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Quantitative Evaluation of Watershed Management Operation via Double mass curve, Flow-duration curve and Moving average methods (Case study: Kushk-Abad sub basin of Iran)

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ABSTRACT

Today, the situation of terrestrial and water resources are crucial due to their over exploitations. It is about 40 years, due to inter-regional and extra-regional effects of destruction of these resources, the implementation of watershed management plans on the natural resources has come into force to control and combat against the threats on all these resources. Despite four decades of executive tasks, these resources are under destruction and all the measures seem to have little effectiveness, totally. Moreover, integrated and ceaseless measures to assess the scope and causes of the failures of initiatives have not been done. The study adopted the qualitative and quantitative methods to assess watershed management of the Kushak Abad basin and Kardeh watershed area of Iran, before and after of the implementation using archival study, direct observation, in-depth interview and questionnaire. In order to sum the results, the factors were divided into seven groups and each then scored by using minor factors. In the present paper, evaluation of watershed management measures has been studied in Kushk-Abad sub-watershed using quantitative methods viz. double mass curve, moving average, discharge-duration curve and hydrologic regime analysis. The results showed that two factors are considered as important factors in the performance plan: the status of the provided plan and lack of economic assessment. The final score is 56 for this project according to the above method which suggest the average performance of the plan.

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INTRODUCTION

These days, it is obvious for all the natural resource scientists that the terrestrial, aquatic and plant resources in Iran is in a critical situation. Several factors caused this situation which the most important ones are: Poor management of the operation, climatic, ecological and socio - economic status [11]. The out and in site impacts of demolish has made that the Politicians and professionals to formulate fundamental solutions for the issue. Soil conservation history in Iran dates back to 1961, meanwhile, there has been the many guidelines and diverse research in this field that the most important ones are: Soil conservation and watershed management plans that are mostly mechanical operations.

Studies show that national and provincial funds allocated to this project from 1968 to 2000. Detailed-executive plans pertaining to watershed and range management are estimated to be about 70 million hectares [9]. Unfortunately, despite four decades of research and administrative tasks and costs arising from implementation of this plan, still these resources are being destroyed and the plans and attempts seem less-effective. Besides, it seems that for the assessment and review of plans pertaining to preparation and execution, design and maintenance operations there has not been taken any coherent and continuous measure [1]. While the watershed plans assessments and their functions have a record of 70 years.

In general, these assessments have been done with different objectives and choice of assessment methods and indicators of watershed management objectives are the prospective goals for the project [12].Brooks

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[2]suggests three indicators of soil conservation, water production and its quality for the plans' assessments due to problems and managements such as lack of statistics, lack of mathematical relationships to estimate production in each region, the inability to quantify all actions and results. Hudson [6] according to the project goals and the time for assessment, states the main factors of project success as the clarity of the project goals and its implementation options for the local people, public participation in plan's preparation, use of resources and local capacity to track and monitor the project post-implementation. Valentine [14] for the assessment of biological practices, suggests the indicators of increase in the qualitative and quantitative indicators of forage, reduction of the poisonous plants and fire hazards threats and concludes that to reach this goal, the pasture improvement and development projects should be in compliance with the local operation system.

Unfortunately, there are not enough studies in Iran and the only comprehensive research of this type has been done by Program and Budget Organization (PBO) through study of detailed plans' reports and their compilation together with the socio economical issues, in which the main barriers on the way of defined goal achievements in the projects had been defined as four factors of lack of communications among different section of project studying, weakness of theoretical foundations, inconsistent application of procedures and negligence of socio economical issues. It's obvious that the criteria and indicators of these resources' degradation should be first assessed so that to prepare the proper guidelines. In order to reach the aim, one of the catchment areas below Kardeh dam, located at the North east of Iran, was selected and through the assessment methods pre-, during-, and post- phases of the project, the effective factors and quail-quantitative indicators on the failure or success of the project were analyzed. The assessment procedure has been done in a continuous way from the development to implementation stages of the plan [8].

MATERIALS AND METHODS

Scope of the Study:

The study area is one of the eight catchment areas behind Kardeh dam in Iran which enters the rivers of Kushak Abad and Kardeh influxes into the Kardeh dam area. It is located at the latitude 50^0 $27^{'}$ N to Longitude 50^0 $40^{'}$ W with an area of 85 Km^2, altitude of 2100 to 3560 m having a cold steppe vegetation and the average of annual precipitation of 400 mm. it consists of three types of land as mountain, hill, upper plateau and fan-shaped debris with totally 6 units of the land components.

The reason for the selection of this area is location on the Kardeh watershed basin and the importance of this dam in Khorasan Razavi Province regarding potable water supply for the local people, irrigation water supply for the local lands and for the industrial purpose, available studies Having a plan of studies, detailed–executive studies, passing at least 5 years of operations and integrated watershed management, and diversity and integration of the executive plan's options.

*Methodology***:**

Overview of the natural resource sector projects in Iran shows that these projects are implemented in three stages: Overview plan at 1:250000, detailed plan at 1:50000 and implementation plan at 1:25000 scale, in the area there are two types of identification (1:50000) and detailed - implementation studies (1:25000). It is worth to remark that mentioned study is a qualitative one and the data collected through direct observation, archival study, in-depth interview and questionnaire. Achieving desired information, researcher through continuous interviews with producers, executors and project take advantage of the presence in the region has achieved the required information and then used the experimental and graphical methods to manage and organize the gained data and [4,5]. The study steps are as follows:

Data Collection from Identification to Execution Phase:

In this section, all the information and studies obtained from the study site by relevant authorities and organizations of natural resources during two decades were collected and revised for the conformity with the time schedule, type and amount of practice and contents of the service summary parts.

Verification and validation:

Through field works and on site sampling, the precision and confidence levels were calculated. The report would be compared with the other organization's reports, if any. Indeed, the purpose of this step is not only as a complementary of the first step and revision of the quality (accuracy) but also as a probe to find any plagiarism and the reason of any difference.

Review report incorporating the options presented:

The amount of use of the basic reports and their applications in preparation of the integration plan will be defined and finally, through field works the feasibility of suggested option regarding technical and regional

issues as well as the available facilities at the executive organization along with the congruency of the plan with the study site will be investigated.

A complete list of proposed operations in the integration plan and its comparison with the list of operations obtained through field and region observations will be gained. The comparison is a three dimensional study: feasibility, technical properties and the volume of operations.

Study of stability and performance of the Mechanical structures and biological operations to achieve effective factors on the degradation and the post operation supervision's methods to identify the problems and bottlenecks.

Investigation and extraction of anticipated costs in the integration plans and its' comparison with the spent costs by using the costs of performed operations and optimal use of costs' list reported by management and planning organization.

Evaluation of project objectives:

As the main objective of the project is to lower the erosion level and to control the sedimentation process, the evaluation of the project objectives were done through using precipitation and sedimentation records, Double-mass curves [15],as well as amended PSIAC model in pre and post operation [3]. Study of economic effects of projects and ideas of local people through field visits and field measurements, interview with exploiters and the completion of questionnaires. Intended benefits at this study included: increase in dry-farmed products, in number of the seedlings in the site, and in people's productivity. The economic impacts of the sedimentation decrease are not regarded due to low alteration of the ratio of produced sediment's volume to the Kardeh dam's reservoir volume (lower than 10%), on the other hand, the destructive impacts of the project such as range land's removal, road construction and the Banket's constructions are not included due to lack of information.

Results:

Double mass curve results:

The use of a double-mass curve is a suitable way to check the consistency of a specific data record. A double-mass curve is a plot of one variable against the cumulative figures of another variable, or against the cumulative values of the same variable for a concurrent period.

Using this method, the cumulative amount of daily precipitation and daily runoff were analyzed for the study period before, during and after watershed operations. This technique determined the change of the point of time when the effects of WMPs are felt assuming consistent conditions for other watershed input parameters prevailed [15].

Interestingly, when the cumulative runoff data is plotted against the precipitation data as shown in Fig 1, the positive effect of watershed management measures were illustrated by a dramatic reduction in runoff with relatively higher rainfall. The fitted lines in Fig 1 were generated using regression for the before, during and after WMP.

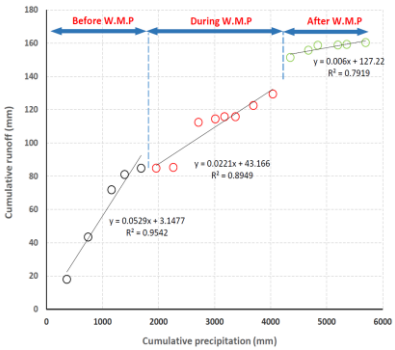

Fig. 1: Cumulative Precipitation-Runoff Plot for KAB for Study Period.

Statistically, from the regression analysis, the slope for "before", "during" and "after" WMP were 0.0529, 0.0221 and 0.006, respectively.

Flow-duration curve's results:

A flow-duration curve illustrates the relationship between percentage of time, or probability, that flow in a stream will equal or exceed a particular value. Statistically, the flow-duration curve is integral to the frequency of occurrence for stream flow of the study area. FDCs are usually prepared with daily discharge measurements over a specified period.

From the analysis of data, three flow-duration curves for "before", "during" and after WMP were plotted (Fig 4.4). The results as shown in Fig 4.4 suggested that changes to the river flow occurred in the three study phases. The change in three flow distribution suggest the influence of check-dams and vegetation control measures in the study watershed.

From the analysis, the flow-distribution for the "before" phase ranged from zero discharge to 0.675 m3/s. Subsequently, with watershed management measures being implemented, the flow range was between zero to 0.588 m3/s. Interestingly, with the completion of check dam construction in the basin, the average daily over flow of Kushk-Abad ranged between zero to 0.432m3/s which is dramatically lower than the preceding periods (Fig 2). This is largely attributed to the mitigation effects of the check-dams which stored excess basin runoff in the short term during rain-storms. Due to the large number of check-dams, 430 in all, they had effectively prevented the occurrence of higher flows in the Kushk-Abad stream network.

The flow duration analysis for the Kushk-Abad basin demonstrated the modification of the river flow regime, although precipitation during the study period shown a relatively consistent pattern as shown in the double-mass analysis. The lower average daily discharge of Kushk-Abad River is therefore largely attributed to the measures undertaken in the study basin. The effects were more pronounced in the "after" period when all measures were fully implemented.

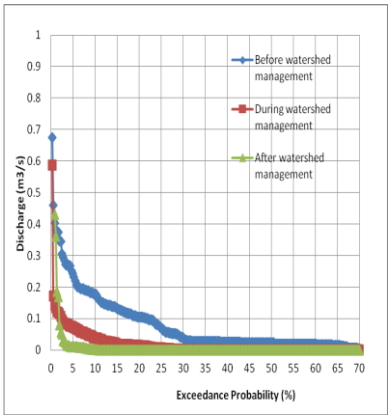

Fig. 2: Flow duration curve for the three study phases.

Discussion:

The points and investigations show that indicators of prepared plan' status have got the minimum points (compared with the total score intended for the study) and this reveals that principles of fundamental planning in the prepared plan have not been concerned causing lowered quality of their application at the next stages and impossible use of them in accurate programming and information composition [10].

The problem is rooted mainly from lack of conformity in the integration of basic studies as at each section a different working unit is applied. The solution can be using a geomorphologic method [1,13].

Regional interviews show that lack of local people, believe in anticipated and executed operations and their incompliance with the people demands are prohibitory factors on the public participation and success of executive [6,14].

Data of Table 1 demonstrates that the more accurate the basic report, the more usable it is at integration plan. Considering the rate of each report's application, one can understand that each one carries a high volume of data with no practical use (e.g. records of daily temperature change, air mass, climate climatogram, shape coefficients, gravilious, equal rectangles, etc.)

Other important issue in the project status is on and post operation monitoring and supervision [14]. Table 2 proves that due to the weakness in supervision, most of the operation phases remained unsustainable and they lack of enough efficiency.

Data of the Tables 3, 4 and 5 as well as the diagram 1 show a decline in the annual sedimentation (18.5%), which can be as a result of rainfall reduction at the late years or sedimentation weirs construction. Getting a better result, three separated actions were done, fist, a period of 4 years during last 30 years was selected with no significant difference with the above mentioned 4 years in terms of precipitation and then its annual sedimentation was compared to the 4 last years of the project. The comparisons listed in the Table 3 illustrate that there is a significant difference between the produced sediment of these two periods. Second, the data of the monthly sedimentation were compared. Table 4 states that the reduction rate of sedimentation during months of March, April and May are not significant; therefore, the constructed structures have not been able to reduce the sedimentation process significantly in those months with the highest rate of floods and weirs. Finally, by revising the data of Table 5, one can find that although 4 years is passed from the project implementation, the

erosion class based on the above model has met no change (the score is lowered from 79 to 75) which reveals that despite a significant decrease in sedimentation, the erosion rate is still stable, in other words the erosion is still in progress and only the structures have reduced the sediments through sedimentation.

Assessment of anticipated, spent and estimated budgets in the project shows weakness of financial management of the projects which are main factors of financial failures and public non-participation leading to a unsuccessful plan [6,15]. Regarding the biological operations, lack of choosing a proper method of grazing, no estimation for the authorized number of the cattle's at the site after project's implementation, lack of post-operation monitoring as well as absent overlaps between executed operations and the region's exploitation system has caused lack of sustainability and durability of the project as they will become effective less after some years of their execution [14].

An interview with planners and project's executers shows that the main reason of non-supervision after the operation is the lack of cooperation between executive (watershed management) and natural resources organizations (natural resources bureau). Considering the categories in Table 5, this project will stand at the class of weak function having 29 points which is mainly resulted by project's defined indicator that carries weakness and difficulties during the phases of project feasibility and compliance of the anticipated and executed operations.

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