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DIAGNOSTIC ANALYSIS FOR THE REHABILITATION OF AN IRRIGATION SYSTEM IN THE STOLAC MUNICIPALITY (BOSNIA HERZEGOVINA)

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SUMMARY - Before the civil war in Bosnia Herzegovina (1992-'95), the municipality of Stolac was mainly devoted to agriculture with 70% of population living in rural areas. After the war, the irrigation systems of the municipality have been abandoned from the public bodies, causing problems of maintenance operations and, then, limit in the use of irrigation water. In addition to that, the migration of people to safer countries contributed to limit the development of agriculture and the renewal of the activities of the region. The solution to that problem may be found in the rehabilitation of the existing irrigation systems, in order to guarantee satisfactory efficiency levels in the water transport. The note presents the first results of the application of the diagnostic analysis procedure (an investigation process which aims at revealing problems, causes and effects related to the relevant actors involved in the system) to an existing irrigation system in Vidovo Polje, located at roughly 33 km from Mostar in Bosnia Herzegovina. Since the focal point of such a methodology is the user participation, information has been collected directly on the field, and the «problems» have been singled out, and classified according to cause-effect relations and structured into a problem tree. Both internal social conflicts and technical inefficiency of the conveyance network came out from the survey and allowed the identification of the critical aspects of the irrigation system of Vidovo Polje.

Key words: irrigation system, rehabilitation, diagnostic analysis, user participation, collaborative approach, performance, system analysis

RESUME *- Avant la guerre civile en Bosnie - Herzegovine (1992-'95), le territoire de Stolac était surtout consacré à l'agriculture avec 70% de la population placée en zone rurale. Après la guerre, les périmètres irrigués ont été abandonnés par le gouvernement, il n'y avait pas de maintenance et la pratique de l'irrigation s'est réduite. En plus, l'émigration de la population a limité le développement de l'agriculture et de toutes les activités dans la région. Une solution possible peut être la réhabilitation des périmètres existants à fin de garantir un transport efficace de l'eau. Ici on montre les premiers résultats qui viennent de l'application de l'analyse diagnostic (une procédure qui étudie les problèmes, causes et effets relevés par les acteurs principaux du système d'irrigation) au périmètre de Vidovo Polije, à presque 33 km de Mostar. Du moment que la particularité de cette méthodologie est la participation des utilisateurs, les informations ont été recueillies sur le terrain et les problèmes ont été organisés sur un arbre des problèmes. L'enquête a marqué comme problèmes principaux à la fois l'existence de conflits internes, et l'inefficacité du réseau hydrique du système de Vidovo Polije.*

Mots-clés: *système d'irrigation, réadaptation, analyse diagnostique, participation d'utilisateur, approche en collaboration, performance, analyse de système*

INTRODUCTION

Bosnia-Herzegovina (BiH), one of the six republics in former Yugoslavia, became, in 1992, an independent nation. Thereafter, a civil war started and finished in 1995, causing widespread destruction and losses of lives. In addition to the destruction caused to the physical infrastructure, there was considerable social disruption and decline in living standards for a large section of the population. In the post-war process of re-building the economic and social base of the country, the government has faced problems related with poor information on people occupation. In fact, agriculture has played an important role in BiH. Before the conflict, some forty percent of the population was full or part time employed in the agricultural sector. The war had a devastating effect on agriculture and food production and, at the end of the conflict, nearly eighty percent of the

population depended on imported food. Since then, several bilateral and multilateral assistance programs have provided for essential farm inputs. The necessity of rehabilitate the existing irrigation systems is seen nowadays as a priority, as suggested also by Biancalani (2006). A systematic analysis of the existing irrigation systems and the individuation of focal activities to improve their performances represent a prerequisite to any successful rehabilitation effort.

Diagnostic Analysis (DA) has been applied to segments of the main channel, the secondary and tertiary channels of the irrigation system in Vidovo Polje, considered representative of the network layout, focusing on the hydraulic and environmental aspects, such as channel silting, water losses, water intake, gates, slope stability, diversion, water quality, etc. The analysis carried out on the pilot segment of the channel may be transferred to the whole system based on the hypothesis of similarity.

The solution tree, derived from the problem tree obtained through to diagnostic analysis, will help to identify the priority activities for the improvement of the conveyance efficiency of the irrigation network. This represents the fundamental step for the development of a participated management system program able to renewal the agricultural activities of a municipality, still suffering for the war effects.

DIAGNOSTIC ANALYSIS METHODOLOGY

Through the term diagnosis of a system (or a situation) it is referred to the procedure for solving a problem by the identification of its causes and the quantification of its effects. Analysis is understood as the process of examining and summarizing the necessary information.

Diagnostic analysis is then defined by Podmore (1983) as a structured investigation examining an irrigation system to identify its values and constraints (Falciai, 1996). It is an approach whereby the identifications and analysis of existing problems lead to understand the underlying causes or contrasts. The problem exists when is perceived a gap or contrast between the “optimum situation” and “real situation”. The “causes” are a limitation to reach the “desired optimum situation”. Through the application of the diagnostic analysis, it is possible to identify the cause-effect relationships so the diagnosis of a situation or a system can be viewed as the process for solving a problem by identifying its cause or causes and qualifying and quantifying its effects.

The Colorado State University, in collaboration with the Pakistan government started in 1974 the On-Farm Water Management Research Project, dealing with the irrigation water management in Pakistan (Jones *et al.,* 1988). They developed and applied the so-called Development Model (Clyma *et al.,* 1977), made up by the three phases: diagnostic analysis (examining both the values and the constraints of an irrigation system), development and assessment of solutions (selecting and testing the potential improvements to the system in which constraints are removed and effectiveness improved is done), program implementation (choosing and developing an improvement program based on selected solutions).

In diagnostic analysis, “system-oriented” and “problem-oriented” approaches can be distinguished. The first one assumes that the best way to identify the problems and constraints of a system is through the analysis of the whole system; the latter one, starts from the assumption that it is possible to identify and define the problems of any system without having complete knowledge of it. Upon the identification of the problems - by system users as well as by the management staff - only data and information, which lead to the adequate definition of these problems, should be collected. The solutions to these problems should lead to the improvement of the overall situation. In the present work, the problem-oriented approach is used, according to a developed problem-solving method, the Objectives Oriented Project Planning (OOPP), created by the United States Agency for International Development (USAID) and further developed by the Deutsche Gesellschaft fur Zusammenarbeit in 1986. The underlying idea of the method is that objectives can only be formulated after the essential cause-effect relationships of the problem have been analyzed. Causes of a problem are visualized in the so-called problem tree, which arranges the identified problems according to their direct cause-effect relationships. By transforming the problem tree into an objective tree, causal mean-end relationships result and these can be considered as an indication of potential objectives to be pursued by the project (Bruscoli *et al.,* 2001).

From the Colorado State University “Development Model” to the Objectives Oriented Project Planning (OOPP) one, the implementation of models to apply the Diagnostic Analysis has taken up the user roles in the identification of the system contrast. After the first model applications, the conclusions evinced that the farm level and the main system level have not been studied in relation with each other, although in practice decisions on main system-level may have big implications for farm level decisions. The utility of the problem tree and objective tree could be enlarged using algebraic structures. The use of logical operators of Booleana algebra would allow the identification of priority activities in the solving process.

CASE STUDY: THE STOLAC IRRIGATION SYSTEM

Diagnostic analysis approach is applied to a portion of the Stolac Irrigation System, situated in Herzegovina-Neretva canton (Federation of Bosnia Herzegovina), near the town of Stolac, about 33 km from Mostar (Fig. 1).

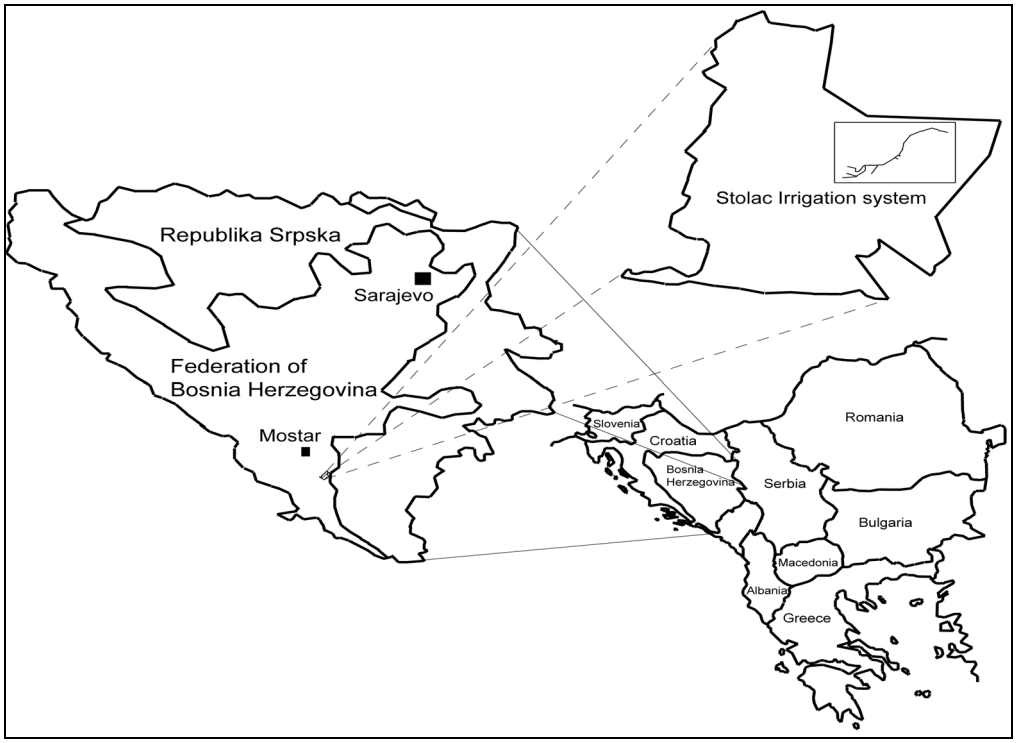

Fig. 1. The Stolac Irrigation System in Bosnia Herzegovina

Analyzing the geographical position of the zone and the history of the phases that have characterized the system life, it is possible to understand the potentiality and the actual deficiency of the irrigation system. The Stolac municipally borders are on Neum, Čapljina, Mostar and Ljubinje in the Federation of Bosnia Herzegovina (FBH), and on Nevesinje and Bileća in the Republika Srpska (RS). The geographical location between FBH (Bosianska and Bosnian Croats) and RS (Sebrs) and the contrasts among the different ethnic groups resulted in the principle driving forces for the war. The consequences of 4 years of war are evidenced by: social desegregation, organization incapacity and infrastructural deficiencies.

The Stolac Irrigation System was build from 1948 to 1953. The current configuration of the system is characterized by the presence of the main adduction channel which diverts water from the Bregava river, a tributary of Neretva river, and channels it into the secondary derivations along a course of 1800 m. The irrigation system channels the water to three zones and each one is inhabited from different ethnic groups: the first zone is the Stolac village (Bosnian Croats Chatolic), the second one is Vidovo Polje (Bosianska Muslim) and the third one is Espoch (Serbs Orthodox). During the war

(1992-‘95), the irrigation infrastructures have been partially destroyed and the actual contrasts, still present among those who have access to water, did not allow improving the unitary management of the irrigation system. From the finishing of the war, the users did not agree to re-qualify the destroyed channel and to operate maintenance activities on the irrigation system.

Diagnostic analysis approach is applied to the adduction and distribution sub-system, referring to the functioning and environmental effects of the gravity irrigation network in Vidovo Polje (Fig. 2). To increase the acceptance of the project planning and to ensure the inclusion of future needs and interests of the system users in the planning, OOPP approach has been applied to elaborate the problem tree of the physical sub-system through informal collaborations between project technical team and users organization delegates.

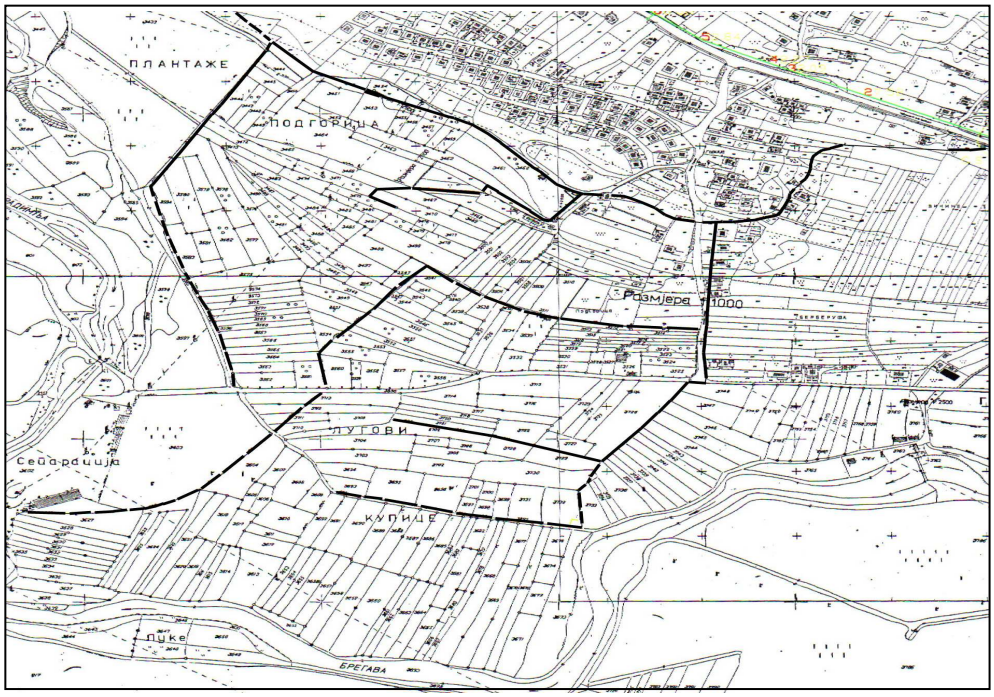

Fig. 2. Gravity irrigation network in Vidovo Polje

During meetings with delegates, after collecting information and data about the channels and the environmental implication of irrigation infrastructure deficiencies, identified problems are analyzed and structured. The core problem is identified in the irrigation water supply inefficiency, in terms of quantity and quality, not conform to demand, causing low agriculture income, field flooding and damages to the aquatic ecosystem. Subsequently, primary causes are structured although the inadequacy of management organization, if not solved, would compromise the future development of the irrigation system. The water irrigation supply inefficiency was mainly due to the inefficiency of adduction and distribution channels and to the lack of a control system of the induced impact on the nearby environment.

From the main problem tree two branches may be individuated (Fig. 3). The problem of the inefficiency of the main channel was due to side and bed discontinuity that causes the water leaking. The second cause was the un-functioning of distribution and derivation gates, causing not exact module diverting. On other hand, the inefficiency of the main channel was strictly related with sedimentation phenomena that produced a channel silting up to 20 cm. The causal chain was more complex. The first cause of canal silting was the input of solid material from slopes upon the channel; the second one was the use, made by the farmers, of the channel as a drainage system. Moreover, the poor maintenance activities had driven to store up a thick sands layer in the channel. The effects of the inefficiency of the main channel were obvious: about the 30% of water was leak along the channel, the water was not enough for all the farmers and the ratio between irrigated and irrigable area was very low (Fig. 4).

The problem affecting the secondary and tertiary channels were common in the zone. During the war, a lot of lower level channels have been destroyed. Then, the lack of management organization and the high costs for rehabilitation of destroyed parts and cleaning operation for the excessive silting compromised the development of the zone.

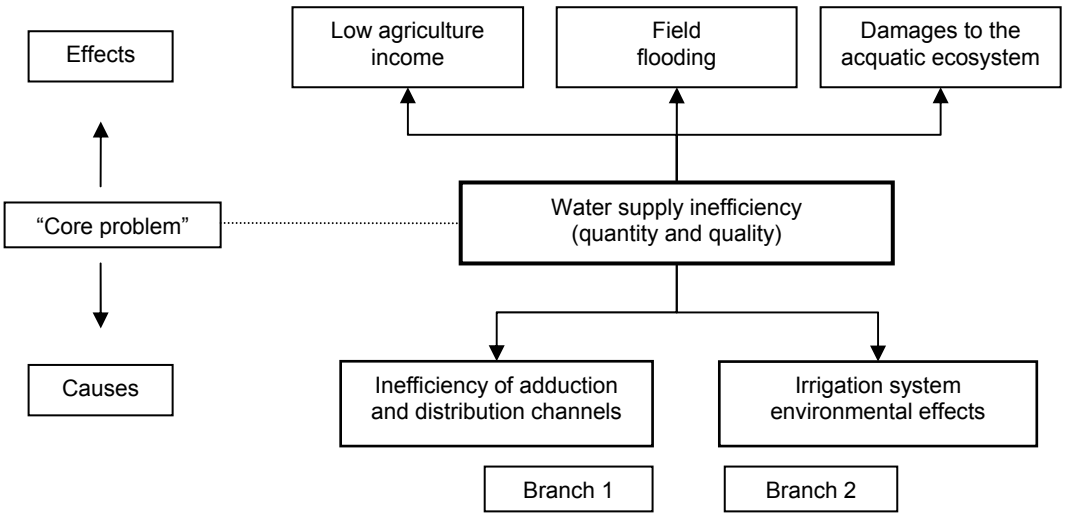

Fig. 3. Problem tree

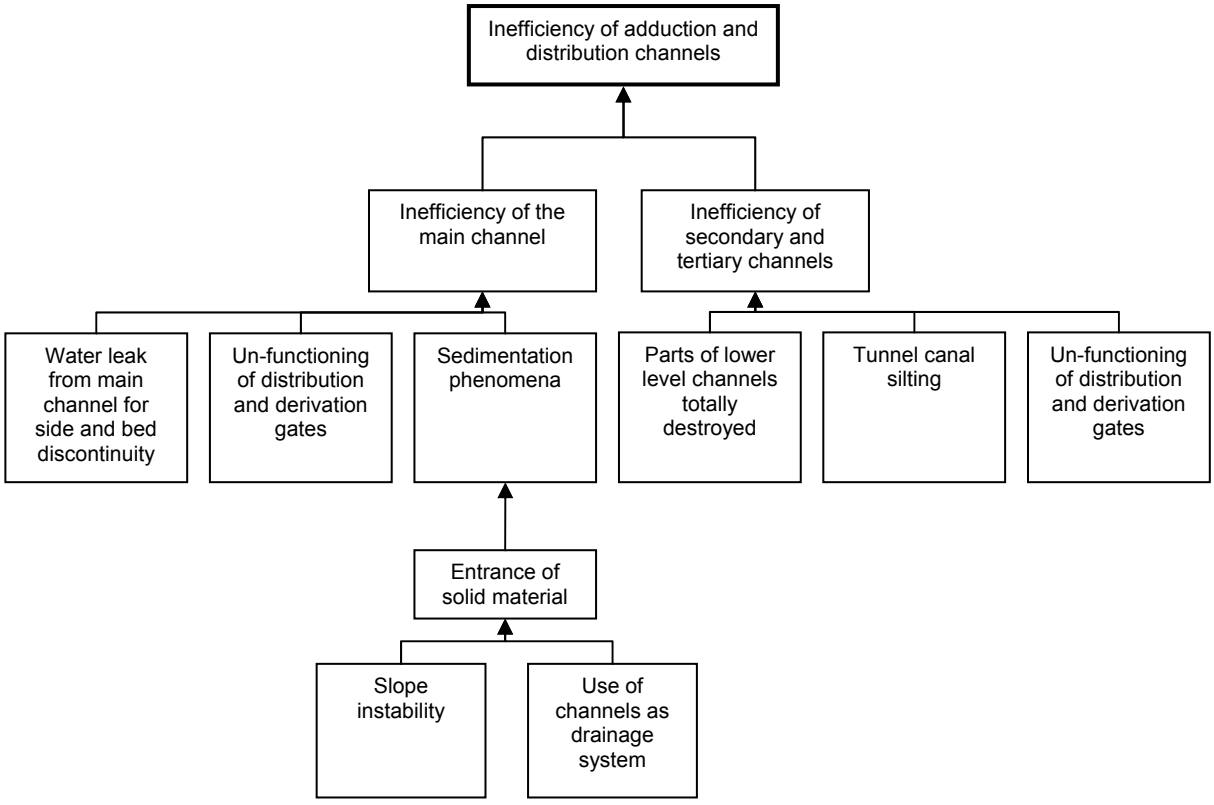

Fig. 4. Branch 1 of the problem tree

Today some farmers divert the water directly from the main channel that flow roughly 5 metres above the fields level, because the other channels are not utilizable.

The environmental effect of the irrigation system is mainly due to the un-control of water excess supply for lack of rehabilitation and maintenance of the drainage network. During the rainy season, when there are no practice cultivations, and during the irrigation season for the lack of distribution infrastructures, the surplus water floods into the fields, causing reduction of cultivable area. Moreover, the irrigation system impact is strictly related with the presence, along the network, of 7 aquaculture basins (*Salmo Trutta*). The waste water is discharged in the channels, increasing the concentration of organic matter and nutrient minerals. The unutilized water discharged in river and the nutrients leached into the soil compromise the aquatic ecosystem. The quality of waster water from the aquaculture basins should be controlled before discharging it (Fig. 5).

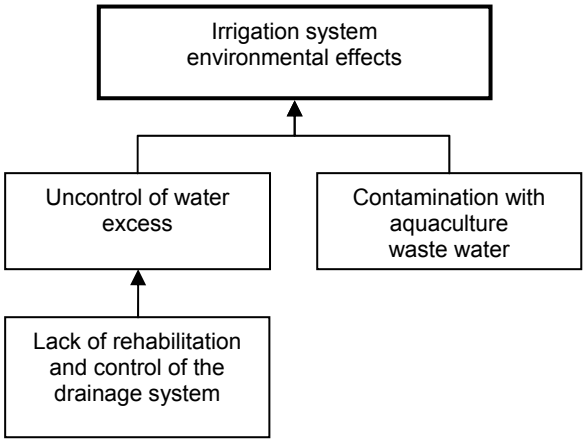

Fig. 5. Branch 2 of the problem tree

The problem tree is then transformed in objective tree where effects become goals and causes become means (Figs 6, 7 and 8). The result of the analysis allows identifying the specific goals, efficiency of adduction and distribution channels and control of the environmental effects of the irrigation system.

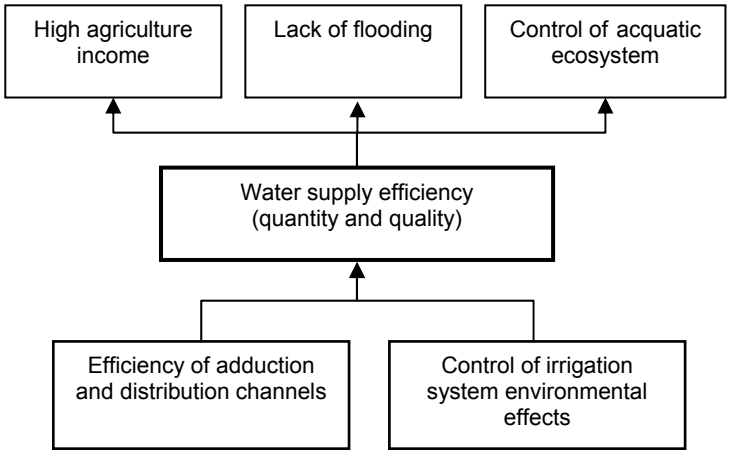

Fig. 6. Objective tree

The actual possibility of achieving these objectives is evaluated in the following phases identifying intervention strategies:

- Restore side and bed discontinuity in the main channel
- Re-construction of minor channels
- Restore the functioning distribution and derivation gates of main and minor channels
- Realization of settling basin before tunnel
- Cleaning of canal silting tunnel
- Rehabilitation of the drainage network
- Control of waste water discharged from aquaculture basins
- Bio-engineering interventions on slopes
- Reinforcement of user organization to guarantee an efficient maintenance program on irrigation infrastructures after being rehabilitated

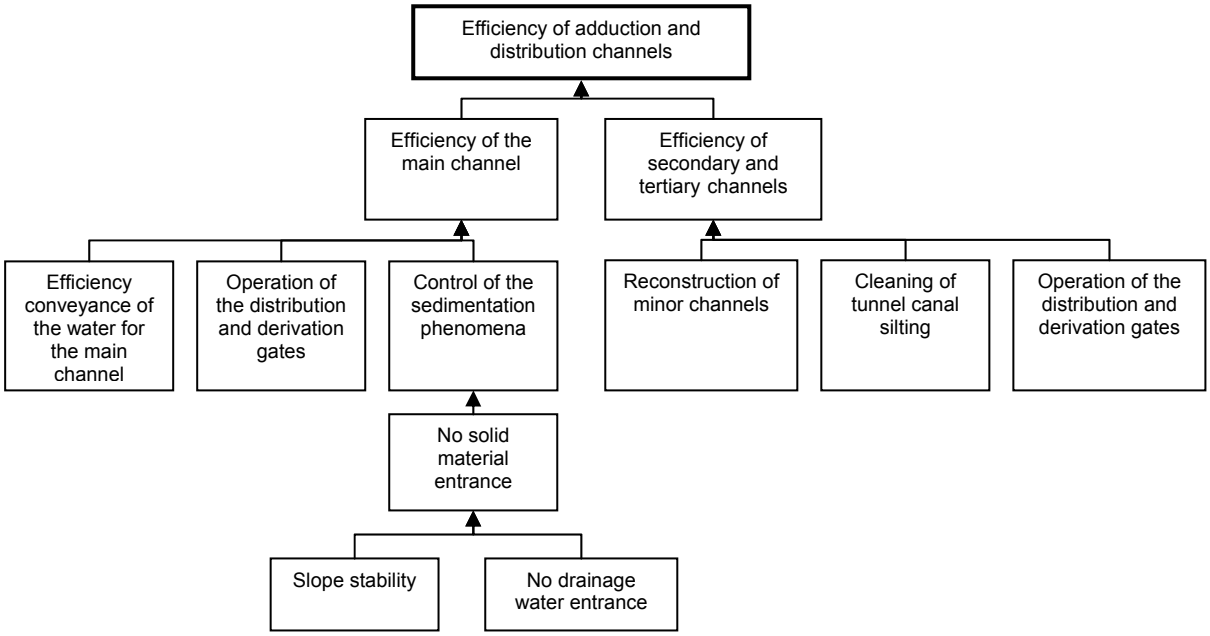

Fig. 7. Branch 1 of the objective tree

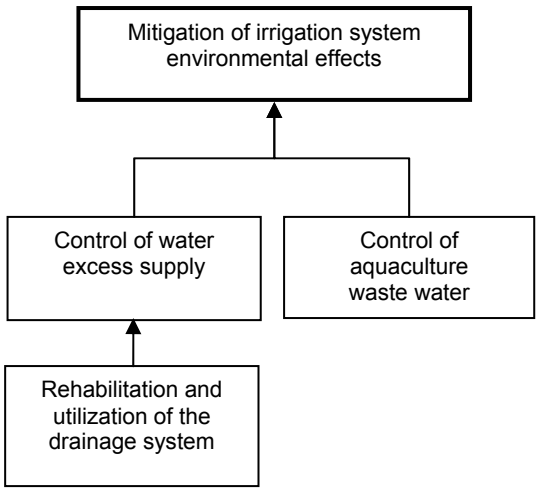

Fig. 8. Branch 2 of the objective tree

REINFORCEMENT OF USERS ORGANIZATION

The rehabilitation of irrigation infrastructures is clearly connected with the reinforcement of users organization to improve the efficient maintenance activities of the network. Before entering in specific questions related to technical aspects, it is necessary to define the general aims of organization and analyse the common typology of users organizations (Fig. 9).

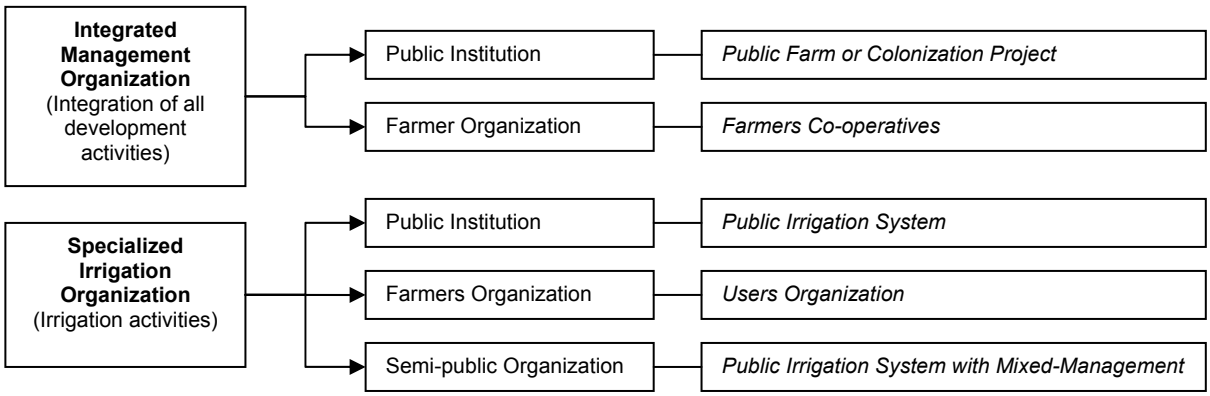

Fig. 9. Different typology of irrigation system management organization (Sagarardoy *et al.*, 1991, mod.)

According to the identification of the general objectives, the configuration of users organization should be adapted to the socio-economic structures (private or public) still present in the zone since the irrigation network represents, first of all, a "social infrastructure". So the balance among user groups and representatives of the decisional level is a priority for every rehabilitation programme.

To the reinforcement of users organization in Bosnia-Herzegovina, three steps can be outlined:

- Investing on the present user organizations and identifying an efficient structural organization for the maintenance of each irrigation district: for example, in the Vidovo Polje zone, it is still present a farmers cooperative, that should be involved in the management activity of minor channels; in the Stolac village, the administrative structures of public bodies, that manage the minor channels in the zone, are still present; in Espoch zone, given the lack of organization, it should be desirable the formation of an users organization able to manage the minor channels in the zone.
- Identification of the ethnic groups distribution within the irrigation area: in the Stolac irrigation system area there are the Stolac village (Bosnian Croats Chatolic), the Vidovo Polje (Bosianska Muslim) and the Espoch (Serbs Orthodox). This configuration will permit to improve the management of the three minor channels.
- Identification of an efficient structured organization for the maintenance of the main channel and the water intake: although it is difficult, starting from the definition of water resource like "public good", it is desirable that the management of the main channel should be under the competence of public bodies with the involvement of users.

Moreover, every organizational levels of irrigation system will be analyzed appraising the user water rights and the way to achieve them. However, the investigation above state and region laws, that regulate the statute and the modality to create and recognize a users organization or farmers co-operative, represents the starting point for the reinforcement of users organization.

CONCLUSIONS

The diagnostic analysis methodology applied to a segment of the irrigation system in Vidovo Polje, has allowed the identification of priorities for the rehabilitation of the system, considering the user as a major actor in the irrigation system. The recognition of the user role represents the further step to the success of the irrigation system. Among the proposed actions, structural interventions on the irrigation network and maintenance operations seem to be of a primary importance. As non structural

interventions, the reinforcement of users organization is required and its configuration should be adapted to the socio-economic structures, private or public, still present in the zone, since the irrigation network represents, first of all, a “social infrastructure”. The balance between user groups and representatives of the decisional level is a priority for the success of every rehabilitation programme.

A final aspect is represented by the prospect that the obtained results from the application of the diagnostic analysis methodology to the Vidovo Polje area could represent the starting point for its application in other irrigation systems in the Bosnia Herzegovina region, characterized by similar problems.

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