigation and drainage systems. Canals and structures evidently constitute a man-made environment, enabling agriculture on lands where without such systems it would be less beneficial or impossible at all. And where irrigated agriculture is the basis of the life and economy in many countries, maintenance of such systems has to be essential as well.

Looking at the maintenance practices with regard to water management systems in The Netherlands and in India we will see that there are considerable differences, not only in the execution methods and organization, but particularly in the intensity and quality of the maintenance and the efforts and finances spent on it. The general picture is that the maintenance of canals and structures is receiving less attention in India than in The Netherlands.
The common Indian statement on maintenance is that it is important, but that government funds are insufficient. This is an easy answer, but is it the real reason? In the Netherlands as well, funds for maintenance are not always sufficient or even worse, the government does not contribute to maintenance costs at all. Yet maintenance practices are quite good although improvements are always possible. Perhaps some of the other factors mentioned above are playing as well to explain the differences in maintenance practices.

In comparing the maintenance situations in the two countries and in trying to learn lessons from each other, it seems worthwhile to try to identify and address "environment factors" as mentioned above. This could perhaps better explain reasons for differences or possibilities and constraints for transfer of lessons from one country to another. But it could also benefit considerations on how to improve maintenance in India (improvement of maintenance in The Netherlands might as well be possible, but this is not the primary subject).

3. MAINTAINING SYSTEM FUNCTIONS

Answers to many maintenance questions largely depend on which functions of the water control system are to be maintained and on the consequences of a loss of function due to inadequacies in maintenance.

Most important of course are the functions directly related to water control. Canals and structures in irrigation canals should have sufficient capacities, and should be able to guarantee the required water levels, for instance for proper functioning of outlets and to avoid overflowing of banks. In any system these functions should be identified and defined, and the maintenance requirements should be based on maintaining these functions.

Drainage systems should basically also have sufficient capacities, in order not to exceed specified water, but the ultimate purpose of this is different, that is avoiding inundation or water logging instead of guaranteeing a required level for distribution of the water supply. In the Indian systems, where irrigation and drainage systems are separated, the differences between the objectives may lead

to different maintenance practices and frequencies. But a more important difference may possibly be related to the institutional and execution aspect. It will be useful to elaborate on this difference between irrigation and drainage canals with respect to maintenance, particularly in the Indian situation.

When system functions are no longer being fulfilled, the cause of this should be identified. Canal capacities are determined by the dimensions of the canal, the water level gradient and the flow resistance, whereas for a given flow size the gradient and levels depend on the dimensions and the flow resistance. It should be realized however, that problems are not necessarily due to maintenance. Incorrect water levels for instance can also be due to deficient operation or to physical properties of structures (cross regulators or outlets). In such cases, maintenance of canals would not improve the situation.

Maintenance should only be done to remedy the cause of not fulfilling the required functions or to avoid such causes to develop. Both of these (function and cause) must therefore be identified to assess the required maintenance actions. The maintenance activities will usually focus on the shape and dimensions of the canal and on the flow resistance. This particularly applies to the under-water part of the profile, which determines the water conveyance and level functions. Maintenance of the part of the section above the water is needed for structural reasons.

The above water control functions (conveyance, distribution and escape of excess water) are mostly dominant in determining maintenance requirements. In The Netherlands, however, gradually more and different functions have been attributed to water control systems, besides the common basic elements of water quantities and water levels. Aspects of different uses of water (such as fisheries, navigation, drinking water) and different society demands (nature conservation, redress ground water pollution, etc.) lead to the inclusion of requirements for water quality and broader environmental concerns.

In Indian irrigation systems this is also becoming more important. Therefore, to avoid negative developments as took place in European countries, it would be appropriate to give timely and due attention to these aspects, to assess whether to include them or not in maintenance considerations. At present in India, other than strict water control functions are apparent in several regions: many canals are used for drinking water as well, but also the health aspect of water-borne diseases (malaria, filaria and bilharzia) may have its bearing on maintenance objectives and techniques. It would be useful to elaborate on this subject of functions and possible diversification in that respect.

Finally, dealing with functions also implies that maintenance should have any real sense. Maintenance for aesthetic or visual reasons only may not be very useful, certainly not as long as financing is a problem. For instance, a canal section can look very much deteriorated, but it can well be that the capacity is still more than sufficient. A canal must not necessarily always be neat and clean (free of any vegetation and with a nice shape). As long as functions are fulfilled it is even better to have some vegetation, particularly above the water level, for slope stability or for ecological reasons.

For proper maintenance one has to have a sound knowledge of the characteristics of the system and its elements and to understand to which functions they contribute. Such a data base is necessary for an adequate monitoring, planning, execution and control of the maintenance, for cost effectiveness of the work and for cost recovery as well.

4. COSTS AND BENEFITS

The need for maintenance as such may be evident: if things are not being maintained, their loose their function and value, investments are not properly being used and all this costs money. However, maintenance as well costs money and further decisions on what, how and how frequent to maintain, therefore should actually depend on a more quantitative analysis of costs and benefits. This is by far not simple, for a number of reasons:

- Relevant data on both elements are often not available;
- Maintenance is often done before deterioration becomes apparent: it is not known what would have happened if it would have been delayed and what the final cost balance of savings and spendings would have been.
- If maintenance is done late, and it has more the character of repair, rehabilitation or replacement, total costs may be higher than actually would have been needed by timely maintenance;
- Benefits are difficult to assess; in fact one should therefore compare the with and without maintenance situation, both under the same circumstances;
- Both costs and benefits may vary considerably depending on many factors.

Evidently data should be collected for the development of an effective maintenance policy. The paradox is, however, that this cannot be done when hardly any routine maintenance is executed. Creation of a pilot project in this respect therefore seems appropriate and is strongly recommended. It could be a great incentive for future maintenance practices and policies to have concrete field data available on real costs and benefits.

A particularly important subject would be to assess the maintenance needs and costs of lined canals. Lining is often advocated to reduce seepage losses, with the additional argument that part of the costs will be recovered because lined canals require less maintenance. This statement can be questioned, but documented evidence is scarce or even absent. Some indications even suggest that maintenance of lined canals might cost substantially more than it is usually said, especially with the deterioration of lining in due course of time. More information should be collected on this issue.

5. MAINTENANCE FREQUENCY

One method of doing maintenance is to monitor functions and to do maintenance works when it is observed that these have started getting affected. When one waits even longer and it is accepted that the system is functioning for some time below its optimum capacity, one speaks of deferred maintenance, which can ultimately get the form of major repairs. In some countries this practice is followed: major repairs or rehabilitations are being carried out, for instance once in 10 years, rather than more frequent regular maintenance to guarantee the proper functioning. The other extreme is what is called preventive maintenance: carry out a regular and frequent maintenance program without functions being clearly affected at that moment, but to avoid that happening.

In any maintenance policy a choice has to be made between these and intermediate options. This choice may be made on purely political or national economic grounds, with or without sound information on costs and benefits. More in detail, a number of factors is affecting the issue. For instance the methods, techniques of maintenance and physical conditions are involved. Methods used affect the quality of the work, and thus the required frequency, but also the costs. Also the specific climatic climate, soil and hydrological conditions play a role. For instance, climate and soil may affect the vegetation, both in type and growth rate. Some aspects in this respect are:

- In some areas regrowth of vegetation is very rapid and maintenance has to be done several times a year.
- In some systems there is one dominant type of vegetation, in others there is a large variety of vegetation.
- In certain areas the irrigation water is heavily silt loaded, requiring frequent desilting, in others there is clear water and desilting is hardly necessary.
- In the Netherlands there are some differences in maintenance between peat, clay and sandy areas. In India there may be differences in alluvial, loamy or Black Cotton (BC) soil areas.

- System design may play a role, for instance steep side slopes may require more frequent maintenance.
- Again, functions can be important: different water control functions may ask for different frequencies, and ecological considerations may change the requirements.

Another aspect is that different frequencies may be required for vegetation control and maintaining the section shape and dimensions. One clear difference can be observed in The Netherlands: usually flow resistance is more frequently and more rapidly changing than the canal dimensions, mostly due to vegetation growth. In The Netherlands therefore two types of maintenance are being distinguished: the "small maintenance", dealing with vegetation control with a high frequency, and the "large maintenance", dealing with section control (reshaping, desilting), with a very low frequency. It has to be seen to what extent this distinction can be made in the Indian systems.

Finally it is advocated to devote adequate attention to the specific requirements for drainage canals. Because of their different functions and characteristics, maintenance aspects (and particularly the frequency) for drainage may differ from those for irrigation canals. Although in The Netherlands generally such separated systems for irrigation and drainage are not known, here the difference between maintenance of permanent water carrying and temporarily dry canals may give an indication of such differences.

6. INSTITUTIONS AND RESPONSIBILITIES

Even having a clear maintenance policy, a necessary data base, and sufficient knowledge on the above issues, a systematic maintenance can only be done if there is a proper institutional and legislative framework. "Institutional" refers to agencies and people specifically responsible for the development and implementation of the maintenance policy. One could even argue that the priority is reverse: first one should have an institution, legislation etc., then the money has to be there, for which a financing policy is required, and only having all this organized the question of how to execute the maintenance can be dealt with.

Several papers in this publication discuss elements of the Dutch Waterboards and their crucial role in maintenance. Of course it will not be necessary and not possible to copy this to the Indian situation. But it would be worthwhile at least to identify where institutional development or modifications in India are

required and which elements from the Dutch experience could be used or not in the Indian context.

Since the beginning of water management in the Netherlands this has been a primary responsibility of the inhabitants of the local communities. Community organization and regulations developed in such a way that each individual (farmer) had to contribute to the proper management of the water systems by executing the maintenance by themselves. Increasing land reclamation lead to the organization of farmers and farmers' representatives (waterboards). Later on, contributions by farmers in labour were replaced by financial contributions and farmers had to maintain only the small ditches on their own land.

In India the situation has developed differently, First there is the fact that new irrigation and drainage systems were built by the government and made available to the farmers. Second, there is the clear division between the main system, managed by the government, and the tertiary unit (the command below the "outlet").
In The Netherlands there is only the division between "government" (actually the Waterboard) and individual farmer. In India there is one extra intermediate level in between government and individual farmers, namely the outlet command, whereby it should be realized that the size of individual farms in The Netherlands often is of the order of an outlet command in India. The problem largely is that with regard to responsibility at that level the situation is confused. In several States Irrigation Acts or similar documents attribute some role to the Government (Irrigation Department, CADA) for varying matters within the chak. In most cases there are problems involved, however. Sometimes, responsibilities and tasks are defined only in general terms and not sufficiently detailed to be workable, in other cases farmers' responsibilities are clearly spelt out, but there is no mechanism for control or sanctions/penalties. Sometimes also, farmers and government are only blaming each other and waiting for the other party to take action.

It seems not realistic to us to expect the government to execute all maintenance within the outlet command. A basic decision is to be made on to what extent government can be (made) responsible. This would require a number of measures: (i) clear formulation of the works for which government is responsible (not just "maintenance" in general, but more specific), (ii) similar indication of responsibilities of the farmers with clear guidelines for the standards of maintenance and (iii) the development of adequate legislation with executable control and sanctions, serving the purpose.
Completely on the other extreme, it is also possible to leave the matter

completely to the farmers (possibly supported by government measures or assistance). However, for farmers to organize themselves and the maintenance within the outlet command, it seems prerequisite that water supply to the outlet is adequate and reliable.

Apart from the above there is the question of institutional requirements for the maintenance of the main irrigation system, which normally concerns the branch- and main canals, distributaries and minors and all their structures. Usually there seems not to be a major problem in this respect: generally, Irrigation Department is responsible. Only regarding the organizational set-up it could be questioned if and how at least some separate division or sub-division should be created to be responsible for maintenance only. The current situation where maintenance is part of the job of the operation staff does not always seem to be effective.

Finally, in the lower reaches of the outlet command there is the question of responsibilities for drainage. This is somewhat more problematic than for irrigation. Within the chak the problem basically is as discussed above. Downstream of the chak, the situation is not always clear. There may be different responsible institutions for smaller drains, larger drains, road crossings in the drains and their may be questions on the division between CADA and ID. In several States, there seems to be no adequate legislation with respect to drainage responsibilities.

Further analysis and investigations are required on the above mentioned subjects, to come to effective recommendations, particularly on maintenance at the level of the outlet command and of the drainage systems.

7. MAINTENANCE PLANNING AND EXECUTION

With respect to planning of maintenance there are basically three policy options:

* An effective monitoring system is installed to identify when and how the actual situation deviates too much from the desired one, and on the basis of that the required maintenance is determined and executed.
* On the basis of experiments or knowledge on the system a fixed plan of regular routine maintenance is developed and implemented, including fixed frequencies (periods), techniques, etc.
* A kind of mixture of the above options: (i) a fixed maintenance plan and schedule, together with (ii) an effective monitoring, the latter enabling more flexibility and prioritising as per availability of funds.

In the above, it is possible to come to a classification of the canals, within the system, each class with its own maintenance requirements. Also, the possible difference between "small" and "large" maintenance has to be taken into account. Small maintenance concerns the regular control of vegetation, to keep the flow resistance low and the flow profile open. Large maintenance concerns desilting and reshaping of the section.

The next question is who is to carry out the maintenance: the government itself with own equipment and personnel, or one or more contractors under the supervision of the government. Pros and cons of the various options have to be identified and analyzed.

Subsequently it has to be seen how the maintenance is to be carried out. Some papers in this publication will go into detail on a variety of techniques and equipment. For centuries the maintenance in The Netherlands was done manually. Labour was abundant and cheap. Increasing labour costs during the last 40 years led to the development of mechanical maintenance and later on chemicals were introduced as well, being cheap and effective, but also constituting serious treat to water quality and environment. Today mainly mechanical means are being applied, while there is an increasing attention for biological methods.

For India it is evident that manual maintenance methods will be dominating for the near future. The question of application of appropriate tools could still be addressed in this sense. Yet, the application of mechanical equipment may be required to be effective under specific circumstances. Criteria will have to be developed on when and where to use mechanical means.

Evidently, policy choices and financial criteria play an important role in the selection of the maintenance methods and equipment. Yet, this choice can also decisively be affected by the function of the canal or by more physical factors such as soil type, topography, etc. Consequently, different solutions may be found for different circumstances.Therefore, for the planning and execution as well, creation of some pilot projects under different conditions, could be useful to develop and test various methods of planning and execution and to provide more inside in various aspects involved.

8. MAINTENANCE CONTROL AND FINANCING

Before executing maintenance works the corresponding finances have to be

available, and after the work has been executed, it should be checked if it has been done according to requirements. Again in both respects, one has to distinguish between the main system and the outlet command.

For the latter a control system has yet to be developed. Its nature will depend on the institutional arrangements, according to the three options described earlier:

- Control can be left entirely with the farmers within the unit;
- Government can exercise the control entirely by itself;
- A control or survey committee (comparable with the Dutch "Schouw" Committee, described in some of the subsequent papers), composed of both government and farmers representatives.

In the latter two options, there have to be clear standards, through which the quality of the executed work can be assessed. Also, it requires an adequate system of legislation and sanctions, as well as financial arrangements.

In the first option, financing is the responsibility of the farmers, in the latter two options there are several possibilities. But in all cases it seems logic that farmers contribute to the maintenance costs, either as a separate fee, or as part of the total water fee. The water fee usually differs for different crops, whereas maintenance costs could be the same. Further work is required to formulate a number of clear options on financing and control, each with their implications and consequences in various respects.

For the main system the situation is less complicated. Responsibility for maintenance, including control of works, is entirely with the government (although there is a discussion of handing over part of the management, for instance on minors, to farmers associations). But here as well, there have to be clear methodologies to assess the quality of the maintenance. This applies particularly when maintenance is executed by contractors or farmers.

9. SUMMARY AND RECOMMENDATIONS

Reviewing the picture of the maintenance problem, the impression is that first the responsibilities and corresponding institutions should be clearly defined and decisions should be taken on a financing policy. In the Indian context the separation between main irrigation system, outlet command, and drainage complicates these issues. Crucial question will be to define the role of the farmers, or conversely the degree of government involvement, in financing as well as in responsibilities for execution and control of maintenance at outlet

command level and in downstream drainage.

Responsibilities for the main irrigation system are not so much a problem, although perhaps organizational aspects can be improved. Here, financing is a major bottleneck, in which it has to be decided to what extent the farmers have to contribute to main system maintenance.

Evidently, an adequate legislation should support arrangements on responsibilities and rights, financing and control.

With respect to the execution of the maintenance it has first to be decided who is to execute the work, followed by and related to the question of how to do it. For the latter question various methods and equipment are available. A number of general criteria can perhaps be developed, but for a real situation it can only be decided in situ how execution will be done, depending on the local conditions (not only physical, but also financial or social). Specific issues in the Indian context are the maintenance of lined canals and of drainage channels.

In all cases execution methods and frequency of maintenance are largely determined by the objectives and functions of the system. These are therefore to be clearly defined, taking into account possible objectives and functions other than directly related to water control.

For proper planning, execution and control of maintenance, a sound data base of the system should be available.

Considering the complexity of the subject and the absence of a long systematic maintenance tradition in India, one cannot expect all problems to be solved at short notice. One recommendation could therefore be to install a task force, for organizing and carrying out further (practical) maintenance research in India. This would have to cover all aspects: institutions, financing, technology and legislation. A second recommendation could be the creation of one or more pilot projects on maintenance. This would serve the above research and could answer questions of appropriate standards on frequencies, techniques and control under various conditions.