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# Factors Affecting the Effectiveness of Runoff Harvesting Dams in Nepal

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## Abstract

The objectives of this study were to measure the level of effectiveness and analyze the factors affecting the effectiveness of runoff harvesting dam projects that have been implemented in *Dhanusha* district of Nepal as an activity of watershed management. 25% or 6 sampled runoff harvesting dams and a total of 71 sampled households representing the water user groups were taken in to this study. A questionnaire for household interview, check list questions for key informant interview and checklists for desk review and field observation were administered covering the variables of effectiveness indicators and factors. The data were analyzed by applying scoring and ranking, descriptive statistics and factor analysis method. It was found that 3 runoff harvesting dams were highly effective and 3 were moderately effective. Highly effective runoff harvesting dams show positive changes in all indicators; increased water availability for irrigation, household use and livestock; decreased soil erosion and disaster; improved moisture retention and microclimate; increased agriculture and forest production; increased household income and enhanced capacity of water user groups. Moderately effective runoff harvesting dams do not bring positive changes in water availability for irrigation; bank cutting and deposition; agriculture and forest production; and household income. The levels of effectiveness of runoff harvesting dams are significantly correlated with the factors upstream management and operation and maintenance at 0.01 levels. It is not significantly correlated with Location, soil type, siltation, participation, conflict of objectives and budget allocation. Thus, the levels of effectiveness of RHD projects are greatly influenced by upstream management and operation and maintenance factor. It is suggested that RHD projects should be implemented following principle of participatory integrated watershed management and development with multiyear plan (at least 3 years) to enhance the level of performance of upstream management and operation and maintenance factor so that level of effectiveness of RHD projects can be increased.

*Key Words:* Watershed management / Runoff harvesting dams / effectiveness / influencing factors / Nepal

## 1. Introduction

There is temporal and spatial variation in water distribution (Hudson, 1987) that makes the life in water deficit area very difficult (Millennium Ecosystem Assessment, 2005). Water shortage and flood disasters are occurring more widely and seriously worldwide. This water resource problem is further

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complicate under population increase, land cover change, and global climate change (UNEP 2002). It is expected that more than two billion people will live under high water stress by the year 2050 and water would be a limiting factor for socio-economic development in various regions (Sekar and Randhir, 2007). Thus, water management is essential for human survival and socio-economic development.

Ancient rain water harvesting had taken place in order to counteract the problem of water shortage (Hudson, 1987). Runoff harvesting is the indigenous knowledge of water management in many parts of the world including Nepal which has been advanced and promoted to combat the problem of too much water and too little water (Chapa, 2002; ICIMOD, 2007 and Department of Soil Conservation and Watershed Management, 2002). Runoff harvesting is an important alternative to large irrigation scheme and has been practiced for fulfilling the water requirements for irrigation, household consumption, livestock watering, preventing soil erosion and disasters, water recharge and moisture retention, increasing forest and agricultural production, biodiversity improvement and environmental conservation (ICIMOD, 2007; Department of Soil Conservation and Watershed Management, 2002).

There are two types of runoff harvesting system applied in Nepal since 1974 as an activity of watershed management. They are dugout type and dam type. The dugout type has mainly been implemented in hilly regions. The dam type has been practiced since 1995 in the *Terai*[1] and *Siwalik*[2] physiographic regions. Although some inefficiency has been reported, there has never been systematic study or research on any aspect of Runoff Harvesting Dams (RHDs) in Nepal (Department of Soil Conservation and Watershed Management, 2002).This study intends to identify the effectiveness level of implemented RHDs in *Dhanusha* District of Nepal and to analyze the contributing factors for their effectiveness. It is expected that better knowledge and understanding of RHDs enhance the implementation status and efficiency of RHD projects in Nepal.

## 2. Material and Methods

### *2.1 Study area and target population*

The study area is *Dhanusha* district of Nepal. This district was selected for this study as it lies in *Teari* and *Siwalik* physiographic region of Nepal where RHD projects were first introduced. *Dhanusha* district lies in central *Teari* which could better represent the districts of this region. A land form of semi plain and undulating land feature situated in between *Terai* and *Siwalik* hills called *Bhawar* where all 6 sampled RHD projects were located. 6(25%) sampled RHD projects were selected from total of 24 RHD projects based on age of the dams, distance from the settlements and area of the storage reservoir in first stage. 71(25%) households based on Bontum (1992), percentage system of sample size calculation were randomly selected for household interview from 282 households of 6 user groups of sampled RHDs in second stage. 4 DSCO officials and 6 VDC personnel were selected for key informant interview. Project books and annual reports of 6 sampled RHD projects were reviewed. Project sites of 6 sampled RHDs were observed during data collection.

[1] A southernmost physiographic region of Nepal situated with stretching from east to west and characterized by alluvial flat pain with high productive land and high population density.

[2] A small hill situated at the north of *Terai* flat plain characterized by rugged topography and erodible soil mantle.

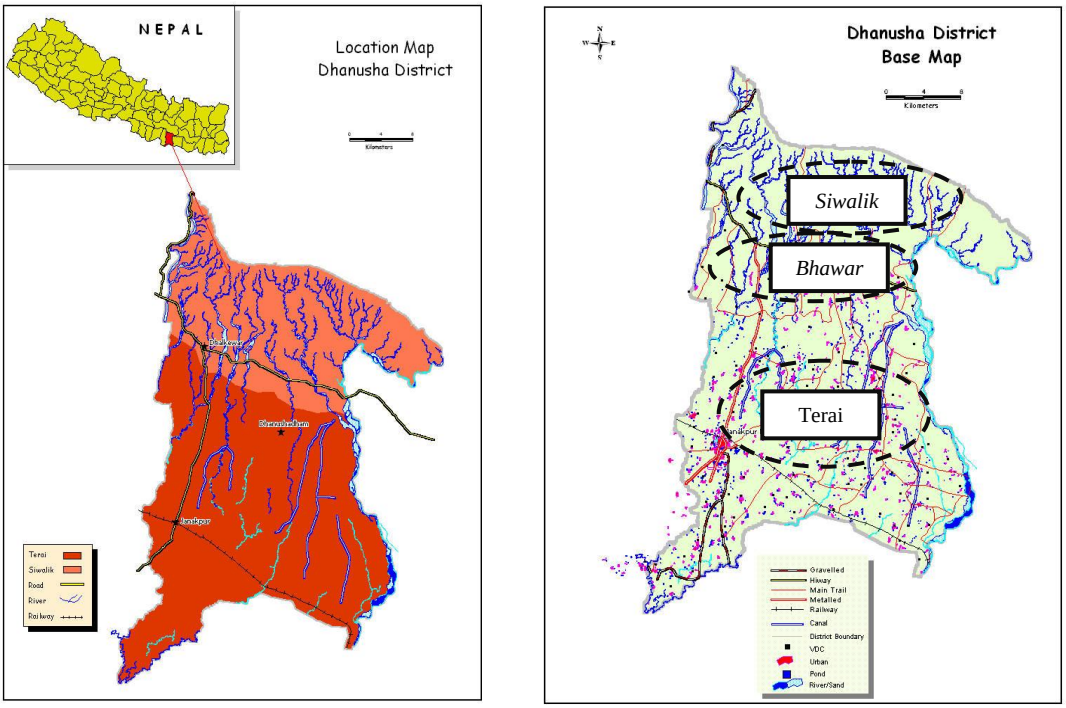


**Figure 1:** Map of *Dhanusha* district

Source: Ministry of Forests and Soil Conservation, Nepal (2005)

### *2.2 Data Collection*

Data were collected through household interview, key informant interview, desk review of project books and relevant documents, and site observation. Methodology and data collection tools were approved by the Institutional Review Board of Mahidol University, Thailand. Major data collected were (a) demographic and socio-economic data (b) data related to effectiveness of RHDs, and (c) data related to factors of influencing the effectiveness. Structured and semi-structured questionnaires were used for household interview, checklist questions for key informant interview, and checklists for site observation and desk review.

Level of effectiveness of RHD projects can be measured by availability of water for irrigation, household use and livestock watering; reduction of water induced disaster and soil erosion; enhancement of microclimate and production system through moisture retention and ground water recharge; increase in agriculture and forest production; increase in household income; and capacity building through knowledge and skills enhancement for water harvesting and user group functioning. Effectiveness of RHD projects can be influenced by various factors such as location and soil type of RHDs site; siltation in storage reservoir; upstream management and development; stakeholder participation for planning and implementation of RHD projects; conflicts during objective setting and its settlement; post project operation and maintenance and allocation of sufficient budget to complete all components of RHD projects. Thus, this study collected the data related to these 6 effectiveness indicators and 8 effectiveness factors of 6 sampled RHD projects.

### *2.3 Data Analysis*

The demographic and socio-economic status of user group households of 6 sampled runoff harvesting dam was analyzed by descriptive statistics. The effectiveness levels of sampled RHD projects were measured by scoring and ranking method. The factors of effectiveness of RHD projects were analyzed through Cross Tab matrix and statistical test, correlation. Microsoft excel version 2007 and Statistical Package for Social Survey (SPSS) version 15 were used for data analysis.

Each of 6 effectiveness indicators had 4 variables. Each variable was allocated 1 score. Thus, total score were 24. All variables were asked to respondents during household interview. All variables were analyzed and score was given based on positive change/increase in value of variable comparing before and after implementation of RHD projects. The score obtained by all variables were sum up and divided by total number of respondents. This provides cumulative average score.

Effectiveness levels of sampled RHDs were identified based on their obtained cumulative average score.Hence, the level of effectiveness was identified as high if cumulative average score were ≥17.0 to ≤ 24.0; as moderate if cumulative average score were ≥9.0 to ≤ 16.0 and as low if cumulative average scores were ≥1.0 to ≤ 8.0.

Each of 8 factors of effectiveness of RHDs had 2 variables which were divided in to high, moderate, and low level of influence on its respective factor. The frequencies of high, moderate, and low level of influence of 2 variables of each factor were used for Cross-Tab Matrix (3×3) to identify the level of cumulative influence of effectiveness factor. They were high, moderate and low level of influence of effectiveness factor. Based on the assumption of the levels of effectiveness of RHD projects depend on different factors, 1 dependent variable (i.e. effectiveness level) and 8 independent variables (i.e. 8 effectiveness factors) of 6 RHD projects are shown in the following Table 1.

**Table 1:** Dependent and independent variables and their units of measurement

| **Variables** | **Observations / Number of RHDs** | **Scales of measurement** | **Units of measurement** |
|---|---|---|---|
| **Dependent variable:** | | | |
| 1.Levels of effectiveness of RHDs | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| **Independent variables:** | | | |
| 1.Location | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| 2.Soil type | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| 3.Siltation | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| 4.Upstream management | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| 5.Participation | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| 6.Conflict of objectives | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| 7.Operation and maintenance | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |
| 8.Budget allocation | 6 | Ordinal | High, Moderate and Low (Level 1 to 3) |

Since both the dependent and independent variables were ordinal scale, the level of effectiveness and factors were converted unit (i.e. rank order) from basic data of measured variables of effectiveness indicators and factors, through scoring and ranking and Cross Tab Matrix, non-parametric Spearman's correlation test were applied in order to find the correlation between levels of effectiveness and factors of effectiveness of RHD projects.

## 3. Results and Discussions

### *3.1 Demographic and socio-economic status of user group households*

The demographic and socio-economic status of user group (UG) is shown in Table 2. Average household size was 6 which was more than national average (i.e. 5 in rural areas and 4 in urban). 54.4% populations of *Haripu*r UG, 52.4% of *Dhanauji*, 47.8% of *Sabedanda* and 45.3% of *Chireshwor* UG

**Table 2:** Demographic and socio-economic status of user group households

| **Variables** | ***Dhanauji* RHD** | ***Sabedanda* RHD** | ***Aurahi* RHD** | ***Madhubasha* RHD** | ***Chireshwor* RHD** | ***Haripur* RHD** |
|---|---|---|---|---|---|---|
| **Household size(Number)** | 6 | 7 | 6 | 6 | 5 | 6 |
| **Age group (years)** | | | | | | |
| Less than 21 | 52.4% | 47.8% | 37.9% | 37.1% | 45.3% | 54.4% |
| 21 to 40 | 36.1% | 31.9% | 44.8% | 39.2% | 32.1% | 26.7% |
| 41 to 60 | 8.2% | 20.3% | 17.3% | 21.6% | 20.7% | 18.9% |
| More than 60 | 3.3% | 0% | 0% | 2.1% | 1.9% | 0% |
| **Occupation (Number of people)** | | | | | | |
| Agriculture | 36.1% | 49.3% | 44.8% | 45.4% | 26.4% | 27.8% |
| Non-agriculture | 11.4% | 7.3% | 25.9% | 24.7% | 39.6% | 42.2% |
| School education | 47.5% | 33.4% | 24.2% | 20.6% | 26.4% | 22.2% |
| **Education (Number of people)** | | | | | | |
| Illiterate | 4.9% | 10.2% | 15.5% | 18.6% | 9.5% | 7.8% |
| Primary | 31.2% | 21.7% | 25.9% | 29.9% | 52.8% | 42.2% |
| Secondary | 63.9% | 68.1% | 58.6% | 51.5% | 37.7% | 50.0% |
| University | 0% | 0% | 0% | 0% | 0% | 0% |
| **Land holding size( ha/hh)** | | | | | | |
| Total | 0.57 | 0.53 | 0.39 | 0.55 | 0.32 | 0.35 |
| Irrigated | 0.21 | 0.18 | 0.15 | 0.20 | 0.04 | 0.07 |
| Non irrigated | 0.36 | 0.34 | 0.24 | 0.35 | 0.28 | 0.29 |
| **Livestock ( number/hh)** | | | | | | |
| Cow/buffalo/goat | 7 | 8 | 8 | 7 | 6 | 8 |
| Bird | 22 | 28 | 49 | 26 | 41 | 28 |
| **Agricultural production (quintal/hh/year)** | | | | | | |
| Production | 28.70 | 20.50 | 20.70 | 24.63 | 10.40 | 10.87 |
| Consumption | 21.80 | 21.90 | 21.75 | 22.00 | 19.30 | 21.87 |
| **Forest production** | | | | | | |
| **Timber (cu. ft./hh/year)** | | | | | | |
| Collection | 11.20 | 10.50 | 9.80 | 8.81 | 7.50 | 7.60 |
| Consumption | 11.20 | 10.50 | 9.80 | 8.81 | 7.50 | 7.60 |
| **NTFPs(quintal/hh/year)** | | | | | | |
| Collection | 6.30 | 3.60 | 6.70 | 6.75 | 4.70 | 3.00 |
| Consumption | 2.70 | 2.55 | 2.30 | 2.47 | 4.30 | 2.77 |

were less than 21 years age, respectively. *Dhanauji* and *Haripur* had more population than national average (51.1%) in age less than 21 years. 44.8% populations of *Aurahi* UG and 39.2% of *Madhubasha* were 21 to 40 years. All RHD UG had more population than national average (26.6) in age between 21 to 40 year. It indicates that majority of the population were middle age (21 to 40 years).

49.3%, 45.4%, 44.8% population had agriculture occupation in *Sabedanda*, *Madhubasha* and *Aurahi* UG, respectively. 42.2% and 39.6% population of *Haripur* and *Chireshwor* UG had non-agriculture occupation, respectively. 47.5% population of *Dhanauji* UG had involved in school education. Nepal is an agricultural based country; more than 76 % population involve in agriculture business which includes agriculture as both major and minor job. The population of non-agriculture occupation also had agriculture as minor job. Therefore, population of all RHD projects was in line with national figure of occupation. Majority of the population (i.e. 68.1%, 63.9%, 58.6%, 51.5% and 50.0%) of *Sabedanda*, *Dhanauji*, *Aurahi*, *Madhubasha* and *Haripur* UG had secondary level education. 52.8% population of *Chireshwor* UG had primary level education. UG population in all RHD had mostly primary level education which was not good for their socio-economic development.

The average land holding size was ranging from 0.32 to 0.57 ha/hh which were less than national average (0.8ha/hh). Majority of the land were non-irrigated. The average number of cow, buffalo and goat were 7 and birds were ranging from 22 to 49. Average agricultural production was ranging from 10.40 to 28.7 quintal/hh/year where as consumption was 19.30 to 22.0 quintal/year. *Sabedana*, *Aurahi*, *Chireshwor* and *Haripur* UG consumed more cereals than production. The deficit was heavier for cereals than fruits and vegetables. Only *Dhanauji* and *Madhubasha* UG had less consumption than production of agriculture products. Timber production, collection and consumption were equal amount for all UG ranging from 7.50 to 11.20 cu.ft./hh/year. UG used timber up to the required quantity and it was not trading. The production and collection of NTFPs were ranging from 3.0 to 6.75 quintal/hh/year where as consumption was 2.30 to 4.30 quintal/year. There were some surpluses of NTFPs in all UG.

RHD user groups were survived with subsistence agriculture integrated to livestock and forest. It was characterized by high population growth, low education level, low income, small land holding size with rainfed agriculture and low production. Food production was less than required quantity. However, NTFPs supported them for some income. Some members in every family engaged in labor work to support their livelihood.

### *3.2 Level of effectiveness of runoff harvesting dams*

Table 3 shows the effectiveness level of 6 sampled RHD projects. Score in the bracket shows the full score/total score or number of respondents responded on that particular variables. Score without brackets shows the calculated score. Based on the analysis of 24 variables of 6 effectiveness indicators, it is found that the effectiveness level of *Dhanauji*, *Aurahi* and *Madhubasha* RHD projects were high. The effectiveness level of *Sabadanda*, *Chireshwor* and *Haripur* RHD projects were moderate. No RHD project was under low effectiveness level.

*Dhanauji* secured 21.0, *Aurahi* secured 20.4 and *Madhubasha* secured 19.7 score in full score of 24.0. *Sabedanda* secured 13.9, *Chireshwor* secured 10.8 and *Haripur* secured 10.67

score. *Dhanauji*, *Aurahi* and *Madhubasha* obtained somehow uniform score in all effectiveness indicators so had high level of effectiveness. Similarly, *Sabedanda*, *Chireshwor* and *Haripur* obtained somehow uniform score in all effectiveness indicators; so had moderate level of effectiveness; but *Sabedanda* had little higher score compared to *Chireshwor* and *Haripur*.

Those RHD projects which were highly effective, *Dhanauji*, *Aurahi* and *Madhubasha*, got positive changes and improved condition of bio-physical and socio-economic after implementation of RHD projects. Before implementation of RHD projects, these areas had lack of water, so lived with water deficit condition; the forest of the upper catchment was degraded; the gully bank cutting and deposition of sediment was rampant; the area looked very dry; agriculture and forest production was quite low; household income of the people was also low; people had no habit to work in groups; they had no knowledge about runoff harvesting dam and importance of watershed management and community development.

After implementation of RHD projects, the area got increased availability of water for irrigation, household use and livestock watering; decreased water induced disaster and soil erosion, except some respondents did not find decrease in bank cutting and deposition; increased moisture retention, microclimate improvement but had no improvement in water level in the wells; increased in agriculture and forest production due to moisture conservation, soil conservation and water for irrigation, but some respondents reported that the rate of increase was not higher; increased household income due to increase in agriculture and forest production specially NTFPs and saving credit scheme but the rate of increase in income was not in higher rate; and enhanced capacity for operation and maintenance of RHD project, group mobilization and saving credit due to various trainings and workshops launched as part of RHD projects. In overall, most of the effectiveness indicators had positive change. The results of this study are consistent with the research done by Sharma and Smakhtin, 2001; Sreedevi et al., 2006; Barry et al. 2008 and Khepar 2001.

Those RHD projects which were moderately effective, *Sabedanda*, *Chireshwor* and *Haripur*, brought positive changes in all effectiveness indicators except water availability for irrigation; disaster and soil erosion through bank cutting and deposition; agriculture and forest production and household income. The areas got water for household use and livestock watering but not for irrigation that did not bring increase in agriculture and forest production thereby in household income. Most of the respondents reported that soil erosion by bank cutting and disaster by deposition was not decreased as expected, though number of event of bank cutting and deposition per year decreased. Like in highly effectiveness runoff harvesting dams, water recharge and moisture retention and enhancement of capacity of user groups for water management and user group functioning increased.

**Table 3:** Scoring of variables of effectiveness indicators and level of effectiveness of sampled runoff harvesting dams

| **Indicators** | **Variables** | ***Dhanauji* RHD** | ***Sabedanda* RHD** | ***Aurahi* RHD** | ***Madhubasha* RHD** | ***Chireshwor* RHD** | ***Haripur* RHD** |
|---|---|---|---|---|---|---|---|
| Water yield | Average trend of availability of water | 10(10) | 10(10) | 10(10) | 16(16) | 10(10) | 15(15) |
| | Water for irrigation (before and after RHD) | 10(10) | 2(10) | 10(10) | 15(16) | 0(10) | 0(15) |
| | Water for hh use (before and after RHD) | 10(10) | 10(10) | 10(10) | 16(16) | 10(10) | 14(15) |
| | Water for livestock (before and after RHD) | 10(10) | 10(10) | 10(10) | 16(16) | 10(10) | 15(15) |
| Water induced disaster and soil erosion | Decreased | 10(10) | 10(10) | 10(10) | 16(16) | 10(10) | 15(15) |
| | Trend of disaster and soil erosion | 10(10) | 10(10) | 10(10) | 16(16) | 8(10) | 0(15) |
| | Bank cutting ( before and after RHD) | 6(10) | 2(10) | 4(10) | 10(16) | 1(10) | 1(15) |
| | Sediment deposition( Before and after RHD) | 6(10) | 7(10) | 8(10) | 8(16) | 1(10) | 12(15) |
| Water recharge and moisture retention | Increased | 10(10) | 10(10) | 10(10) | 16(16) | 10(10) | 15(15) |
| | Trend | 10(10) | 10(10) | 10(10) | 16(16) | 8(10) | 10(15) |
| | Microclimate improvement | 10(10) | 10(10) | 10(10) | 16(16) | 2(10) | 15(15) |
| | Water availability in well increased | 0(10) | 0(10) | 0(10) | 0(16) | 0(10) | 0(15) |
| Agriculture and forest production | Increased | 10(10) | 2(10) | 10(10) | 16(16) | 0(10) | 0(15) |
| | Average trend of increase in production | 5(10) | 0(10) | 5(10) | 8(16) | 0(10) | 0(15) |
| | Agriculture production (before and after RHD) | 10(10) | 2(10) | 10(10) | 15(16) | 0(10) | 0(15) |
| | NTFP production (before & after RHD) | 10(10) | 0(10) | 10(10) | 13(16) | 0(10) | 0(15) |
| House hold income | Increased | 10(10) | 2(10) | 10(10) | 16(16) | 0(10) | 0(15) |
| | Trend | 3(10) | 0(10) | 4(10) | 1(16) | 0(10) | 0(15) |
| | From agricultural production | 10(10) | 2(10) | 10(10) | 15(16) | 0(10) | 0(15) |
| | From forest production | 10(10) | 0(10) | 10(10) | 14(16) | 0(10) | 0(15) |
| User capacity building | Enhanced capacity | 10(10) | 10(10) | 10(10) | 16(16) | 10(10) | 15(15) |
| | Skill in operation of RHD | 10(10) | 10(10) | 8(10) | 13(16) | 9(10) | 11(15) |
| | Skill in maintenance of RHD | 10(10) | 10(10) | 5(10) | 11(16) | 9(10) | 9(15) |
| | Participation in saving credit scheme | 10(10) | 10(10) | 10(10) | 16(16) | 10(10) | 13(15) |
| | Total score | 210(240) | 139(240) | 204(240) | 315(384) | 108(240) | 160(360) |
| | Total respondents | 10 | 10 | 10 | 16 | 10 | 15 |
| | Cumulative average score | 210/10=21.0 | 139/10=13.9 | 204/10=20.4 | 315/16=19.7 | 108/10=10.8 | 160/15=10.67 |
| | **Level of Effectiveness level of RHDs** | **High** | **Moderate** | **High** | **High** | **Moderate** | **Moderate** |

### *3.3 Analysis of factor affecting the effectiveness of runoff harvesting dams*

Each factor has two variables which were evaluated as high, moderate and low level of influence on respective factor. The frequency of high, moderate and low level of influence of 2 variables of each factor were analyzed through Cross Tab matrix to find out the cumulative influence of related factor on effectiveness of runoff harvesting dam. Level of influence of each effectiveness factor was divided in to High, Moderate and Low. Level of influence means degree of supportive role a factor play to achieve a certain level of effectiveness of RHD project. Thus, level of influence of 8 effectiveness factors on 6 sampled RHD projects are shown in Table 4.

The level of influence of all, 8, factors on effectiveness of *Dhanauji* RHD project were high that supported this RHD project as highly effective. 4 factors (i.e. soil type, siltation, participation and conflict of objectives) had high, 3 (i.e. location, operation and maintenance) had moderate and 1(i.e. upstream management) had low level of influence on effectiveness of *Sabedanda* RHD project that supported this RHD project as moderately effective.6 factors (i.e. soil type, siltation, participation, conflict of objective, operation and maintenance and budget allocation) had high and 2 factors (i.e. location and upstream management) had moderate level of influence on effectiveness of *Aurahi* RHD project that supported this RHD project as highly effective. 5 factors (i.e. siltation, upstream management, participation, conflict of objectives and operation and maintenance) had high and 3 factors (i.e. location, soil type and budget allocation) had moderate level of influence on effectiveness of *Madhubasha* RHD project that supported this RHD project as highly effective.

**Table 4:** Summary of level of influence of effectiveness factors on effectiveness of sampled RHD projects

| Name of effectiveness factors | Level of influence of effectiveness factor on effectiveness of RHD projects | | | | | |
|---|---|---|---|---|---|---|
| | ***Dhanauji*** | ***Sabedanda*** | ***Aurahi*** | ***Madhubasha*** | ***Chireshwor*** | ***Haripur*** |
| 1.Location | High | Moderate | Moderate | Moderate | High | High |
| 2.Soil type | High | High | High | Moderate | Low | High |
| 3.Siltation | High | High | High | High | Moderate | Low |
| 4.Upstream management | High | Low | Moderate | High | Low | Low |
| 5.Participation | High | High | High | High | High | High |
| 6.Conflict of objectives | High | High | High | High | High | High |
| 7.Operation and maintenance | High | Moderate | High | High | Moderate | Moderate |
| 8.Budget allocation | High | Moderate | High | Moderate | High | High |

4 factors (i.e. location, participation, conflict of objective and budget allocation) had high, 2 factors (i.e. siltation and operation and maintenance) had moderate and 2 factors (i.e. soil type and upstream management) had low level of influence on effectiveness of *Chireshwor* RHD project that supported this RHD project as moderately effective.
5 factors (i.e. location, soil type, participation, conflict of objectives and budget allocation) had high 1 factor (i.e. operation and maintenance) had moderate and 2 factors (i.e. siltation and upstream management) had low level of influence on effectiveness of *Haripur* RHD project that supported this RHD project as moderately effective.

From above Table 3 and Table 4, the frequencies of the 1 dependent variable i.e. level of effectiveness and 8 independent variables i.e. effectiveness factors of sampled RHD are summarized in the following Table 5.

**Table 5:** Summary of frequencies of dependent and independent variables of sampled RHD projects

| Variables | Observations | | | |
|---|---|---|---|---|
| | Number of RHDs | High(1) | Moderate(2) | Low (3) |
| **Dependent variable** | | | | |
| 1.Level of Effectiveness of RHDs | 6 | 3 | 3 | 0 |
| **Independent variables** | | | | |
| 1.Location | 6 | 3 | 3 | 0 |
| 2.Soil type | 6 | 4 | 2 | 0 |
| 3.Siltation | 6 | 4 | 1 | 1 |
| 4.Upstream management | 6 | 2 | 1 | 3 |
| 5.Participation | 6 | 6 | 0 | 0 |
| 6.Conflict of objectives | 6 | 6 | 0 | 0 |
| 7.Operation and maintenance | 6 | 3 | 3 | 0 |
| 8.Budget allocation | 6 | 4 | 2 | 0 |

The above dependent and independent variables were fed in to SPSS 15 version for non-parametric statistical test of Spearman's correlation. The test shows that the level of effectiveness of sampled RHD projects were significant with the factors upstream management and operation and maintenance at the 0.01 level where as it was insignificant with the factors location, soil type, siltation, participation of stakeholder, conflict of objective and budget allocation. Thus, the level of effectiveness of RHD projects is greatly influenced by upstream management and operation and maintenance factor.

## 4. Conclusion

The user group households involved in the management of RHD projects is characterized by high household size, low education, low income, subsistence agriculture with small land holding size rainfed and low productivity. Except *Dhanauji* and *Madhubasha*, all have lack of food sufficiency and have to depend on non-agriculture businesses such as labor work for their livelihood.

The *Dhanauji*, *Aurahi* and *Madhubasha* RHD projects are highly effective as they have increased water availability for irrigation, household use and livestock watering; decreased soil erosion and disaster; improved moisture retention and microclimate improvement;

increased agricultural production and household income and enhanced UG capacity for runoff harvesting dam management and UG functioning. The *Sabedanda*, *Chireshwor* and *Haripur* RHD project are moderately effective as they have increased in water availability for household use and livestock, improved microclimate and moisture retention and enhanced capacity of user groups for RHD project management and user group functioning. In contrast, they have not increased water availability for irrigation. They have not increased in agriculture and forest production and in household income. There is still soil erosion by bank cutting and disaster by deposition, though number of event of bank cutting and deposition per year is decreased.

The levels of effectiveness of RHD projects are significant with the factors upstream management and operation and maintenance. They are insignificant with the factors location, soil type, siltation, and participation of stakeholder, conflict of objective and budget allocation. Thus, the levels of effectiveness of RHD projects are greatly influenced by upstream management and operation and maintenance factor. Therefore, RHD project should be implemented within the frame work of participatory integrated watershed management and development and suggested that it can be done by preparing multiyear plan, at least 3 years, and ensure its implementation.

## 5. Acknowledgements

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