



UNIVERSITI PUTRA MALAYSIA

***TECHNICAL AND SOCIAL EVALUATION OF WATERSHED
MANAGEMENT
IN KUSHK- ABAD WATERSHED BASIN, IRAN***

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By

BAHRAM MOHAMMADI GOLRANG

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
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November 2014

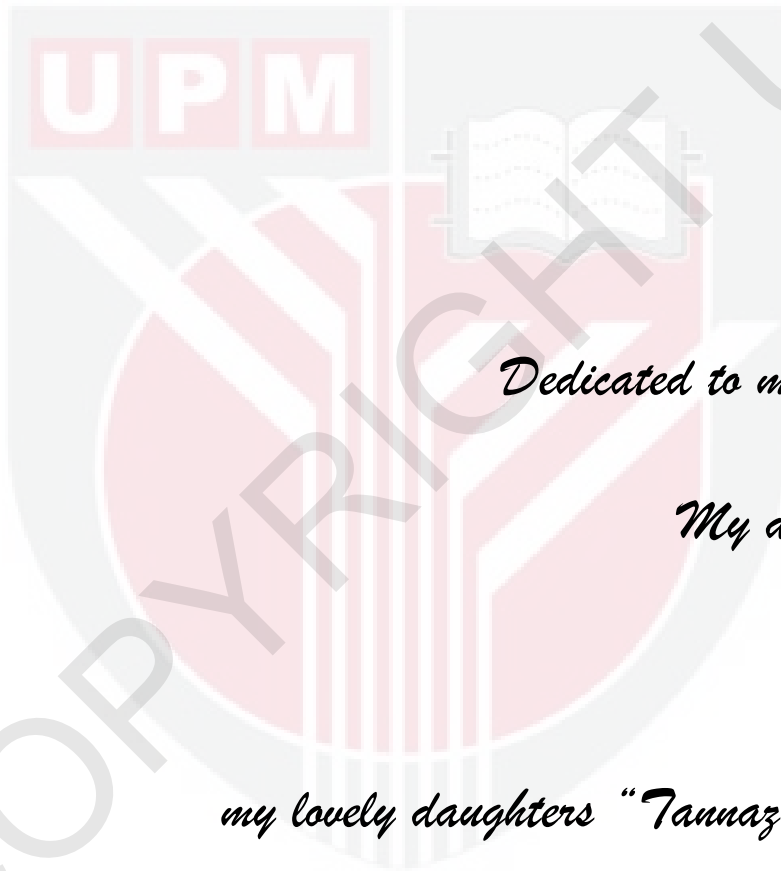
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DEDICATION



Dedicated to my kind wife

My dear parents

and

my lovely daughters "Tannaz & Delnaz"

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment
of the requirements of the degree of Doctor of Philosophy

**TECHNICAL AND SOCIAL EVALUATION OF WATERSHED MA-
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By

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November 2014

Chairman: Associate Professor Lai Food See, Ph.D

Faculty: Forestry

Watershed degradation due to soil erosion is considered a major challenge in Iran, despite the introduction of several projects aimed at mitigating this environmental menace. Issues related to technical and social complexities of the watershed projects are difficult to evaluate, in spite of lessons learned from past experiences. In order to address such challenges, it is essential to assess fundamental social and technical issues involved. Previous attempts using quantitative and qualitative evaluation methods separately had their strengths and weaknesses. Addressing this issue requires an integrated watershed management approach. This study presents an integrated model using technical and social approaches for evaluation of the Kushk-Abad Basin (KAB) watershed projects in Iran. The study was conducted within an 85 km² zone of the KAB, which is a sub-basin of the larger Kardeh dam catchment. The study is aimed at evaluating socio-demographic and technical factors affecting KAB Watershed Management Program (WMP) taking into consideration pre, during and post project scenarios, particularly on the land treatment efforts initiated by the Watershed Management Organization of Iran.

The social evaluation study was designed to determine the factors that affect variation of level of participation in WMP in Iran. In this regard, a conceptual model was developed to: 1) identify characteristics that lead to the participation in WMP, and 2) determine the factors that affect variation of level of participation. In each of the selected three villages within the KAB locality, 200 individuals were randomly interviewed using a structured questionnaire for assessment of their socio-economic characteristics and participation in the various watershed management programs. The sample size used was based on the Cochran formula with a confidence level of 0.05. The respondents' level of knowledge, attitude, expectation and satisfaction of previous watershed programs were examined against the level of participation. On the other aspect, the technical evaluation study examined watershed management and bio-engineering processes of structures through measures implemented during operations.

Based on a series of statistical analysis from the use of chi-square, factor analysis and regression, the results of the social evaluation study suggested significant relationship between knowledge, expectation and attitude on WMP with participation among the villagers in KAB. The relationship between age, household size, number of sons after 15 years, size of irrigated and rain-fed lands were positively correlated with watershed participation. The results of this study showed that the level of the respondents' knowledge on WMP was low, while expectation; satisfaction, attitude and level of participation ranged from moderate to high.

Results from the technical evaluation study revealed that the double mass curve demonstrated significant changes to flow distribution, suggesting the effectiveness of check-dams in mitigating basin runoff. With check-dams affecting almost 35% of the basin area, runoff in KAB also show significant reduction in peak discharges from the flow duration analysis. Soil erosion and sediment loads were effectively contained by the check dams of different types including gabion, earth-fill, brush-wood and loose-stone dams. From field measurements, as much as 37% of the sediment loads were stored behind these dams since their construction. Results of qualitative evaluation showed that WMP was effective on 6 variables (flood occurrence, river sediment transport, agricultural yield, well capacity, orchard and livestock). The study findings showed that all check dams (except brush-wood) were structurally in good order. Additionally, the relative performance for both seeding and seedling planting were good, while contour furrow was moderate, and tree and shrub planting were weak.

The findings further showed that land treatment techniques were largely check-dams and bio-engineering methods from seeding to tree planting to address the soil and water conservation objectives of watershed management. This study provided some theoretical and practical implications and recommendations on their participations in the Watershed Management Project. In summary, this work recommends that social exchange and reason theory are appropriate to explain the variations of participation level.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

**PENILAIAN TEKNIKAL DAN SOSIAL TERHADAP AMALAN KAWASAN
LEGEH DI EMPANGAN KARDEH DALAM KAWASAN TADAHAN AIR
KUSHK - ABAD, IRAN**

Oleh

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November 2014

Pengerusi: Profesor Madya Lai Food See, PhD
Fakulti: Perhutanan

Kemusnahan kawasan tadahan air akibat hakisan tanah dianggap satu cabaran yang besar di Iran, walaupun dengan pengenalan oleh beberapa projek yang bertujuan untuk mengawal ancaman alam sekitar ini. Isu-isu yang berkaitan dengan kerumitan teknikal dan sosial bagi projek tadahan air adalah rumit untuk dinilai, walaupun terdapat pengajaran daripada pengalaman yang terdahulu. Dalam usaha untuk menangani cabaran ini, ia adalah penting untuk menilai isu-isu sosial dan teknikal asas yang terlibat. Cubaan sebelum ini yang menggunakan kaedah penilaian kuantitatif dan kualitatif secara berasingan mempunyai kekuatan dan kelemahan mereka yang tertentu. Oleh itu, isu ini perlu ditangani dengan pendekatan yang lebih bersepadu dalam pengurusan kawasan tadahan air. Dalam kajian ini sebuah model bersepadu akan dibentangkan menggunakan pendekatan teknikal dan sosial bagi penilaian projek tadahan air Lembangan Kushk-Abad (Kushk-Abad Basin (KAB) di Iran. Kajian ini dijalankan dalam zon seluas 85 km² di KAB, yang merupakan sub-lembangan yang lebih besar daripada empangan tadahan Kardeh. Tujuan kajian ini adalah untuk menilai faktor-faktor sosio-demografi dan teknikal yang mempengaruhi Program Pengurusan Kawasan Tadahan Air KAB (KAB Watershed Management Program (WMP) mengambil kira senario pra, semasa dan pasca projek, terutamanya dalam usaha rawatan tanah dimulakan oleh Watershed Management Organization di Iran.

Kajian penilaian sosial ini telah direka untuk menentukan faktor-faktor yang mempengaruhi kepelbagaian tahap penyertaan dalam WMP di Iran. Dalam hal ini, satu model konsep telah dibangunkan untuk: 1) mengenal pasti ciri-ciri yang membawa kepada penyertaan dalam WMP, dan 2) menentukan faktor-faktor yang mempengaruhi perubahan dalam tahap penyertaan. Dalam tiga buah kampung yang terpilih di kawasan KAB, 200 individu telah ditemubual secara rawak menggunakan soal selidik yang berstruktur untuk menilai ciri-ciri sosio-ekonomi dan penyertaan mereka dalam pelbagai program pengurusan kawasan tadahan air. Saiz sampel yang digunakan adalah berlandaskan kepada formula Cochran dengan nilai tahap keyakinan sebanyak 0.05. Tahap pengetahuan responden, sikap, jangkaan dan

kepuasan terhadap program pengurusan kawasan tadahan air yang sebelumnya telah diperiksa berdasarkan tahap penyertaan mereka. Pada aspek yang lain, kajian penilaian teknikal dijalankan untuk memeriksa pengurusan kawasan tadahan air dan proses struktur bio-kejuruteraan melalui langkah-langkah perubahan yang dilaksanakan dalam operasi.

Berdasarkan siri analisis statistik yang terdiri daripada penggunaan kaedah khi-kuasa dua, analisis faktor dan regresi, keputusan kajian penilaian sosial mencadangkan terdapat hubungan yang signifikan antara pengetahuan, sikap dan jangkaan terhadap WMP dengan penyertaan di kalangan penduduk kampung di KAB. Hubungan antara umur, saiz isi rumah, bilangan anak-anak selepas 15 tahun, saiz tanah disalurkan oleh pengairan dan hujan menunjukkan hubungan positif dengan penyertaan terhadap program pengurusan kawasan tadahan air. Hasil kajian ini menunjukkan bahawa tahap pengetahuan responden terhadap WMP adalah rendah, manakala jangkaan; kepuasan, sikap dan tahap penyertaan adalah dalam lingkungan sederhana hingga tinggi.

Keputusan daripada kajian penilaian teknikal menunjukkan bahawa lengkung jisim berganda mempunyai perubahan taburan aliran yang ketara, mencadangkan bahawa keberkesanan empangan kawal dalam mengurangkan air larian di lembangan tersebut. Dengan pengaruh empangan kawalan yang melibatkan hampir 35% daripada kawasan lembangan, air larian di KAB juga menunjukkan pengurangan yang ketara dalam aliran puncak dari analisis yang dijalankan pada jangka masa tersebut. Hakisan tanah dan beban sedimen berjaya dibendung oleh empangan kawalan pelbagai jenis termasuk bronjon, tambak bumi, kayu dan batu. Dari ukuran di lapangan, sebanyak 37% daripada beban enapan telah disimpan di kolam empangan ini semenjak mereka dibina. Keputusan penilaian kualitatif menunjukkan bahawa WMP adalah berkesan terhadap 6 pembolehubah (kejadian banjir, pengangkutan enapan sungai, hasil pertanian, kapasiti perigi, ladang dan ternakan). Kajian menunjukkan bahawa semua empangan kawalan (kecuali empangan kayu) mempunyai struktur dalam keadaan masih baik. Selain itu, kedua-dua pembenihan dan penanaman anak benih adalah dalam prestasi relatif yang baik, manakala kontur kerut adalah sederhana, dan pokok renek dan tanaman lemah.

Hasil kajian seterusnya menunjukkan bahawa sebahagian besar teknik rawatan tanah terdiri daripada empangan kawalan dan kaedah bio-kejuruteraan terdiri dari pembenihan dan penanaman pokok dalam usaha pemuliharaan tanah dan air serta mencapai objektif pengurusan kawasan tadahan air. Kajian ini memberikan implikasi dan cadangan teori dan praktikal tentang penyertaan mereka dalam Projek Pengurusan Legeh. Kesimpulannya, kajian ini mencadangkan bahawa pertukaran sosial dan teori sebab adalah paling sesuai untuk menjelaskan kepelbagaian tahap penyertaan.

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I certify that a Thesis Examination Committee has met on 7 November 2014 to conduct the final examination of Bahram Mohammadi Golrang on his thesis entitled "Technical and Social Evaluation of Watershed Management in Kushk-Abad Watershed Basin, Iran" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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DECLARATION

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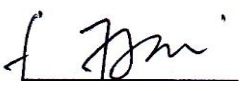
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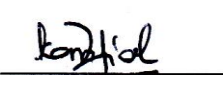
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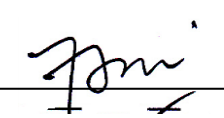
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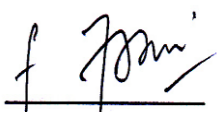
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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BMP	Best Management Practice
CC	Contingency Coefficient
CV	Coefficient of Variation
DV	Dependent Variable
EDA	Exploratory Data Analysis
EPM	Erosion Potential Method
FA	Factor Analysis
GIS	Geographic Information System
HEC-HMS	Hydraulic Engineering Committee-Hydrologic Modelling Sys-
IV	Independent Variable
IWM	Integrated Watershed Management
KAB	Kushk-Abad Basin
KMO	Kaiser-Meyer-Olkin measure
LSD	Least Square Difference
LPI	Largest Patch Index
LUCC	Land Use/Cover Change
MPSIAC	Modified Pacific Southwest Inter-Agency committee Commit-
MOA	Ministry of Agriculture
MSA	Measure of Sampling Adequacy
MUSLE	Modified Universal Soil Loss Equation
NGOs	Non-Governmental Organizations
PP	People Participation
PSIAC	Pacific Southwest Inter-Agency Committee
SCS	Soil Conservation Service
SL	Sediment Load
SPSS	Statistical Package for the Social Science
UNDP	United Nation Development Program
USLE	Universal Soil Loss Equation
VIF	Variance Inflation Factor
WHO	World Health Organization
WMP	Watershed Management Program
WMO	Watershed Management Operation
WM	Watershed Management

CHAPTER 1

INTRODUCTION

Watershed management involves the process of implementing land and water conservation practices for the benefit of affected watersheds. Population growth in Iran coupled with rural development and increasing agriculture practice had led to overgrazing and forest logging which leads to many environmental and socio-economic issues in the rural watersheds (Zarekia *et al.*, 2012). It has been estimated that 100 million cubic meters of soil is deposited in the reservoirs of Iran annually which is the result of serious soil degradation in upstream areas (Ahmadi *et al.*, 2004).

After land reforms in the early 1960s, the natural resources in Iran were managed and monitored by the respective government and agencies (Bagherian *et al.*, 2011). In reality however, land resource use by the local population in particular were difficult to manage by the Iranian authorities. This issue is an old one with constant problems in natural resources management that has exacerbated land degradation and non-sustainability of natural resources use (Haji-Rahimi and Ghaderzadeh, 2008). In recent years however, people participation is playing a greater role in decision making processes in watershed management (Rezaei *et al.*, 2011). According to the United Nation Development Program (UNDP) report in 2006, Iran faces serious environmental challenges, acknowledging that the natural resources have been substantially degraded. In this regard, the Iranian government established several policies related to sustainable management of land and water resources which were mostly top down strategies which were unfortunately, not successful.

Watershed evaluation can be approached via two main methods, i.e. quantitative and qualitative (Kerr, 2007). A quantitative approach provides measured outcomes with statistical tests that support the validity of findings (Patton, 1997). But even the most optimistic evaluators declare that the conclusions driven by a project are always subject to context-specific conditions (Campbell and Russo, 1999). Qualitative methods provide the means by which this context can be recognized and may be used to examine the threats of validation process. To deal with the watershed complexities, both evaluation approaches, i.e. quantitative and qualitative should be considered (Patton, 1997; Greene and Caracelli, 1997).

This study evaluates the watershed operations or watershed management techniques used in the Khushk-Abad Basin (KAB) in Iran. This work was conducted in collaboration with the Ministry of Agriculture (MoA) and Ministry of Jihad Sazandegi.

The KAB is one of the sub-watersheds of the bigger Kardeh watershed where agriculture is important. The Kardeh reservoir also supplies water for irrigation to agricultural lands downstream of Kardeh and drinking water for the city of Mashhad. Following the implementation of structural measures and biological techniques in KAB is considered an important than in the Khorasn razavi province specifically and Iran generally. Previous work in KAB had been written on the importance of this area with respect to implementation of watershed management procedures but there is little work conducted in the technical, economic and social assessments to deter-

mine the strengths and weaknesses of the intent of watershed management in this part of the Kardeh basin.

1.1 Statement of the Problem

The Kushk-Abad Basin (KAB) is one of the sub-watersheds of the important Kardeh watershed which is responsible for irrigation to agricultural lands downstream of Kardeh and drinking water for Iran's second largest city, Mashhad. Because of its important role in the provision of water resources, there were numerous watershed management projects in this region. In fact, because of the implementation of various structural and biological measures in this region, KAB is considered a very important area in the Khorasan Razavi province specifically and in Iran generally. Apart from water resource, KAB has regional implications with regards to essential watershed management operations. Some of these problems can be listed as follows (Tabatabai *et al.*, 2006; KGONR, 2010):

1. High sedimentation rate of 11.24 tones per hectare per year
2. Destructive flash floods due to rocky and steep slopes and rugged terrain
3. High livestock pressure (6 times over the permitted capacity) on poor and very poor rangelands
4. High water demand from wells and Qanats
5. High migration to urbanized areas due to economic poverty and lack of education
6. Low people participation in watershed programs

The problems listed above have placed KAB area in a challenging position. In this regard the government of Iran has established several policies on sustainable management of land and water resources in recent years. Watershed projects were conducted to reduce basin runoff and improve soil protection. These projects are usually time consuming and very expensive to implement. Therefore, the assessment of these watershed management operations is a major issue which requires investigation and in-depth analysis. In view of these issues, the examination into the strengths and weaknesses of the projects are considered to be very important for the preparatory stage for the next generation of watershed management projects and future developments plans and programs. Evaluation of implemented watershed projects can lead to optimizing similar watershed projects elsewhere. During the evaluation exercise, the questions that require satisfactory responses were primarily dealing with: Have the watershed management operations been successful? Are we achieving what was expected?

Another important issue is the problem of people participation in watershed management projects. Despite the importance of KAB and implementation of watershed operations, there is very little research devoted to investigation of social watershed operations in this area (Ahmadi *et al.*, 2004; FRWO, 2011).

For sustainable and better management of natural resources, various policies have been devised, the most promising of which is the management of natural resources through participation of the local people and beneficiary communities. In recent years the government of Iran has developed this approach in natural resources man-

agement in several rural areas with the KAB Watershed Management Program (WMP) being one of these participatory programs.

However, the involvement of local people in natural resources management activities has been often difficult (Rehman and Chisholm, 2007). Therefore there is a great need to know the level of participation by the local communities and explore the factors which makes participation efforts successful.

Many studies have developed various and sometimes different views concerning the dimensions of participation. These studies were usually descriptive in nature and focused on demographic and socio economic factors (Masiah, 2006). Much of the literature revealed that participation in voluntary programs depends on farmer's attitude and behavioral response (Defrancesco *et al.*, 2008). In response to this, more complex behavioural approaches have also been proposed, paying attention to a number of farmers personal characteristics, such as motivation, values and attitude.

Up to a few years ago, researchers have entered a stage explaining farmer's behavior using principles of social psychology and behavioral models (Searle, 1989; Gilles, 1995; Wilson, 1997; Mahon, 1998; Dimitri and Nicholas, 2002; Dolisca *et al.*, 2006; Masiah, 2006). In Iran there is limited research conducted in the context of participation using such models or approaches especially in watershed management programs. This study attempts to analyze people's participation in WMP based on social exchange and reason action theory to examine the relationship of these theories with participation to provide a better understanding of participation in WMP in Iran.

1.2 Research Questions

The main purpose of this study is to evaluate the watershed management operations namely; technical and social in WMP and addresses following questions:

1. Among the constructed (structural and bio-engineering) constituents which one has been more effective and functional?
2. Which of the quantitative and qualitative methods in assessing the technical watershed management operations is more appropriate?
3. Which kind of the constructed (gabion, loose stone, brush-wood and earth-fill) check dams in the watershed basin have been more useful?
4. Which kind of the bio-engineering (seeding, planting of seedling, contour furrowing, tree planting and shrub planting) in the watershed basin has been more useful?
5. What are the people's socio demographic characteristics in KAB?
6. What are the levels of people's participation included: Attitude, Knowledge, Expectations, Satisfaction, and Participation in WMP?
7. What are the relationships between socio demographic characteristics, knowledge of WMP, Attitude toward WMP, expectation of WMP, satisfaction of prior programs and their levels of participation in WMP in KAB?

1.3 Research Objectives

The aim of this study is to evaluate the watershed management programs initiated and implemented from 1991 to 2002 in KAB mainly from two aspects, technical and social in order to examine the contribution of the watershed management program in the study area, two objectives were outlined:

1. To evaluate watershed management and bio-engineering examination of structural technically through the measures implemented during the operations period.
2. To evaluate check dams based on age, trap efficiency and function.
3. To identify respondent's socio demographic characteristics in KAB.
4. To determine differences of people participation in WMP based on selected socio demographic characteristics.
5. To assess respondent's knowledge of WMP, attitude toward WMP, expectations of WMP, satisfaction of prior WMP and the level of participation in WMP.

1.4 Research Hypotheses

The hypotheses of this study were:

1. There is a positive relationship between people participation and technical operation performance.
2. The Gabion check dams function is as well as loose-stone check dams.
3. Seeding and planting of seedling are as well as tree planting and shrub planting.
4. The success rate of structural aspects of WMP is more than of bio-engineering operations.
5. Based on villagers approaches, watershed management operations have been effective
6. The quantitative evaluation approach is more meaningful than qualitative evaluation technique
7. There is a positive relationship between socio demographic characteristics and level of participation in WMP.
8. There is a positive relationship between knowledge of WMP and level of participation in WMP
9. There is a positive relationship between attitude toward WMP and level of participation in WMP.
10. There is a positive relationship between expectations from WMP and level of participations in WMP.
11. There is a positive relationship between satisfaction from previous program experience and level of participation in WMP.

1.5 Significance of the Study

Although watershed management is almost new in Iran, there have been many projects implemented in different basins. However, fewer studies have been done on the evaluation of these projects. On the other hand, among the studies which have evalu-

ated WMP, either socially or technically, to my knowledge, there is no study that integrated both paradigms (social and technical factors). Therefore, this study is significant in the sense that it adopted an integrated approach, especially in the scope of participation and technical factors in WMP evaluation.

There is a vast literature dealing with socio-economic variables in the evaluation of WMP. Most of the literature are descriptive, and rarely applies to a scientific theory. To my knowledge, this study is the first to analyze the level of participation based on social exchange theory. Besides, it provides further consideration to factors related to participation by incorporating the variables of exchange factors which can significantly contribute to peoples' participation.

Finally, this study is deemed significant since it adds to and expands the existing scholarship on WMP of which the significant impact on water harvesting is deniable.

1.6 Limitations of the Study

Every research has its own limitation; this study represents the first effort to examine the level of participation based on social exchange theory in Iran. There is a limited research in Iran that has been conducted on the context of participation using theoretical model, especially in watershed management programs. In this study the researcher has attempted to analyze people's participation in WMP based on social exchange and reason action theory to examine the relationship of these theories with participation to provide a better understanding of participation in WMP in Iran. Similarly, in this research, as any other initial study, the researcher must identify and address the limitations.

The first limitation of this study pertains to the survey instruments. Questionnaires were used to examine issues and data quantitatively. Consequently, the extent and scope of data collection were limited to the items identified in the questionnaire.

The second limitation is the population: population of the study was limited to people's residing in the three WMPs at the time of study, and the data for the study were gathered from three WMPs who were presented at the time of data gathering.

Lack of suitable roads in mountain area is a limitation to survey studying area and evaluate all built structures. Snow is the most important limitation during cold seasons for surveying. And also villagers migrate to urbanized area during cold seasons. So the third limitation is short-time period for sampling. The best time for sampling is in summer.

Finally, due to time and financial constraints, this study was done only in some of the selected WMPs in KAB in Iran; therefore, the result of the study may not be applicable in the other parts of Iran.

1.7 Thesis Structure

The thesis consists of six chapters. Chapter 1 presents the introductory background, problem statement, research questions, objectives and limitation of the study. Chapter 2 focuses on the review of relevant literature concentrating mainly on watershed management studies in Iran, specifically in KAB. Chapter 3 describes the study ba-

sin and data sets followed by a discussion on the methods used in the technical and social evaluation. Chapters 4 and 5 include the results of the study describing the technical evaluation aspects (via quantitative and qualitative methods) and then on the social evaluation facets. The final chapter is devoted to summary of the findings and conclusions of the study. Some recommendations for future research are also proposed.



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