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# 1 SMALL SCALE WATER RESOURCES DEVELOPMENT

## 1.1 Alternate Dual -Mode Working Systems for the Collection and Use of Rainwater in High-Rise Buildings for Non-Potable Purposes

**Dr. Adhityan Appan**

Nanyang Technological University, Singapore

**Ho Hua Chan & Wong Hou Jin**

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### Abstract

In a country having a limited land of 631 km<sup>2</sup> where more than 80% of the population lives in high-rise buildings, ways and means have to be found to maximize the collection of runoff. One such method is to collect the rainfall from the roofs of high-rise buildings and to use it for non-potable purposes only. As currently about 25% of potable water is being used for toilet-flashing purposes, the proposed system could result in considerable savings in the use of potable water and pumping costs incurred to store this water in roofs of the high-rise buildings. Earlier proposals have defined the methodology of such systems but, in this paper, special emphasis is made establishing a working system that can be implemented in two different ways. In one of them, a light sloping roof is built on the roof slab and roof water collected in a rainwater tank and in the other, water collected in the roof slab is directed to a water tank located in the floor below. The collected rainwater in both cases is then distributed to all the water cists. Since there could be a limitation to the volume of the rainwater tank due to structural constraints, the tank is also connected to the potable water tank but only receives such water as and when there is insufficient rainwater. As more than 45% of the buildings in the location under study are 12 stories in height, the modified version of an existing computer model was used and it was possible to determine that the optimum size of the tank should be 146 m<sup>3</sup> and that initially about 80% of the tank should be filled with potable water. Whenever the water level fell to dead storage level potable water was to be pumped to about 34% of its volume. On the whole it was calculated that 4% water savings in terms of domestic consumption could be effected. The proposal with the tank on the roof slab was far cheaper, in terms of capital and running costs, and the collected roof water was also cheaper than current potable water by about 25%. The study established that a dual-mode rainwater cistern system can be built into an existing high rise building in Singapore and it is also economically a viable proposition.

## 1.2 Social Choice in Water Harvesting

**Mr. F. Szidarovszky, Mr. A. Eskandari**

University of Arizona, U.S.A

### Abstract

Social choice procedures are introduced and applied to solve a special water-harvesting problem in northern Arizona. The methods include plurality voting, the Borda count, the Hare system, pairwise voting, and dictatorship. These procedures are applicable in all cases when the alternatives are

simultaneously ranked by the different decision makers. Since no quantification of the criteria is needed, these methods have special importance. If the criteria cannot be quantified, objective function values are hard to get, or they are very uncertain, then these methods are the procedures to be applied.

**KEYWORDS:** water harvesting, social choice, multi-criteria decision making.

### **1.3 A Catchment Water Balance Model for Estimating the Groundwater Recharge in the Arid And Semi-Arid Regions of Iran**

**Dr. Esmail Khazaie**

University of Birmingham, UK

#### **Abstract**

This paper presents a new model of the rainfall-runoff-groundwater flow processes applicable to semi-arid and arid catchments in the south east of Iran. The main purpose of the model is to assess the groundwater recharge to aquifers in these catchments. The model takes into account the main mechanisms contributing to groundwater recharge in the region and deals with the effects of spatial variation in the hydrological processes by dividing the catchment into different regions of broad hydrologic similarity. The model has been applied to the Zahedan catchment and the results from this study are discussed briefly.

### **1.4 Rainwater Utilization in Arid Zone of Shiyang River Basin Gansu Province, China**

**Prof. Gong Xiaohu, Mr. Wang Benjin, Mr. Chine Ziyong**

Gansu Agricultural University, P.R. China

#### **Abstract**

Hexi corridor of Gansu Province belongs to arid region, with annual rainfall about 170 mm, evaporation between 2113 mm and 3300 mm, and average temperature ranging from 5 to 10 degree. Due to the favorable conditions of energy, sunshine and rich land resources, it is suitable to develop agriculture in the region which is the commercial base of agriculture in the province. The paper discussed and analyzes the farm irrigation in a case study of Wuwei county in Shiyang River basin. Water resources include rainfall, stream flow and groundwater. Rainfall is the basic resource which mainly occur in the mountain areas. Its distribution in time and space and its magnitude not only control the water and glacier status, but also directly influence the formation, distribution and variation of runoff in the basin. The study focuses on the conversion and reuse of surface and groundwater. Meanwhile, the relationship between water resources features and agricultural development is analyzed and some measures are proposed.

## **1.5 Band-Sar: A Practice in Optimum Using of Water and Soil Resources in an Arid Region**

**Mahmood Arabkhedri and Afshin Partovi**

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### **Abstract**

In arid regions shortage of water resources forces farmers to use floodwater for crop production. There are several reports about floodwater harvesting from Asia, Africa and America. Flood irrigation also has been practiced in Iran for many years. Traditional farms, called band-sar, can be observed in central south and northeast Khorasan province (NE of Iran). Although the structure of band-sar is very simple, it has many benefits such as increasing soil moisture's, crop production, groundwater recharge, soil protection, and preventing water loss to kavirs and saline lakes.

In the present research, the band-sar systems are studied. In addition to field observation, the meteorological data is analyzed and the aerial photographs and topographic maps are interpreted. In this paper, the result of climatic conditions, physiographic and soil properties and classification of band-sar are reviewed and a map of band-sar distribution is prepared.

## **1.6 Utilization of Rainwater Resources for Developing Dryland Agriculture in the Gansu Province of China**

**Baoxiu Zheng**

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### **Abstract**

The Gansu province of China is an arid province, with serious soil and water losses. In particular, in a rainfed area of 150000 km<sup>2</sup>, water is the primary factor in agriculture. Furthermore, it is too difficult to provide enough water for the inhabitants and livestock. It is very important to solve the water problem in this area. Based on the Research results and the engineering practices of rainwater catchment, since the late 80's, this article describes the technical and economical feasibility of the utilization of rainwater resources for agriculture in Gansu, and it also sums up successful experiences and patterns. This paper points out the fact that utilizing rainwater is the best way of development for the rainfed agricultural areas. Experiments show that, in the area, with 250 to 400 mm precipitation, 80 to 130 m<sup>2</sup> of artificially hardened field can provide drinking water for a 5-member family and livestock 135 to 270 m<sup>2</sup> of lined field can provide water for supplemental irrigation of 0.067 ha of terraces. The input, will be only half of that of the water diversion or pumping projects, Henceforth, meeting the drinking water demand as a priority consideration, the rainwater will also extend to develop the supplemental irrigation for the, whole rainfed area, to enhance the life style, and to help proper utilization of natural resources in the ecosystem.

## 1.7 Religious Aspects of Using rainwater in the Quran

**Salahi Esfahani**

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### Abstract

"Do you not see that God drives gently the clouds then joins them together, then piles them up (layers over layers) then you see the rain coming forth from their midst?" (An-Nur: 43)

Glancing at the Holy Qur'an, one can understand that all the waters on the earth have originally poured down from the sky (Al-Mu'minun: 18) and by Divine Will, some parts formed as land and some parts as water and dwelling places. The rain which has come thereafter, being proportioned and accounted for, with the difference that the original waters formed from the first clouds which came into existence in the sky and the rain coming thereafter, although coming from the sky (at atmosphere), have their source in the waters on the earth. The waters flow in the form of streams, springs, and rivers, some parts of which are exploitable in certain places (Az-Zumur: 21), after which streams (Ibrahim: 32) and spring (Ya Sin: 34) came into existence. Some of the terrestrial phenomena which the Qur'an encourages us to contemplate are rain, its conservation on the earth, its appearance in the form of streams and springs, and other forms such as the seas which have appeared from the source of rainwater (An-Nahl: 14, Al-Jasiyah: 12, and Bani-Israel: 66). The appearance of plants has been said to have originated from rainwater in more than 30 verses of the Qur'an (Al-Hijr: 19, An-Nahl: 89), and God has created various forms of plants from the rain. Verses 25-32 of Chapter Abasa refer to the growth of grape, olive and date trees, and also abundant gardens of fruit and grass to be of the same source. Also, the growth of special plants and the relations between terrestrial and celestial phenomena are considered in the article.

## 1.8 Sustainable Development in Arid Zone Rajasthan, India: The Role of Rain Water Harvesting Systems

**S. Ramanathan**

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### Abstract

The development in post-independence Rajasthan (India) has led to a paradoxical situation. The state led transformation to increase the productivity of the desert "waste" has led to shrinking and degraded commons, land degradation and marginalisation of the poor. These is a growing concern for the need to identify sustainable alternatives to use its natural resources to meet the needs of the society. The revival of rainwater harvesting and its integration with modern forms of water supply is considered by many to be one such alternative. Rain water, harvesting is a cultural tradition in Rajasthan, and was the means to secure livelihood in the desert. However, the rainwater harvesting systems in Rajasthan are now faced with major crisis. Their decline has been caused by many factors: chiefly the state policies and programmes.

This paper argues that the rainwater harvesting systems are relevant even now. It argues that massive inflow of water into the desert has created more problems than it has solved. It is argued here that the conflict is not between the modern forms of water supply and the traditional rainwater harvesting techniques. The need is for a holistic approach to enable sustainable use of resources in the desert. For

this purpose, the paper describes the different techniques of rain water harvesting prevalent in the arid region, and as well as their management and use. On this basis, the paper shows the valuable lessons they offer to the modern forms of water supply. It is also pointed out that as the rain water harvesting systems are not distinct units; it would be possible to integrate them with modern forms of water supply. This would enable sustainable use of resources, ensuring safe minimum standards or safe well being in the desert. As the experience of NGOs Rajasthan has shown, it is possible to attain this only by decentralized development involving the community. The paper concludes by examining the institutional options for the revival of rain water harvesting systems in the arid regions of Rajasthan, in the context of a constitutional amendment on democratic decentralization.

## **1.9 Cost-Benefit, Economic Analysis of the Seasonal Flood Impacts on Water Supply: Taftan Region Case Study**

**Ali Khazai**

Ministry of Jihad-e-Sazandegi, I. R. Iran

### **Abstract**

The Taftan basins received more attention after the economic evaluation of a preliminary feasibility study. The locality of the watershed basins is about 60 Km from the Khash city. The annual precipitation, varies between 150mm to 250 mm. Thus, inevitably the watershed basins have a tremendously high, potential of better climate conditions in the Baluchestan province. Nevertheless aridity is a dominant characteristic for the climate of the province of Baluchestan province, with hot humid summers and mild winters. Although there is considerable climatic variation from the Taftan Watershed basins to other parts of the province, aridity is a common feature of this dry tropical environment. In this regard, the surrounding area comprises of low-lying plains, where the low and frontal ranges, Mirjaveh, Tahlub, Dasht-e-Khash, and Dasht-e-Gohar Koh are located. These consist of very fertile soil and are a productive range of lands in the province, covering an area of approximately 11,186 hectares. Due to slopes and heavy short-term rainfall during winter and spring, destructive floods have occurred 7 to 10 times a year. According to the present evidences and statistics, the entire project area is sparsely populated. 13 settlements with a population of about 710 families are usually located irregularly in the basins. Floods cause dramatic damages to the region, and as a major concern, have caused a decrease in depth and fertility of soil, in all the steep agricultural and dry farming lands throughout the province. Surveying the Taftan, the watershed basins level of economic development, social and economic status, as well as, identifying torrent control and water spreading and soil conservation measures, and the development of many villages in watershed basins, recommended the Taftan watershed basins project. The project required a big investment, being quite costly, with a lengthy productivity. In other words, the practical performances in the field of water and soil conservation in various basins or geographical regions require heavy investments. The most important point is that the productivity of such investments require a longer period of time. On the other hand, a continuous maintenance of the project imposes heavy costs thereon. The above factors total up an ultimate budget of 50 Milliard Rials within a period of 20 years. During the first two-year plan, the cost of improvement of soil conservation, operations and construction works, amounted up to 1 Milliard Rials. The Taftan watershed basins project, practically started in the year 1993. The operations from 1993 up to the end of 1995 included construction work such as those of small Stony dams, using gabions (fences), building rock barriers, trenches and terraces on the counter lines of the Taftan watershed basins. According to reports, loose rock dams with a height of 0.5-0.8 m and a

length of 12,000 m; Gabion check dams with a height of 1.5-3 m, and a length of 800 m. Cement masonry check dams, with a height of 1.5-5 m and a length of 25 m, have been constructed.

## **1.10 The Role of NGOs in Community Water Resource Development in Ethiopia**

**Grima H. Michael,**

Disaster Prevention And Preparedness Commission, Ethiopia

### **Abstract**

The present paper is aimed principally at depicting the role of non-governmental (humanitarian) organization, better known as NGOs, in the area of community water resources development in Ethiopia and hence at sharing some of their experiences to interested bodies and also propounding the overall efforts (including merits and demerits) of these organizations in the sector. By so doing, it would be possible to draw the attention of concerned parties and prompt them to take the necessary actions each of them are expected to.

There is no intention to cover in this paper the entire range of activities which NGOs have accomplished in the water sector in the country. Instead, some agencies, which are believed to be representative and have had more significant involvement in the sector, are identified and the waterworks which they have carried out Over the last few successive years are shown to help the readers draw some conclusion on the subject

The paper is divided into four major headings. The first one is an abstract which introduces the paper just in short; and the second chapter gives brief accounts of Ethiopia including its physical and socioeconomic settings; the third chapter outlines the central theme of the paper, namely the “water role” of NGOs, in which are discussed the general background of NGOs, their involvement in water sector, accomplishments of selected NGOs, common strategies/approaches applied by them and some analytical comments on NGOs Water works. The fourth chapter forwards some recommendations for the due consideration of the concerned agencies for better results and more fruitful contribution towards the sector in the time to come ahead.

## **1.11 Water and Sustainability**

**Joseph Keve**

Mumbai, India

### **Abstract**

Water being one of the most important elements of nature, needs to be viewed, understood and used in tandem with all other elements. The perspective and mode of collection, storage and utilization of water have a direct impact on the health and well being of nature and all beings, present and future. Several regions and communities all over the world, have created great imbalances in their situation through indiscriminate and unsustainable ways of dealing with water and water sources. This paper highlights the need to understand the linkage between various elements in nature the role water has played through the centuries and traditions, and the problems that came along with industrialization, recommends several principles and practices which could both correct some of the present imbalances and also contribute to a more sustainable future for all of humanity and other beings. The paper

suggests that all development should be based on an understanding which is holistic, sustainable and safeguards the interests and future of the total universe. As suggested by some of the examples described in the paper, there are valuable and sustainable traditions with water in our own country and daily life. The first step taken would be to search in our traditions and culture. Answers to some of the most complicated problems that confront us lie within our own leach and situation.

Studies show that Earth has existed for over 4000 million years, humans 3500 years, agriculture 5000 years, and the use of fossil fuels a mere 200 years. At the current level of consumption of fossil fuel, there are only 40 years left for its complete depletion, which sounds terrible! Whether we like it or not, this present generation will have to take some of the most critical decisions regarding the future of this planet.

## **1.12 A View to Rainwater Utilization and its Role in Rural Areas Development in Arid and Semi-Arid Regions of Iran**

**Mohsen Shariat Jafari, Ali Akbar Abbasi**

Soil Conservation and Watershed management Research Center, Iran

### **Abstract**

One of the most important problems in arid and semi-arid regions, is the shortage of water. Low flow springs and seasonal rivers, that usually flow in winter und springtime, are the main water sources in such areas. Seasonal floods that flow after heavy seasonal or cyclic precipitation are the most important indication for such rivers. Therefore, making use of rainwater utilization system in these areas is necessary, because of their essential role in agricultural, civilization and social-economical development.

One of the most common system for storing rainwater and low flow springs, is cement and earth ponds in various sizes and shapes that usually are constructed by local people. These systems, usually can be filled using two simple, and economical methods, as follow:

- Making use of the slope runoff, and the seasonal rivers' flow, in a gravitational method.
- Making use of sub- surface flows that appear in low flow seasonal springs,

This paper introduces a common rainwater harvesting system, and then individually refers to the rehabilitation role of these systems, and their problems, and other characteristics in the typical region of the northwest of Tehran (south of the Alborz mountains), as follows:

- a) Investigation of distribution, shape, size and technical problems of these systems in mentioned region.
- b) Explanation of watershed management activities and innovation systems established by people in making use of harvested water by means of agricultural development.
- c) Assessment Of problems related to sedimentation.
- d) Investigation of slope instability risk, under the influence of loading, by non-criterion development of these structures on slopes
- c) Discussion, conclusions and suggestions far optimization of systems.

### **1.13 Water Resources Development for Farming in Arid Regions: A Natural Catchment System Case Study**

**Mohammad Reza Daneshvar (1)**

Jihad Eng. Services Co., I. R. Iran

**Mohammad Reza Ekhtesasi (2)**

Desert Research Center (IDRC), I R. Iran.

#### **Abstract**

Due to lack of plant cover and large impenetrable mountainous lands in the center of Iran, a considerable portion of the rainfall turns into runoff and eventually forms floods in the Kavir pits (playa). It is possible to gather the runoff in order to use them in development of small productive units of farming, animal husbandry, etc. During recent years, private enterprises have made small soil dams, using cement blocks and tar, to gather runoff from a natural catchment of Taft, Yazd. It may keep up to 8,000 m<sup>3</sup>. These pools can supply water to 12 Hectares of almond farms by drip irrigation, eight poultry farms for breeding chicken, and for fish culture. This method could be applied for other mountainous regions of central Iran, with the rainfall over 150 mm for the development of stable employment units. In this system, besides introducing special characteristics of these people's successful project, the runoff coefficient of the area under study was 13% and the curve number in that catchment was calculated 95, which is good for similar projects in other regions.

### **1.14 Groundwater Availability Studies in Ghataprabha Sub-Basin in India**

**P.K.Majumdar, B.K.Purandara**

National Institute of Hydrology, India.

#### **Abstract**

Study of groundwater availability in Hukkero Taluk of Ghataprabha sub-basin of Krishna basin in Karnataka State, India has been carried out. History of the ground water occurrence in the region has been reviewed as per the work done by State Department of Mines and Geology in the year 1975 and then by Central Groundwater Board in the year 1980. Present situation is assessed through various analysis including Pumping and Recovery tests, in a location where most of the failed wells have been noticed. Kumarswamy's method of calculating well Rock Permeability has been preferred. Permeability values range from 0.08 m / hr to 0.346 m / hr. Probable reasons have been discussed and remedial measures have been suggested.

### **1.15 Storage Wells, Providing Water Resources in Small Scale**

**Alireza Arabinedjad**

Abhar, I.R.Iran

#### **Abstract**

Storage wells are those wells that are excavated with large diameter and /or wide mouth. A Storage well is constructed for rainwater collection and running water storage. The basic structure of the well

is as a well with a large diameter and medium depth of about 20-40 meters and has a body with holes to make possible the flow of water into the well.

Inside these wells, various pumps are installed and used as required. Wells that are excavated with these technical specifications, although from the point of rate of basic water supply is certainly appropriate and satisfactory, but being used for some time, due to blockage of water entry holes, the rate of water supply of the well decreases and they must be reconstructed and opened so that the well could provide the required amount Of water.

For completion of storage wells, more research, studies and experiments were carried out and in the year 1947, a well was excavated in the city of Bern in Switzerland more complete specifications and required stipulations to provide drinking water. Such wells, due to their unique structure, were called storage wells and then was renamed by a Swiss engineer by the name of Felman as the Felman wells.

From the time these wells were developed, a large number of them have been excavated in various countries of the world. The average life of these wells is about 50 years, In our country, storage wells were excavated and constructed at Sefidroud and Langar area 30 years ago in the Imam Zadeh Hashem region, a district of Rasht province for the first time, in order to supply the city water. In Esfahan, 8 of these wells have become operational to provide drinking water for plants. Excavation and usage of such wells has been well ,worth and successful in supplying cities, mini-cities, large industries and plants and factories with water and in recent years, excavation of storage wells for regions where excavating has had some limitation as to geological conditions, have improved greatly.

The excavation of this well can besides collection of rain and other precipitations and their storage, be one of the methods for supplying water to mountainous regions and regions which do not have vast plains with alluvial-plain and in comparison with qanats where traditional methods are used in such regions to supply water, has a storage and controlled manner and prevents waste or water at times not required.

The importance of collection and retaining of snow and rainwater is specially important for human life since man has lived on water. Water, in its natural cycle, has always been flowing in the form of liquid, solid and gas and it has been mankind who has always been a guest to water, but unfortunately, the guest has not always respected its host and has contaminated it, but with all these, the guests were to go and the one who still remains is water.

In my paper titled “ Water, the alphabet of life” which I presented on drinking water in Ardabil I wrote; The Dutch drink the same water that the Germans and the Swiss drank and then poured it into the “Rhine” river or the coffee and tea that we drink today, can contain the water molecules that fed thirsty dinosaurs millions of years ago “, our duty is to retain and project every drop of water running in rivers and springs and not let drinkable, refined water and rivers to become contaminated by poisonous material and microbes, children should in their turn try to protect and retain this water. I, from this “ Holy scientific tribune” announce to the world that the first victims of contaminated water today are the children and most causes of death in children is due to diarrhea and due to contaminated water. In addition to protecting the Nation’s water, protecting the water itself and not wasting water is the responsibility of all mankind. For these reason, for better storage and retainment of storage well water and improvement of their usage, I recommend that water will be the most important and the most life-giving element of the 21st century, this is true today, since a barrel of oil in the world markets is worth 16 dollars, but a barrel of Coca-cola 70 dollars, a barrel of orange juice 108 dollars and even higher is a barrel of mineral water at 190 dollars. I now quote a poem by” Sokhanvar” on water;

Water; purer than human soul  
Water; in plains and gardens  
Water; often comes down from the sky  
Water; whatever I see is a sign of it  
Water; every corner of the world, I see  
Water; without, life meaningless  
Water; this life always-happy stays  
Water; cannot change its world, never  
Water; expensive and more expensive but cheap  
Water; sometimes river and sometimes spring  
Water; comes of the mountain, it comes  
Water; abundantly every where it is  
Water; everywhere I see, everywhere  
Water; no doubt it is of love  
Water; love without it is not Water; the mirror of live, it is  
Water; without water, love is not

Finally, everything is alive with water from the viewpoint of the Holy Quran.

## **2 FLOODWATER HARVESTING AND ARTIFICIAL RECHARGE OF GROUNDWATER**

### **2.1 Assessment of Damages Sustained by the Gareh Bygone Plain Flood Water Spreading Systems in the Deluge Of 1986**

**Dr. Ahang Kowsar**

Fars Research Center for National Research and Animal Husbandry, I.R. Iran.

#### **Abstract**

An exceptional event during 2nd – 7th December of 1986 occurred in which some localities in southern and central Iran received nearly 3 times their Mean Annual Precipitation (MAP), caused a deluge which resulted in 424 deaths and a financial loss of US\$ 1.714 billion in the affected areas. The 218.8mm of rain in the Gareh Bygone Plain (GBP), 1.5 times its MAP, produced 92 hours of flood peaking at 300 M<sup>3</sup> S<sup>-1</sup> on December 3rd, 1986. Although the Floodwater Spreading (FWS) systems are usually designed to withstand flows with the return period of 15 years, the GBP system sustained relatively small damages in this event, which had a recurrence interval of more than 100 years, less than 2.5% of the earth banks were ruined, and about 20% of masonry drops collapsed in a completed FWS system. Where masonry drops had not been installed in the gaps, 8.7% of the earth's banks were washed away, and about the same amount was breached. Removal of the bed load from the inundation

and conveyor-spreader canals, and restoration of the banks, cost about 30% of the market price of the original earth-moving expenses. The cost of damage to the FWS systems amounted to 2.5% of the losses that the deluge would have inflicted, had it not been mitigated by these systems.

## 2.2 A Simulation Model of Flood Control in the Subsided Area

**Yushiro Iwao, Koichi Kawazoe & S. M. R. Emami**

Saga University, Japan

### Abstract

Flooding is a problem of lowland area which usually causes damage to the facilities and property. Its estimation and control becomes important especially in the lowland area. Heavy rainfall on July 2, 1990, produced a flood in the Saga plain, lowland in north of Ariake Sea in Kyushu Island, Japan. This area is endangered by land subsidence due to withdrawal of groundwater. A simulation based on the network model consists of six tanks developed to reproduce the actual flooding of the area. From the achieved results it can be concluded that the comprehensive ability of drainage can be obtained by such simulation and the real drainage capacity has been decreased by the land subsidence phenomena. Finally, it can be concluded that the proposed model can be extended for controlling flood distribution into the artificial recharge system of groundwater in arid regions.

## 2.3 Palygorskite Transport Through the Vadose Zone: A Progress Report

**Mehrdad Mohammadnia and Ahang Kowsar**

Fars Research Center for Natural Resources and Animal Husbandry

### Abstract

Desiltation of turbid floodwaters is a prerequisite for Artificial Recharge of Groundwater (ARG) in the Gareh Bygone Plain (GBP) in southern Iran. Although sedimentation basins (SB) occupy about 80% of the ARG systems, still, some of the suspended clay-sized particles in the percolating water may theoretically move towards the water table and clog the Vadose Zone (VZ). Moreover, probable alteration of clay species in the humid soil in the hot, dry environment of the GBP may intensify the problem and shorten the useful life of the ARG systems. X-Ray Diffraction (XRD) patterns and Transmission Electron Microscopy (TEM) of the ARG watershed rocks and surface soil samples indicate the presence of chlorite, mica, smectite, and palygorskite (PG). Systematic sampling of the VZ within and without the SB, and XRD and TEM analysis of the samples revealed accumulation of PG in the phreatic zone of the control well which probably had been supplied by the 30 year flow of a qanat. The highest amount of PG was detected in a depth of 4.8 to 5.3 M where probably the high percentage of silt + clay provided the needed tortuosity to trap the PG particles.

## 2.4 Mathematical Model for Determination of Inundated Area

**Dr. Mohammad Ebrahim Banihabib**

Soil Conservation and Watershed Management Research Center, I.R.Iran

**Professor Muneo Hirano**

Kyushu University, Japan

### Abstract

Most damages and deaths take place when floods overflow riverbanks and inundated through the area which human properties are located. Most of the available mathematical models for simulation of the flood flow are based on one-dimensional approximation. There are fewer researches for the simulation of the two-dimensional flood flow and most of them are not compared with experimental results. A Numerical scheme is proposed to integrate divergent form of governing equations of two-dimensional flow. Advantage of this scheme to the Ponce-Yabusaki schemes in using implicit scheme is described. In this study, an attempt is made for verification of the model by experimental data. Perspective of verification deliberately shows the quest in verifying the two dimensional behaviour of flood flow. A proper case for verification is chosen on the desired circumstances. The flood of dam-break is chosen for comparison. The simulation results are compared with experimental ones to verify the model. Two sorts of comparisons are done. The simulated wave fronts of dam-break flood are compared with experimental ones to confirm simulated spreading patterns of the flood at two various times. The comparisons between simulation results and experimental ones are discussed and it is shown that the results of model have good agreement with experimental ones. Finally, it is concluded that the experiment verifies two-dimensional simulation of flood flow.

## 2.5 The Effects of Floodwater Spreading Project on Population Mobility in the Gareh Bygone Plain

**Dr. Khosrow Movahed**

Jihad-e-Sazandegi, Shiraz

### Abstract

Population mobility and migration within countries is one of the problems of recent years, especially in developing countries where urbanization and rapid growth of larger cities has resulted in burgeoning Squatter communities, unemployment and lack of public facilities. National government and city administration have found it hard to cope. Various program have been designed to keep back urban flow, to attract rural migrants by opening new lands, to resettle landless poor through highly capitalized agricultural settlements, and to disperse activities through regional development. Land development represents a practical solution to many developing countries.

In all of history, human beings have depended on water for the fundamental aspects of their lives. It requires water resources to be developed to meet human needs for agriculture.

Water development planning is a grandiose plan to control water flow in a fiver basin. It means stopping wealth running to waste; no longer wasting the rainwater. One way which could be adopted to prevent this waste of runoff is floodwater spreading in a suitable region.

The purpose of this paper is to find the effects of floodwater spreading on population mobility referring to the Gareh Bygone Plain in Iran. The Gareh Bygone Plain was selected in January 1983 with the main objective of utilizing floodwater spreading systems.

To accomplish this purpose, this paper is organized as follows: after the introduction, the investigated region is introduced. This is followed by explaining the methodology and empirical results of the study and finally the conclusions are presented.

## 2.6 The Flood Runoff Utilization in Beijing

**Huishibo Xie**

Senchuan Tsinghua Univ., China

**Zhang Jianxin**

Beijing Hydraulic Bureau, China

### Abstract

In this paper the water resources of Beijing, and its problems have been discussed. Using the mathematical model and simulation, the influence of different groundwater depth on infiltration of rainfall has been calculated and analyzed. Based on the rainfall-infiltration model, the calculation of runoff and the runoff factor has been introduced. Furthermore, the Nash instantaneous unit hydrograph method has been used in analyzing the runoff process. Finally, the paper applied the established hydrological simulation in analyzing the potentiality of flood runoff utilization.

## 2.7 Profitability And Flexibility of Flood Spreading Systems in Iran: The Case of the Gareh Bygone Project

**Asadolah Bakhtiar, Dr. Ahang Kowsar, Sayyed Hamid Habibia**

Fars Research Center for Natural Resources and Animal Husbandry, I.R. Iran.

**Dr. Bahaddin Najafi**

Shiraz University, I. R. Iran.

### Abstract

A benefit-cost ratio method was used in the economic analysis of the flood spreading system executed in the Gareh Bygone Plain, Iran. Its very high ratio ( $B/C=22$ ) indicates that this system is a low cost method in desert rehabilitating and artificial recharge of groundwater. Although its effectiveness is very high, its environmental damages are very low.

From interviews with the beneficiaries, some socio-economic effects of the project were studied. Groundwater increase has brought forth the increase in irrigated areas, and has altered the rain-fed farming into an irrigated one. Occupation of the peasants, who are mainly the Arab nomads, has changed from a traditional animal husbandry to agriculture-animal husbandry. Employment and income have increased, and the migration has decreased in the rural areas close to the project.

## 2.8 Infiltration Ability Enhancement in Sedimentation Basins by Sowbugs

**Gholamreza Rahbar & Ahang Kowsar**

Fars Research Center for Natural Resources & Animal Husbandry, I.R. Iran

### Abstract

Turbid floodwater is the only resource available for artificial recharge of groundwater (ARG) in the Gareh Bygone Plain, Iran. Disposition of the suspended load in the sedimentation basins (SB) is a prerequisite for ARG where such waters are used. The crust formed on the soil surface by these sediments substantially decreases the infiltration ability in the SB, thus reducing their effectiveness. Although root channels and surface Cracks should increase infiltration, their total contribution to drainage is insignificant. Fortunately, invasion of sow bugs (*Oniscus* sp.), and a pest of *Atriplex lentiformis* (Torr Wats), has dramatically improved the infiltration ability of the SB; their burrows, with a diameter of 0.7 and a depth of 40-65 cm, which number up to 10 m<sup>-2</sup>, provide an easy access for water to reach the aquifer. The infiltration rate of the sowbug-invaded area, as determined by the double ring method, was 7.3 cm/hr-1 as opposed to 1.7 cm/hr-1 for the control. Cautious introduction of plants attractive to sow bugs is an environmentally sound method of extending the economic life of ARG projects.

## 2.9 Mathematical Modelling of Shallow Water Flow in a Flood Spreading System

**Payman D.Arasteh, S. Reza Vahhadj**

Soil Conservation and Watershed Management Research Center, I. R. Iran

### Abstract

The purpose of this paper is to describe a simple and accurate model to simulate shallow' overland flow in flood spreading basins. A quasi-two dimensional (Q-2D) model is developed because of simplicity over 2D models and more accuracy over 1 D models. In Q-2D model the flow region is divided into several parallel strips. The principle assumption is the negligibility of lateral slope of spreading plains, which means there is no exchange of mass and momentum between flow stripes. A computer program has been provided on the basis of finite difference technique to solve the governing equations. Because of the lack of observation data in flood spreading systems, the model was used to simulate the flow phases for more than 20 irrigation borders and was compared with their observed data. Then the model was used to simulate the overland flow in a flood-spreading basin in Bisheh Zard Basin, Fars Province, I. R. Iran, as a case study.

## 2.10 Optimal Distribution of Artificial Recharge and its Stability

**Associate Professor Nozar Samani , M.Sc. Siavash Behrooz**

Shiraz University, I.R.Iran

### Abstract

A numerical model is used to examine the effects of various management programs on the optimal distribution of artificial groundwater recharge in the Dariyan Plain, east of Shiraz, Iran. Minimizing

draw down, pumping cost and ground subsidence are considered as management goals, and suitable sites for artificial recharge are located. Stability of these sites as optimum sites, in each case, is examined and illustration through the change of pumping, rainfall, recharge and evaporation rate. This study demonstrate that appropriate decisions can be made after careful consideration of basin characteristics and management goals. A definite recharge discharge framework is necessary to select the optimum site and deviation from this can shift the site.

## **2.11 Modeling of Contaminants Transport in a Stratified Aquifer with a Random Walk Method**

**M. Ajalloueian ,M. Bues, L. Demassieux**

Laboratoire de Geomecanique, France

### **Abstract**

A random walk method is proposed for a radial flow in a stratified aquifer. This method was used to one and two-dimensional horizontal flow in previous studies. The model takes into account the variability of properties of aquifer layers in a radial flow field, for example: discharge, thickness and effective porosity. The method is based on the motion of individual particles. The convective component of the solute flux is calculated in a set manner way and the dispersive component is simulated by a random walk motion. Numerical results are in good agreement with the analytical solutions. The model is applied in a radial flow field with a pumping well. Several examples for different types of aquifers are given.

## **2.12 Evaluation of Idje Artificial Groundwater Recharge Project, Esfahan, Iran**

**Dr. Ezatollah Raeisi, Farshad Koohyan Afzal**

University of Shiraz, I. R. Iran

### **Abstract**

An artificial recharge project was implemented in Idje, in southern Iran. Silt-free water from a few karst springs was diverted to 13 recharge basins during the wet periods. Performance of the project was evaluated by measuring the basic infiltration rate at several stages, daily inlet discharge, depth of sediment accumulation on the basin floor and the depth of the water table in a well downstream of the project. Major ions, calcite saturation index and carbon dioxide partial pressure of water samples were also determined. The data obtained during one recharge season indicates:

- The area of the recharge basins significantly depended on the basic infiltration rate.
- Point measurement of the infiltration rate by the double ring method, was not representative of the field. It is recommended to measure the infiltration rate by the water balance method, in a pilot basin with similar sides, slopes and water depth.
- Silt-free karst spring water is suitable for artificial recharge.
- Floodwater in excess of the design discharge, produced several problems such as destruction of the banks, settlement of suspended material and inundation of downstream farms.

A successful recharge project should follow the design criteria during both the construction and operation stages. Overall, most of the designed parameters were in acceptable range in the Idje project. Sediment accumulation and inundation of downstream farms could be prevented if water intake is limited to the base flow of the karst springs.

## **2.13 Rainfall and Floodwater Harvesting through Storage in Paleochannels**

**Prof. Wu Chen, Prof Yu Fenglan**

Hebei Academy of Sciences, P.R. China

### **Abstract**

It is reported that there are more than 300 paleochannels of the Yellow River, Zhanghe River, Hutouhe River, Chaobaihe River and Luanhe River between 0-30m under the ground in the North China Plain. They cover about 45000 km<sup>2</sup>, and are composed of fine sand, silt and silt clay from lower part to upper part. Experiments make it clear that by direct rainfall penetration about 31% of the total rainfall water can be stored underground. The groundwater recharge rate by rainfall penetration is on the average 168,000 m<sup>3</sup>/d-km<sup>2</sup>.

Now in the North China Plain, the aim is basically reached to make the rainfall complete penetrate underground without any flood disaster in condition of Up to 200mm/d precipitation. There is little surface runoff into the sea in ample rain years. Most of the rainwater percolates into the underground paleochannels or is contained in reservoirs, pools and canals. These make the prerequisite for making good use of the rainfall resources.

## **2.14 An Unsaturated Flow Model for Evaluation of Flood-Spreading Projects**

**M. Kouchakzadeh**

The University of Tarbiat, I.R.Iran,

**M. A. Banihashemi**

The University of Tehran, I. R. Iran.

### **Abstract**

Infiltration from the shallow flow which is dominant in flood-spreading projects, is an important means of groundwater recharge in arid parts of the world. Soil moisture profile is changed in time, based on the total soil water potential, soil characteristics, soil moisture content, overland flow depth and other factors. These characteristics of soil profile can be modeled, using a few assumptions, by the Richard's equation, which is a nonlinear parabolic partial differential equation.

Richard's equation, in its one dimensional form, is solved numerically, using finite difference method in order to calculate the variation of soil suction with time. An implicit scheme with explicit linearization is used to discretize the Richard's equation. Applying the algebraic, discretized equation in its general form to all nodes in the soil profile, resulted in a system of equations which is solved using Thomas algorithm, (TDMA). The relationship between soil moisture content/potential and hydraulic conductivity may be obtained either from tabular data prepared in advance for 20 groups of soils (Rijtema 1969) in data files or by the empirical formulas defined in subroutines. The results are

compared with the results of another numerical model called "chemflo", and good agreement between the two can be observed.

## **2.15 Predicting the Formation, Dissipation, and Shape of Mounds Beneath the Artificial Recharge of Groundwater Basins**

**Fardin Boustani**

The Islamic Open University (Daneshgah Azad), I.R. Iran

**Ahang Kowsar**

Fars Res. Center. For Natural Resources and Animal Husbandry, I.R.Iran

### **Abstract**

Artificial recharge of groundwater (ARG) has been recognized as a very important method in Iran. The rise and fall of water table, and the shape of the mounds beneath the ARG basins, depend on the size and shape of the recharge area, on recharge rate and its duration, and on aquifer characteristics. To evaluate the quantitative effects of ARG on water table level several computer programs were developed and compiled. These programs included analytical solutions of Bouwer for rectangular basins, Glover and Hantush for circular and rectangular basins, Baumann for circular basins, and Marino, and Rai and Singh for canals. These programs predict the rate of growth and the shape of recharge mounds. Among these, the Hantush and Baumann methods for circular basins and Bouwer method for rectangular basins, presented many limitations and disadvantages. The sensitivity of mound dimensions in response to aquifer parameters is illustrated. The accuracy of the other methods has been validated by executing them utilizing the observed data from a circular basin in Zeyaran, Ghazvin, and a rectangular basin in western Fresno County, California. Finally, the computer programs have been extended and finalized to predict the shape of recharge mounds developed under the multi-basin and multi-canal projects.

## **2.16 Evaluation of Artificial Groundwater Recharge Using Mathematical Methods**

**A. Fatehi Marj**

Soil Conservation and Watershed Management Research Center, I. R. Iran.

### **Abstract**

Gareh Bygone floodwater spreading initiated in 1982 on the Gareh Bygone Plain, 50 km south east of Fasa Fars Province. Iran. The object of this study is to evaluate the project in terms of groundwater recharge. Due to insufficient data on groundwater fluctuation, groundwater simulation was used in evaluation of the project. Some limited data, like soil moisture in 3 sites of flood schemes, data on wells in 1993 and approximation of the groundwater level in 1978, was used to validate numeric models.

In order to estimate groundwater recharge, two mathematical models were applied. The average annual recharge to the ground, and average annual discharge were estimated. The models applied are three dimensional models of the MODFLOW, and one dimensional model of the SWATRE. MODFLOW was also used in predicting the groundwater table for the next 6 years.

## 2.17 Simulation of Ground Water Flow in an Artificial Recharge System

**Peyman D. Arasteh, S. Reza Vahhadj**

Soil Conservation and Watershed Management Research Center, I.R.Iran

### Abstract

Artificial recharge is a practice to transfer surface water into the ground water basin, by human being. An artificial recharge system is designed with different objectives and by different methods. One of the most important objectives is the use of stored water in dry periods and the most common method of artificial ground water recharging is, the flood spreading. A surface water spreading system particularly increases the infiltration opportunity time by decreasing the flow velocity and increasing the surface storage. The variations of water table level and storage volume are identified by solving the ground water flow equation.

In this paper, we consider the unsteady two dimensional ground water flow. For this purpose a computer program has been written to solve the corresponding equation by finite element technique, and partial discretization method was used to take into account the time dependent phenomena. To verify the model, two analysis methods of Glover and Hantush was used, because of the lack of observation data. Then the model was applied to simulate the growth of ground water mound below an artificial recharge basin in Bishop Zard Basin, Fars Province, I.R.Iran as a case study.

## 3 WATER SUPPLY

### 3.1 Rainwater Catchment Systems: Development and Guidelines

**Professor Yu-Si Fok**

University of Hawaii at Manoa, USA

### Abstract

Rainwater catchment systems (RWCS) have been in use for centuries. However, since most have been developed by users with private funds, few public sector decision-makers acknowledge the contribution RWCS have for water conservation and for water supply by including RWCS construction guidelines in their building code. Due to the great progress in the environmental protection movement and because public water supply systems have shown their inability in satisfying the ever-increasing demands for piped water, the need for RWCS development guidelines, that take these factors, into consideration, becomes evident.

This paper aims to document existing RWCS guidelines; to report the current progress of RWCS guideline development in Hawaii; to present problems related to the RWCS guideline development, especially those problems related to the affordability of the RWCS development in Hawaii; and finally to suggest ways for the establishment of universal RWCS development guidelines.

In summary, using the guidelines developed for Hawaii as an illustration, this paper points out the importance of conducting its cost analysis on items included in the RWCS guidelines. To ensure that they are complied socially and economically, guidelines must be user friendly and affordable.

### **3.2 Operation of Zayandeh – Rud River–Reservoir System, Using Uncertain and Variable Demand**

**Mohammad Karamouz**

Amir Kabir University, Iran

**S. Jamshid Moosavi**

Jamab Consulting Engineers, Iran

#### **Abstract**

Most of the current models of reservoir operation assumed constant demand for water consumption, whereas the demand in any specific month is changing from year to year due to meteorological and climate changes as well as changes in crop patterns, irrigation practice, etc.

In this paper, the need for considering variable water demand has been demonstrated, and ways and means of incorporating variable demands in reservoir operation models have been investigated. Comparisons have been made between the assumption of fixed and variable demands in developing operating policies. The effectiveness and ability of these policies were tested in real time operation, when the demand, in fact, is variable. The application of the proposed models and methodologies have been implemented on the Zayandeh-rud river-reservoir system. The results of this study have shown the significant value of using variable and uncertain demand in modeling river-reservoir systems.

### **3.3 The Optimal River Management by use of Stochastic TIDP (Tracking Incremental Dynamic Programming) Model**

**Ki Ho Park**

Kyungdong College, Korea

**Muneo Hirano**

Kyushu University, Japan

#### **Abstract**

The Stochastic Tracking Incremental Dynamic Programming (STIDP) model with Neural Network which is suitable for analysis of operation policies of multi-purpose and multi-unit water resources system has been developed in this Study. The proposed STIDP method deals with the optimization of decision vectors and state vectors and the newly proposed formula is applied to a real river basin system. Also the prediction of inflows of each reservoir and tributary is executed by use of stochastic sub-routine of STIDP model. The two kinds of clear benefits are obtained from this application: the increasing benefit of domestic, industrial, irrigation, power generation water supply to enhanced IDP model and conventional DP model.

### **3.4 Sacredness of Rain Water in The Iranian Culture and its Harvesting for Drinking and Agricultural Purposes**

**A. A. Movahed Danesh**

University of Tabriz, Iran.

#### **Abstract**

Rainwater has been given a holy place in ancient Iranian culture and religious beliefs, even more after the flourishing of Islam. Rainwater is considered as a highly respectful gift from God, and polluting of it, specially as rain water, has been condemned as sin. In ancient nomenclature for months, the most rainy month of spring in Azerbaijan, is called "Nisan". From the viewpoint of etymology, the month of Nisan is somehow related to the occurrence of continuous rainfall. Rainfall may completely remove air pollutants, and used to be considered as a sacred, ever lasting, holy, and curing material for patients in some regions. In the snowy region of Azerbaijan, snow as the special form of rain, used to be collected in caves for subsequent use during the drought years. Melted snow used to be served for drinking purposes. In southern parts of Iran, direct collection of rainfall used to be implemented by applying a unique system known as the "Berkeh", as the sole source for drinking water. A similar method has been very successfully applied in Boshahr for the dry farming of grapes, figs, and some other crops. The attraction towards a new technology, which presumably should have been done in a logical combination with domestic technology, unfortunately took place separately. Even in some cases, the new technology stands against the domestic one, and further causes its decline. In this research study, by focusing on culture and beliefs, the holiness of rainwater and domestic technology for its use in agricultural products, along with tillage technology for dry farming of grapes in Boshahr (that was conducted by Prof. Movahed Danesh in Boshahr. 1990) will be presented regarding the capability for updating and restoring of aforementioned technology.

### **3.5 The Promotion of Rainwater Catchment Systems in Botswana**

**G. R. Enyatseng**

Botswana Technology Center, Botswana.

#### **Abstract**

Botswana has a semi-arid climate and only two rivers, the Okavango and the Chobe, which are perennial. In many rural areas, there is a scarcity of water for drinking and washing purposes. Rainwater catchment has been recognized by both governmental and non-governmental organizations in Botswana, as having an important role to play in providing some of the country's water supply. There is therefore, a need to provide simple and economical rainwater storage facilities that can be constructed using locally available resources. Although imported galvanized steel tanks have been commonly used in the past, they have seldom lasted well due to corrosion. Imported plastic tanks have also been recently used, and have not lasted long. Reinforced concrete water tanks are expensive and require complex formwork. Brick tanks have also been used, but have proved not to be durable due to poor workmanship, and poor construction details.

A study was carried out in the early 1980s by the Botswana Technology Center (BTC), in order to promote ferrocement water tanks which would be economical and durable. The technology was well received by governmental institutions and other rainwater users, but unfortunately due to poor workmanship and poor quality control, some of the ferrocement rainwater tanks constructed

experienced leakage problems. A joint project between the Botswana Technology Center, and the Rural Industries Innovation Center (RIIC), to conduct a training course in ferrocement tank constructions for artisans in Botswana, and to field test a revised ferrocement tank design, is complete and was carried out in 1994 over a period of 2.5 months, and in 1996 over a period of 5 .5 months.

### **3.6 Rainwater Harvesting for Drinking**

**S. J. Hashemian ,M. Radial, M. Hakimdjavadi**

Institute of Water and Energy, I. R. Iran

#### **Abstract**

Five pilot scale amended watersheds were included in the studies conducted in Dastak, Bushehr from locally available material from which their yield, durability and reliability were investigated. No runoff could be collected from untreated sandy soil catchments. But, the amended catchments showed a good yield of 50-80%. The five catchments were made of asphalt, polyethylene, paraffin wax, concrete and mosaic tiled roof. Runoff collected from the asphalt treated catchment had a yellow colour, but, the water quality of the rest were good. Polyethylene covered with gravel is damaged by grass, thorns and foxes. The concrete catchment and mosaic tiled roof showed a better yield and was considerably the most reliable catchment

### **3.7 Rainwater Catchment Systems and Rainwater Utilization in a University**

**Isao Minami**

Japan International Rainwater Catchment Systems Association, Japan

**Ichiro Kita, Kunihiro Kitamura**

Agricultural College, Ishikawa Prefecture, Japan.

#### **Abstract**

Comprehensive rainwater utilization can be realized through the introduction of rainwater catchment systems in the new campus of the Faculty of Agriculture, Kinki University. For example, Tameike, regulation pond against peak flood discharge and the laboratory of rainwater utilization in an artificial desert.

The construction of the Agricultural Faculty of Kinki University in the Tomio area in Nara city, Nara Prefecture was a very good chance to introduce various rainwater catchment Systems and laboratory of rainwater utilization, which collects rainwater from the roofs of vinyl houses.

This paper shows an example of the comprehensive rainwater utilization namely rainwater storage for drought, flood control, and set up of the new laboratory to study the rainwater utilization in an artificial desert.

### **3.8 An Evaluation of a Village Water Supply Scheme.**

**Wan Nor Azmin Sulaiman, Mohd Nasir Hassan, Mohd Kamil Yusoff, Muda Azizi**  
University Pertanian Malaysia, Malaysia

#### **Abstract**

In Malaysia, upland watersheds support more than 2,500 small community rural water supply schemes. Almost 90% of the projects were implemented by the Malaysian Ministry of Health. This paper presented the physical, technical, economic and social

aspects in the planning of a small rural water supply scheme in a village of about 1,320 inhabitants. The source of data for this study was obtained from questionnaire, interviews and direct field sampling. Environmental problems related to water quality and sustainable flow of water during peak demand were identified to be the major one even though the system is technically efficient. Effective watershed management strategies and future rehabilitation work in the water supply system were proposed.

### **3.9 Utilization of Water for Recreational Purposes in Taiwan**

**Andrew Lo**  
Chinese Cultural University, Taiwan.

#### **Abstract**

Lack of adequate water supply is becoming a new challenging problem in many parts of Taiwan. The extent of industrial development, the people's living standards, and their economic abilities are all higher than those in the 1980s. Every one of these factors represent a much higher demand for water. The demand for residential, industrial, and agricultural water use, may be marginally provided by both surface and groundwater supply. Water use for recreational purposes should turn to rainwater for satisfying many of their needs. Among them, a pavement catchment system at a scenic park, farm ponds for game fishing, and rainwater harvesting at a camping ground, have proven to be very successful in providing recreational water supply. This again adds to yet another potential multi-faceted use of rainwater.

### **3.10 The Effects of Canal Sedimentation on the Adequacy of Releases Through Their Head Regulators – Case Study**

**Salih Hamad Hamid**  
Irrigation Water Corporation, Sudan

**Ahmed Babiker Abu Obieda**  
Hydraulic Research Station, Sudan

#### **Abstract**

Efficient management of irrigation water supplies, particularly in arid regions is becoming more and more important as the demand for Water grows rapidly with the World's increasing population. An essential part of conservation the accurate measurement and regulation of flow discharges. On the other hand, the performance of flow regulators is subjected to changes over time both by external

environment and changes within the system, unless periodic evaluation and adjustments are made. Changes such as canal sedimentation can cause serious problems not only by reducing the canal carrying capacity, but also extent to have considerable effect on the hydraulic performance of the regulators. In this paper, the upper portion of the Rahad Irrigation System (RIS) comprising the main Canal head regulator and the head reach, is taken as case study. The reach has been previously surveyed by a team from the Hydraulic Research Station (HRS) and is found to have lost 43% in average of its conveying section, mostly in the section sides. A negative change in the canal bed slope is also detected. And here the performance of the head regulator under the above physical changes in its downstream reach is investigated, stressing on its behavior during peak demand periods.

The head regulator is found to release only 58% of the maximum allowable design flow, even after the upstream water level has been raised by 64 cm above the recommend design level, i.e. the flow is largely controlled by the downstream channel conditions.

### **3.11 The Instrumentation and Field Testing of a Rainwater Collector**

**Alan Fewkes**

The Nottingham Trent University, U.K

#### **Abstract**

This paper describes the results from field testing a rainwater collector installed in a UK house for a period of one year. The rainwater collected from the system was used for WC flushing. The capacity of the collection or storage tank is critical in the design of such systems. Sizing models have been proposed by researches. but none of the models appear to have been verified or refined using field data.

The collected data was used to assess the sensitivity of the sizing model to the time interval of the rainfall and WC flushing time series. The analysis confirms sizing models should be based on a maximum time interval of one day. The refinement of models to utilize smaller time intervals such as an hour does not result in a significant increase in accuracy.

Rainfall losses from the catchment area were modeled. The inclusion of rainfall loss parameters into sizing models is required but a degree of latitude in three estimation is possible whilst preserving model accuracy.

### **3.12 Urban Water Life Cycle Management in the Sydney Region**

**Dr. Simon Beecham, Mehdi H. Khiadani**

University of Technology Sydney, Australia

#### **Abstract**

Sydney, the largest city' in Australia, is located on the east coast of the state of New South Wales (NSW). The Sydney region has experienced enormous change in the relatively short time since European settlement Resource management for the early settlers focused on exploitation rather than conservation or management. Since the 1960s there has been a community-wide concern for the environment. Sydney's air pollution was that time described as potentially as bad as Los Angeles'. Our rivers were described as grossly polluted and example of soil erosion were identified on a massive

scale. Public concern at this stage centered on conservation and the Australian Conservation foundation was established in 1965. Its membership grew steadily from 1000 in 1967 to 13,000 in 1981 to 20,000 in 1991.

In the 1990s the emphasis has moved towards environmental management and its associated responsibilities and accountabilities. Community expectations in this, as in many other areas, are realized through public actions, voting patterns and, more recently, willingness to pay ( Sydney Water Corporation, 1991)

This paper aims to identify some important environmental issues for the Sydney region. In addition, the social, economic and technological factors that shape our current and future management options are highlighted. For example, public education, appropriate pricing, and newly available water reuse technology all influence our total demand for water supply.

A case study is presented to illustrate some of the main ideas. It describes the management of the Hawkesbury-Nepean river basin. Which provides Sydney with 97% of its water supply.

### **3.13 Water Harvesting For Sustainability in the Indian Arid Zone of Rajasthan**

**M. A. Khan, A. S. Faroda**

Central Arid Zone Research Institute, India

#### **Abstract**

Increased demographic pressure and societal advancement result in acute water shortage for drinking, agriculture and for industrial purposes. This problem is more severe in the Indian arid zone of Rajasthan which is characterized by low and erratic rainfall, high evaporation rate, and low ground water potential. Some of the most viable water harvesting Systems innovated for the sustenance of the local population on a long term basis are the nadi, tanka, and khadin, In many areas, these systems got relegated into relative insignificance with the introduction of a large scale centralized water supply system. However, with an increase in water demand, the traditional systems have been revived and structurally improved for better storage and management of rainwater. The other water harvesting systems which have been found useful and adopted are anicut, gully plugs, Water harvesting dams, water spreading, percolation tank, sub-surface barriers, and sand-filled dams.

Rainwater harvesting catchment is an integral component of any water harvesting system. The catchment may be an impervious land, roof top or paved surface. Runoff efficiency of different types of roof experimented at Jodhpur ranged from 33 to 85% of monsoon rainfall. In case of highly permeable land surface, a catchment may be treated artificially using a suitable sealant. Among the several water proofing materials used for catchment treatment, the Junta emulsion was found most effective with 68% runoff efficiency, followed by sodium carbonate with 66% efficiency.

### **3.14 Study on Reservoirs Storage Regulation for Effective Water Utilization Using DPDP**

**Ichirokita, Konihiko Kitamura**

Ishikawa Agricultural College, Japan.

**Isao Minami**

Japan International Rainwater Catchment Systems Association, Japan

#### **Abstract**

In Japan, the average annual precipitation is 1.800 mm. There are, however, many areas where people suffer from water shortage for agricultural use, due to small amounts of precipitation in irrigation periods, such as, coastal areas of Seto Inland Sea. Generally, in these areas, rainwater is stored in small reservoirs called Tameike, and water is used intensively. When some reservoirs are located apart from each other, there is an imbalance in water supply. It could be that some of them have abundant storage, and others are short of storage because of different conditions, such as the state of rainfall distribution. If some reservoirs have the surplus storage and it can be discharged to be shared among the reservoirs in short of storage, which are connected through a canal, limited amount of water is utilized more effectively. Dynamic programming (DP), has been one of the most powerful methods for optimization of the operation policy of complex water resource systems. Therefore, an attempt to determine the optimal amount of the discharge for the regulation amongst the reservoirs connected to each other, is made by Discrete Differential (DP), which can lead to the optimal solution more effectively. Calculation results suggest that the limited amount of water can be utilized more effectively, due to the regulation of storage among the reservoirs.

### **3.15 Economical Studies of Experimental Catchments Built For Collection of Rainwater**

**M. Rad .S. J. Hashemian, M, Hakim-Javadi**

Sharif University, I.R. Iran

#### **Abstract**

Six samples of catchment basin models were built in Dastak region in Bushehr to compare the expenses and the catchment efficiency. Area and the slopes of the models were almost equal. For an area of about 100 m<sup>2</sup>, the present value, initial and running cost, and the value at the end of their active lives were calculated. The interest rate of 4% was used for the calculation, the annual investment for 1 m<sup>2</sup> was calculated for each model. In view of the average yearly precipitation, and the catchment efficiency, the price of 1 m<sup>3</sup> of rainwater collected, was calculated. For rural, dry areas, per capita consumption of 30 Liter/day of water was calculated and compared for different possible catchments, and the two methods of paraffin covered or cemented basins were the most efficient and economical ways of providing water needs for most rural dry regions of southern Iran.

### 3.16 Different Purpose of Rainwater Catchment in China and their Environmental Effects

**Li Lijuan**

Institute of Geography, China

**Zhang Guoyou**

The Geographical Society of China, China

#### Abstract

In this paper, the types of rainwater utilization in China at present and their environmental effects are discussed. Considering the purpose of rainwater catchment, the three groups are: (a) Roof and courtyard rainwater catchment for drinking purpose; (b) Measures of rainwater catchment in nonirrigated agricultural area; (c) Catchment and utility of floodwater from urban surface. The conclusions are as follows: (a) Rainwater catchment systems from roof and courtyard can make full use of rainfall and supply constant, dependable and clean drinking water for local people. Meanwhile, compared with large water works, rainwater catchment systems have features of small size and scattered spatial distribution, so its negative effects on the environment are less, which is good for conservation. (b) In the northern part of China, rainwater catchment system on sloping lands not only kept water and soil from eroding, but improved crop production conditions, and also reduce sediment into rivers and lightened the burden of flood protection. Deep ploughing and covering measures increased water use efficiency and crop production output. (c) Besides, floodwater collection from a city surface has more direct effects on environment. Floodwater collection can release water shortage problems of the cities, less pressures on groundwater, and less flood hazard in cities. Moreover, after some processes, floodwater can be used as the source in recharge groundwater. It can alleviate the environmental issues related to groundwater. Floodwater can also be used for irrigating trees, grasslands and flowers, or replenishing water bodies to keep delightful scenery in the city. (d) Rainwater catchment system has high development potential in china. Rainwater catchment will be also useful for supplying drinking water to the people who live scattered on the top of Limestone mountains, small islands, and regions where the water quality is bad for drinking. In comparison to transforming good water from long distances, rainwater catchment will be the only easy way to solve this problem of shortage.

Rainwater catchments have a long history in China. Chinese people have compiled and developed various forms of rainwater catchment. They made rainwater catchment an important, even, in some cases the only source of drinking water, both for human consumption and livestock watering and as production in some special areas. With rapid population growth and urbanization, water resource shortages and environmental issues are becoming serious so many governments have their attention drawn to rainwater catchment although it is an old technique. Rainwater

catchment cannot only complete the inadequacy of centralized water supplies, it also lessens existing environmental issues to some places without adverse effects on environmental, since features of rainwater catchments are small scale and scattered spatial distribution. Therefore, rainwater catchment is an important way for utilization of sustainable water resources utilization in the 21-st century. The authors sum up the purposes of rainwater catchment, and discuss their environmental effects in this paper, based on present practices of rainwater catchments in China.

### **3.17 Planning Strategy Study for Roof Rainwater Catchment Systems**

**S.C.Chu, C. H. Liaw, Y.L. Tsai**

National Taiwan Ocean University, Taiwan

**J.C. Chen, J.T.Chen, S.C.Lee**

Industrial Technology Research Institute, Taiwan

#### **Abstract**

With the Sustained growth of economy in this country water demand has been on the increase at an alarming rate. On top of the added natural environment restrictions and public awareness of environmental production, the traditional water resource development approach has encountered many problems that resulted in water shortage in many regions. Exploration of alternative water sources to alleviate deficient water resource has become the top research priority in the near further.

Taiwan is a rainfall abundant country. Using rainwater catchment at building rooftops should be a potential feasible solution to supplement public water supply. The water right controversy does not exist with the easily collected rainwater. It has been widely used and promoted in many foreign countries. The size of catchment system depends on the water demand. Hydrologic conditions and the cost and benefit of the investment

This study initially examines the demand and hydrologic conduits. The water input is simulated using several rainfall record intervals such as daily or weekly records. and the Critical Period Technique Sensitive analysis is conducted on the variables on the affecting the system that include catchment area .duration of rainfall records. and water demand. Similar analysis is repeated using the Gould's Matrix Method . Results from both analysis are compared .The relationship between water release .storage capacity, and rooftop catchment area is established under different water demand conditions. This information would be useful and essential for the planners and decision -makers in selecting and optimizing the best rainfall catchment system design.

### **3.18 Design of Rooftop Rain Catchment Systems in Micronesia**

**Dr. Leroy F. Heitz P.E., Dr. Shahram Khosrowpanah P.E.**

University of Guam, USA

**Dr. Stephen Winter**

Appropriate Technology Enterprises Inc.

#### **Abstract**

This paper reports on the results of a research study funded by the US Geological Survey, Water Institute Program through the University of Guam Water and Energy Research Institute of the Western Pacific (WERI). The purpose of this project was to develop and disseminate criteria to be used in the design of new or refurbishing of existing individual water supply systems for various islands in the Federated States of Micronesia (F.S.M). The end product was a set of design criteria for sizing combined rooftop rain catchment systems (RRCS) / groundwater systems so that these systems can provide a continuous Water supply even during drought conditions.

A Windows based computer simulation model called "ROOFRAIN" was developed to evaluate the effectiveness of various RRCS configurations for varied use rates. An inventory of use rates, catchment sizes, and tank configurations was made for various island groups in the Federated States of Micronesia. This information was used to update and verify past studies, which have been made concerning water consumption in Micronesia. Rainfall data and water use rates served as input to the RRCS model. Output from the model was used to develop a set of design tables to be used by island sanitariums and residents in planning the design of new or the upgrading of existing RRCS systems. A brochure containing these tables has been printed and is being distributed to be island residents in the Federated State of Micronesia.

### **3.19 The Value of Rainwater and the Importance of Storage in Iran**

**Zahra Salahy Eslam, Zohre Araby Nejad**

Abhar, Iran

#### **Abstract**

About 75% of the Earth is covered by water, 3% of which is edible. Unfortunately, due to rapid changes taking place with industries due to new scientific achievements, mankind has been polluting this little edible water, either supplied by rain or snow, or stored in dams. Seasonal rainfall and atmospheric precipitation in general, is a valuable investment on nature's part, which manifests for different regions of the Earth. Depending on the level of education and experience of the rural inhabitants in the region, catchments are used to collect and store rainwater for drinking, agricultural purposes, forestation etc. The Value of rain in the dry belt region, where drought is felt in extremes by me inhabitants, is such appreciated compared to the regions where water is abundant.

Study of me past shows the importance of rainwater collection in various manners. The people of Iran are the founders of reservoir dams construction, and are the inventors of the 'ghanat' excavation in the past era. Others have learnt this technique from the Iranians, and it is a pleasant coincidence for the 8th International Rainwater Catchment Systems Conference to be held in the country where the people themselves are one of the first inventors, innovators and founders of the rainwater catchment systems. Iran's ancient dams, and the manner in which they stored rainwater in the olden days, and the method used to transfer, divide, and distribute the water amongst people, particularly the farmers, is an issue which has been considered by historians.

The term 'dam' is the synonym of 'barrier'. Dams have been built from the old days in Iran to the water level in rivers in older to divert the water to the banks. In ancient Iran such dams where called 'shadravan'. Some historian acknowledge Iran as one of the first countries to be familiar with the dam building technique. We can find remains of 59 remains of 59 barriers or dams in various parts of the Islamic Republic of Iran. Due to irregular rainfall temporal pattern in Iran, many rivers and water resources are seasonal and no doubt, counting on these resources to fully satisfy the water demands may not be possible.

## 4 HYDROMETEOROLOGICAL ASPECTS

### 4.1 Theohydrology/ Hydrotheology , Rainwater Catchment in its Broadest Perspective

**Prof. Richard Heggen**

University of New Mexico, U.S.A

#### Abstract

In virtually every theological understanding. Rainfall is a gift from God. Rainfall is a soothing resource having an aesthetic of its own. Throughout recorded history and over the world, humans have looked into rain for a hint as to the nature of God. A reevaluation to many has been the concept of cycle the perpetual replenishment of both physical and spiritual sustenance.

In early times, God was employed as an explanation for all things. Divine will sufficed to explain why a river ran downhill. Nature was the handiwork of God. With the advent of scientific through however, a reverse occurred in philosophical viewpoint. The world's "natural" laws and measurable behaviors became a basis for theological understanding, The European God become the supreme mechanical engine.

With the scientific revolution, science might have replaced religion altogether. But in fact, the two viewpoints found mutual reinforcement in a common natural phenomenon. The synergistic understanding was in the hydrologic cycle. Nature mimics the cycle of life ordained by God (proof of the nature of rainfall to the theologians of the time) and God property obeys such laws as conservation of mass ( proof to the scientists).

The circle, the completed cycle, has symbolic meaning in most faiths. The circle has explanatory power in most scientific domains. The circle has an artistic attraction in fact, to many who deny allegiance to any theological or scientific perspective

This paper reviews the intertwined history of religious belief and scientific study, as both have addressed the basis of rainfall. The theme of the completed cycle is the bond. The paper makes use of historical illustrations by religious artisans and scientific explorers.

In this larger perspective, rainwater catchment is not just some socio-economic-technical endeavor, Rainwater catchment is a window, albeit one, into the human desire to reconcile the physical and spiritual world

### 4.2 Evaluation of Three Continuous Rainfall-Runoff Models, A New Approach

**F. Sharifi**

Soil Conservation and Watershed Management Research Center, Iran

#### Abstract

Three water balance rainfall-runoff models, the 3 parameter SFB, the variable source area A WBM model and the 11-parameter SDI model are compared using data from 8 natural catchments in Australia to evaluate the accuracy of runoff predictions. Parameters are estimated by optimization using the total stream-flow and on separated base-flow and surface runoff. Parameters are also

estimated directly from individual events using base-flow recessions and water balance calculations. Parameter estimation directly from Individual events shows promise and should be further investigated. Parameter estimation based solely on the total stream-flow may present misleading results, and errors in predicted base-flow and surface runoff may cancel each other and give approximately correct total flows. Results of this study show that the number of parameters and the degree of complexity are not the only requirements for modeling accuracy and a simple model with a good physical basis can give a good prediction.

### **4.3 Back Propagation Neural Networks in River Flow Forecasting**

**Prof. Huynh Nong Phien**

Asian Institute of Technology, Thailand

**Mr. Nguyen Tan Danh**

Southern Hydraulic Research Institute, Vietnam

#### **Abstract**

Back Propagation Neural Networks have been widely and successfully used for forecasting in various fields, especially in stock market prices. In this study, they were used to forecast daily river flows in two basins, namely the Da Him and LA Nga basins, in Vietnam. It was found that the Back Propagation Network Models Provided satisfactory forecast discharges for both basins. Moreover, the discharges were also forecast from data of different stations within the La Nga Basin input directly and separately to the model. In this case, however, the model took longer time to run and the correspondent forecast discharges were not as accurate as when those obtained with mean value data.

### **4.4 Seasonal and Long-Term Behaviour of Rainfall in Sub-Saharan Africa**

**Eng. Dafalla Mohamed Yousif & Eng. Mufaddal Eltayeb Mohamed**

Ministry of Irrigation, Sudan

#### **Abstract**

Sub-Saharan Africa (SSA) spans latitudes that include both desert and tropical weather conditions. Floods and drought usually take lives and damage property. In Africa drought has seriously damaged national economies and affected the well being of African people. The persistence of drought conditions for more than two decades in Sub-Saharan Africa has prompted a wide variety of analysis.

The statistical analysis has been carried out for climatological records for many stations spreading all over the Sudan, which will represent the Sub-Saharan Africa (climate in the Sudan varies from desert in the far north to equatorial in the far south). However in these statistical analysis it is aimed to understand the long-term behavior and trend of rainfall to cope with drought in the region. Using time series analysis the general trends for all selected stations have been determined, which have shown decreasing trends. Frequency analysis is used for the determination of suitable distribution for annual and monthly rainfall. Hence, the amount of rain associated with certain probability of occurrence can be predicted. Such findings would be useful for design and planning to cope with drought

## 4.5 Forecasting Drought in Western Provinces of Iran: A Time Series Approach

**Prof. Mohammed Reza Meshkani**

Shahid Beheshti University, Iran

### Abstract

Undoubtedly, drought is one of the worst enemies of man. Various definitions have been proposed for drought especially from agricultural viewpoint. They all boil down to construction of some indices which form the basis of drought evaluation. These indices do not enjoy universal application. In various zones, some indices are more suitable than others.

One of the numerous indices defined for drought is de MARATONNE's aridity index. It is used to define climatic limits of deserts, prairies, and forests.

In this paper, we construct a historical set of monthly drought index by using meteorological data for Kerman shah and Kurdistan provinces. The index used is de MARATONNE's and the period is 1970-90. These time series are then modeled as stochastic systems. The models have been used to forecast the future values of the drought index for 1991-95. A Comparison of observed values and predicted values for 1991-93 proves the capabilities of these models.

## 4.6 Complex Hydrological Analysis of the Kardeh Reservoir, and its Effect on the Flow Regime

**Abolfazl Mosaedi, Istvan Zsuffa**

Technical University of Budapest, Hungary

### Abstract

Water is a subject of great importance for people and their environment. Decisions on the utilization of water depend mainly on its availability, variability and usefulness both in space and time. The situation is more complex in the arid and semi-arid regions of the world. The problem is that in short period it is too much which results in floods, and for long periods it is too little and there is not enough water. Reservoir plays a vital role in controlling floods.

A special method has been utilized in this study to evaluate the flow regimes of the Kardeh River and the possibility of diverting its water for water supply and for irrigation in farms, with different yield-demand situations and probability conditions.

In this Study the following analyses are considered:

- Time-series analysis;
- Statistical hydrology (homogeneity test; probability distribution of high and low water; complex analysis of high water period);
- Special applications (water resources estimation; and reservoir computation for water supply and complex purposes and for flood attenuation).

The daily discharge statistics of the Kardeh river, for the 1964-1989 period, are utilized in this work. Based on the reservoir yield function curves, a suitable size can be selected for the reservoir to meet the water demand at Kardeh. Also the flood attenuation by the reservoir is analyzed, using design

flood waves and reservoir, simulation. While designing for flood waves of different probability, different weir types and weir sizes are analyzed for different storage levels and base flow during the flood. Moreover, by using reservoir simulation, the so-called 'simulation based on long discharge time series method', different weir types and sizes for different storage levels and base flow are investigated.

#### **4.7 The Effect of Urbanization on the Increasing Trend of Flood Occurrence: A Case Study of Tehran**

**Amir Saberi**

Ministry of Jihad sazandegi, I.R.Iran

**Jamal Ghoddousi**

Soil conservation and Watershed Management Research Center, I.R.Iran

##### **Abstract**

The development of urban dwellings and establishments has always caused significant problems due to the increase in population and transformation of farmlands into urban areas, which in effect has brought about a transition in the natural ecosystem structure and hydrological balance of these regions. The hydrological imbalance of water zones not only cause large floods and a fall in basic runoff, but is also a cause for erosion. Of other urban occurrences is the changing of the urban natural waterways. With the changing of these waterways and the urban areas seepage increase and expansion will increase dangers caused by floods. In Tehran, in the last four decades, flood occurrences have been on the rise. In a way that, in the first decade, 14, in the second 15 and the third and fourth 33 and 54 cases of flood have occurred respectively.

To review the causes of flood increase in Tehran we conducted Studies in the hydrographic zone networks and the natural and morphometric characteristics and surface runoffs of the zone and ultimately review was carried out regarding the relation between urban development and the increasing trend of floodwater taking into consideration the CN and rational methods.

#### **4.8 Atmospheric Views in the Glorious Quran, and Related Climatological Findings**

**Abrahimi, N. G. Sepehrian, M**

Natural Resources and Animal Research Center of the Jihad-e-Sazandegi, Iran

##### **Abstract**

The holy book of the Quran, is a collection of all heavenly books, with the view of Imam Ali as the Messenger. It is a source of science 'which has not neglected anything' (The Sow sureh, verse 38).The Quran has different dimensions, and with advancing time, newer dimensions of its facts seem practical. Nearly 1,400 years ago, The Glorious Quran expressed observations and approaches in different verses such as Yunus, verse 10; The Family of Imran, verse 3; Elevated Places, verse 7: etc. These have valuable advise for the people with regard to viewing, thinking, paying attention to the facts of nature and the well-organized creation. Natural phenomenon which are repeatedly mentioned by the holy Quran are of the wind and rain, which arc the communication and mercy of Allah. These

phenomenon have been presented in about 120 verses, directly under different names, faces and signs, either together or separately.

This article briefly attempts to describe a special view of the Quran with regard to the great mercy of Allah (Rain), by introducing some verses along with translation, views and interpretation; it's adaptation in new scientific views in the field of climatology, such as wind production, general circulation, classification of wind, types of clouds and rain, and effective factors on precipitation, etc.

#### **4.9 A Distributed Hydrological Model using a Four Kilometer Square Grid.**

**Dr. M. A. Sheikhzeinoddin**

Birmingham, USA

##### **Abstract**

A distributed parameter model was developed to simulate the hydrologic response of a watershed. The model was written in Fortran 77, and was run on an IBM 3081-D mainframe. The model was designed to accept NEXRAD (Next Generation Weather Radar), hourly rainfall data, whenever available. The model used the Green and Ampt method for infiltration, kinematic routing for overland flow and channel flow, and exponential decay relationships for interflow and base flow from groundwater. A 4\* 4 km grid size was used for the examples in the study, which is approximately the size of one pixel of NEXRAD imagery. Each cell had one or more in-flows from other neighbouring cells, but it had one out-flow to the adjacent cell in the down gradient direction. This process from cell to cell continued until the runoff reached the main channel. One calibration storm, as well as two verification storms for the Tallapoosa river basin was simulated to evaluate the model's performance. Also, a series of sensitivity analysis runs were made to show the effects of different parameters on the outflow hydrographs. The model effectively simulated the runoff hydrographs at the outlet of the watershed. The model can also be used to simulate the effects of land use on runoff hydrographs.

Impervious grid elements can be specified in the model to represent urbanization of the watershed. The Kalman filter was used to generate feedback from measured flow to update the state variables and the flow rates. The application of the Kalman filter was found to remarkably improve the accuracy of runoff hydrograph predictions.

#### **4.10 An Investigation into Rainfall Runoff Processes aiming at Estimating Runoff from Ungauged Catchments**

**F. Sharifi**

Soil Conservation and Watershed Management Research Center, I. R. Iran

##### **Abstract**

Different methods in the estimation of flow characteristics of catchments and the concepts of runoff generation from rainfall are reviewed. Several of the most widely used rainfall runoff models are discussed and comments on the selection, optimization, evaluation and problems associated with parameter estimation of these models are made. The use of these models in ungauged catchments is also discussed and some comments are made.

## 4.11 Analysis and Evaluation of Important Models for Estimating The Potential Evapotranspiration

**Dr. A. N. Darir**

Aleppo University, Syria

### Abstract

Evapotranspiration (consumptive use) is a key factor for estimating irrigation requirements and this depends on the climatic circumstance.

Evapotranspiration (ETP) can be determined by direct measurements, empirical climatic formulas or by using evaporation measurements as indices. Direct measurement will give the best evaluation of ETP if it is available.

In this research, 12 well-known climatic empirical methods have been selected from literature and used for estimating potential ETP under semi-arid areas, which is similar to the northern part of Syria.

The original data were derived and adapted from the meteorological station (Tel hadya, Jindiress and Breda), thus the purpose of this research is to select a few of the most popular methods for estimating the potential ETP in semi-arid areas. The methods used in this study were compared with the direct measurement methods (Class A Pan, Lysimeter).

Daily and monthly potential ETP values were calculated and used for the statistical analysis which showed significant differences between the observed and expected values. The latter were calculated from the formulas of both Thornthwaite and Mayer. In conclusion, these two formulas were not applicable for the semiarid areas such as those prevailing in northern Syria. The other ten formulas were not significant and proved to be correct.

## 5 WATER QUALITY

### 5.1 Collection of Runoff in Urbanized Catchment for Augments for Augmenting Storage in Conventional Water Impoundment Schemes

**Dr. Adhityan Appan**

Nanyang Technological University, Singapore

### Abstract

Limited land and competing demands for its use from an ever-increasing industrial sector has led to the maximization of land utilization in Singapore. Currently almost half the land of 631 square kilometers is being used as water catchment. This includes some urbanized areas where there is intense high-rise buildings, light industries and paved areas. The main objective of this paper are diverted to storage ponds after, which the water is pumped /gravitated to the impounding reservoir which receives surface runoff from less urbanized areas. The waters entering these ponds are closely monitored and sensors ensure that only qualify level that are -acceptable are directed to the storage ponds followed by selective onward transmission. These collection systems, which have been in existence from 1985, are operating quiet successfully. Special systems were designed to prevent the

ingress of rubbish and to accentuate sedimentation. The quality of the raw water obtained is comparable to that from a conventional protected catchment. It can be concluded that, with proper management including improved water quality monitoring systems, urban storm runoff can be successfully collected and stored as a raw water can be transferred to an impounding reservoir to augment the Storage volume.

## 5.2 The Role of Seepage Velocity on Contaminant Transport Through Saturated and Unsaturated Soils

**Dr. Kazem Badv**

Soil Conservation and Watershed Management Research Center, Iran

### Abstract

The contaminating effect of the percolated rainwater through the waste in landfill sites, one from rainwater catchment areas, was studied in an environmental perspective. The effect of the seepage velocity of the Percolated rainwater on transport of contaminants through the underlying granular soils of the landfill site was evaluated by a series of laboratory experiments together with the analytical Study. Results showed that the effect of seepage velocity in migration of chloride through the unsaturated granular materials such as fine gravel and coarse clear stone was significant and for the range of seepage velocities examined, the dominant transport mechanism was by advection. However, for the case of saturated or nearly saturated material such as fine sand and silt, this effect was not significant and the dominant transport mechanism was by diffusion.

## 5.3 Quality Issues in Rainwater Harvesting for Kenya

**Dr. G.K. Bambrah**

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**Ms. S. Haq**

Velochem Ltd., Kenya

### Abstract

Although Kenya leads the way in utilization of rainwater catchment in Africa, in the recent past many reservations have been expressed about the suitability of using untreated rainwater for human consumption in this country. This paper is a response to this concern and contains a review of rainwater quality for Kenya.

Unfortunately, there is no available comprehensive field study or other record on evidence to support of case for use of untreated rainwater for potable uses. In practice however, in large parts of Kenya, particularly high rainfall areas surrounding Nairobi, rainwater is certainly utilized for household uses and human consumption and in many cases the rainwater is not even pre-treated in any way before use. Due to lack of resources, the authors were unable to carry out a practical research study on this subject. For this reason, the present paper has necessarily been limited to a review of existing literature and analysis of the information contained therein, to derive a framework for assessment of rainwater quality in Kenya.

Key words: Rainwater, Quality, Potable, Kenya.

## 5.4 Urban Storm Water Re-Use: Opportunities and Constraints

**R. A. Ghafouri**

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**Dr. B. C. Phillips**

Willing & Partners Pty. Ltd, Australia

### Abstract

It is increasingly being recognized that new urban development and/or re-development of existing urban areas require the formulation and implementation of new practices which recognize that both storm water and wastewater are a resource not a nuisance to be disposed of as quickly as possible into receiving waters. In recent years this has led to the greater consideration of re-using storm water and wastewater after treatment as a recycled water supply.

The issues surrounding the possible re-use of storm water are discussed through the presentation of two case studies of possible storm water re-use schemes for urban catchments. These studies included a review of water quality requirements for re-use contained in Australian and international guidelines and the effect of climatic conditions and the temporal distribution of water demands on the utilization of storm water.

It is concluded that while the cost of re-use water is currently still greater than the cost of potable water in Australia, any decision on a storm water re-use scheme should not only take into account an economic analysis but also count other factors including social and environmental factors. However, the cost incurred in supplying potable water continues to increase as greater and greater demands are placed on the drinkable water resource by population growth and economic development. Over time, the cost of re-using storm water and/or treated wastewater will become more cost effective in comparison with simply using potable water for irrigation and domestic outdoor activities.

It is also concluded that in arid and semi-arid zones of Australia, a growing practice is to implement aquifer Storage and retrieval (ASR) schemes to Capture, store and re-use Storm water. ASR schemes can also improve poor quality groundwater which typically allows the mixed water to be used for irrigation Purposes.

## 5.5 Use of Horizontal-Flow Roughing Filtration Combined With Slow Sand Filtration in Rural Areas

**Wang Yungsheng**

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### Abstract

The article deals with an appropriate rainwater treatment process, horizontal now roughing filtration (HRF) combined with slow sand filtration (SSF). The great advantage of this process is its safety and stability, simplicity and reliability in rural areas. The practical experience of Hebei Province in China has shown that the combination of HRF and SSF can remove nearly all turbidity from rainwater.

Much of the original organic material present, a large proportion of any color, and nearly all bacteria. The process ,will have a potential in future rural rainwater technology of China.

## 5.6 Sources of Pollution for Rainwater in Catchment Systems, and Environmental Quality Problems

**Seyed Ahmad Mirbagheri**

Shiraz, University, Iran

### Abstract

This paper brings about the study on point and non-point sources of pollution for the rainwater in the catchment systems. Rainwater quality and pollution are evaluated by the means of physical, chemical, and biological changes. Pollution from the atmosphere, soil surface and soil water interaction are determined and reported. Sediment and toxic materials are two main pollutants in the study area. Pesticides used in this study are were Molinate and 2Methyl-4-Chlorophenoxyacetic acid. The maximum concentration of Molinate was measured where the suspended sediment was maximum. It is necessary to adopt environmental and agricultural policies in order to control the water quality in catchment systems.

## 5.7 Rainwater utilization for fluorosis control

**Prof. Bo Ling**

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### Abstract

Rainwater catchment systems are regarded as the most appropriate technology for water supply in dry, fluorosis endemic areas. As is known, when the alternative water source which has normal fluoride levels, such as river, stream, spring, deep well and rainwater is adopted, the waterborne disease can be controlled or possibly eradicated.

Since 1985, instead of high-fluoride water, the rainwater has been, directly or indirectly, utilized to supply the drinking water in Ningxia and Gansu of China. A total of 373.000 people who live in the fluoride endemic areas have extricated themselves from a fluorosis predicament at low cost.

## 5.8 Combined Application of Rainwater and Treated Sewage for Irrigation of Multipurpose Trees

**Masoud Bagerzadeh Karimi, Anoshirvan Najafi**

Natural resources and veterinary research center, Eastern Azerbaijan

**Mohammad Moghadam Vahed**

University of Tabriz, Iran

### Abstract

In order to use a combined water rain and treated sewage sludge, an experiment was conducted on "Vitis Vinifera" grape, following a complete randomized block design with there treatments in six replicates in the Turkey Research Center Station situated in the village of Tatar on the southern margin of Aras river in 1996. There year old grape saplings were used as experimental material. Teb saplings were planted in each experimental plot.

The irrigation treatments included:

1. Collected rainwater.
2. Treated sewage, and.
3. A 1:1 ratio of combined rainwater and treated sewage.

Total weight, mean diameter, quantity, appearance and freshness, and largest core diameter of one-year twigs were evaluated at the end of first year of growth. Variance analysis of the obtained data did not reveal significant differences among treatments. On the other hand, obtained mean values from the treatments of sewage were significantly low as compared to other treatments. This phenomenon may be related to the high concentration of dissolved salts and moisture retention capacity of treated sewage. Nevertheless, application of a combined rain water and treated sewage sludge removed aforementioned drawback characteristics, and furthermore, increased the number of twigs, appearance and freshness, and mean weight of one year twigs in comparison to the saplings treated solely by rain water. Even though collected data did not reveal a significant differences within two mentioned treatments during the first year of experiment, it is predicted based on observable evidences that the combined treatments of rain water and nutrient rich treated sewage sludge, will show promising results during proceeding years.

## 5.9 Fluctuation in the Quality of Rainwater Stored in Indoors Container

**Prof. Kunihiko Kitamura**

Ishikawa Agricultural College, Japan

### Abstract

There are many regions around the world where only rainwater is the main water source for drinking or domestic use. In these regions rainwater cistern systems play an important roll in supplying water. Also in Japan, it has been recognized that rainwater should be utilized as a new water source to mainly save tap water in urban areas. In addition to such uses, it is considered that rainwater can be used instead of tap water when sources cannot supply water because of the damage caused by a disaster such as an earthquake. Rainwater itself has a good water quality. Therefore, if rainwater is immediately used after it is collected there is no problem in its utilization as to health safety. Change in its Water quality, however, may take place during storage for a long period. There is a need to investigate fluctuation in the rainwater quality during storage for its safer use. For this purpose rainwater falling OD a greenhouse was collected through the gutter fitted to its lower part and stored in a polyethylene container. The water quality of the stored rainwater was analyzed periodically for three months without addition of more rainwater during the trees month's summer. The result show that there is a little fluctuation in the water quality.

## 5.10 Salinity Reduction in Groundwater by Floodwater Spreading

**Abdolhasan Pooladian**

Nomads Affairs Administration, I.R. Iran

**Ahang Kowsar**

Pars Res. Cen. for Nat. Resources and Animal Husbandry, I.R. Iran

### Abstract

Shortage of fresh water is the main limiting factor in the development of the Gareh Bygone Plain (GBP), 200 km to the SE of Shiraz, Iran. Floodwater spreading for artificial recharge of groundwater (ARG) In the GBP has substantially increased the volume and noticeably reduced the salt content of the reserves. Over pumping during the drought of 1992-93 resulted in an alarming salinization of groundwater, while the ARG of 1993-94 reversed the trend. This, along with a concentric increase in the electrical conductivity (EC) of well water is an indication that ARG enhances water quality as it simultaneously increased its volume in the aquifer. The EC ranges from 1.261 dsm-1 in the center of GBP-ARG systems to 11.640 dsm-1, about 5 km from it.

## 5.11 Hydrogeochemical Study of Dryland Salinisation in the Burkinbah Creek Catchment, Cumnock, New South Wales, Australia

**Gholam Abbas Kazemi, William A. Miine- Home**

University of Technology, Sydney, Australia

### Abstract

Buckinbah Creek Catchment, 80 km in area and located 350 km northwest of Sydney, is under the threat of dry land salinisation with patches of salt scalds spreading throughout the catchment .To identify the causes of dry land salivary and possible mitigation options, an extensive hydro geological study is currently being undertaken. As part of this study, 17 shallow piezometers have been drilled to supplement the private bores in monitoring water table and providing water samples. Previous works elsewhere in the region have shown that shallow groundwater flow systems are significant factors in salt transport

The initial investigations indicate that saline sites are in areas with less than 2 meters depth to groundwater. The groundwater ranges from 337 to 4610 ppm in total Dissolves Solids. Chloride, Sodium, and magnesium are major ions of the groundwater chemistry reflecting the concentration of seawater. Rainfall rate of 600 mm per annum together with high recharge rate as a result of land clearing have contributed to the rising of the water table. Geological structures in some cases have served as pathways for seepage of groundwater to the ground surface, and very complex groundwater flow paths are indicated.

## 5.12 Effect of Water Flow and Water Intake Variations on Quality Reduction of Karoon River in Khuzestan

**N. Djaafarzadeh**

Ahwaz University, I. R. Iran

**K. Morowati, A. M. Feghi, S. Rostami, H. Kaabi**

Environmental Protection Head Office, I. R. Iran

### Abstract

This survey tried to evaluate the results of filed research and library studies by using the meteorological and hydrological data in determining the quality reduction mechanism of the Karoon and Dez rivers.

The results of studies during 1994-95 show the changes of river water quality from north to south in the Khuzestan Province.

The survey shows the correlation between the increase of water intake and wastewater discharge into the river; and the reduction of river water velocity in the lower section of the river reducing the dissolved oxygen of the Karoon.

These results also show that because of the increasing sedimentation and probably by anaerobic decomposition of organic matter in bed sediments, the taste and odor of the water has increased in many places where water intake has occurred. On the other hand, for this reason, the biodegradable organic load in the water has increased.

Based on these results, the reduction in the volume of water now during some months in each year; and pouring of municipal and industrial wastewater, and excess water from agriculture fields into the orientation of these rivers, are the most important factors for the reduction in water quality of the Karoon and Dez rivers.

## 5.13 Quality Of Water and Extent of Pollution in Parts of the Central Yamuna River Basin

**Dr. M. R. D. Farahani**

Nai- Wali Gali, India

### Abstract

The area lying in the upper Ganga-Yamuna Doab is comprised of the districts of Ambala, Karnal, Sonapat, Panipat, Faridabad, Gurgaon, Ballabhgarh and Union Territory of Delhi. The northwestern part of the Yamuna basin covers the Indo-Gangetic plain and is composed of alluvium of the quaternary to recent age. From the lithological logs of bore holes drilled to a depth of 120 m, it is seen that alluvium down to 120 m essentially consists of clay, clay with kankar, clay with sand or silt, fine to coarse sand with kankar and occasional gravel beds. In the western part of the Agra district, Vindhyan sediments are exposed in the western part of Mathura district. On the other hand, Aravali rocks appear which represent quartzite.

Samples from both surface effluents and various groundwater bodies reveal a significant increase in various contents. The concentration of biological oxygen demands and total suspended solids in the

effluents may be extreme in the case of wastewater from Delhi Milk Scheme, where BOD is generally over 2,000 mg/l.

The concentration of total dissolved solids (TDS) in water samples from Union territory of Delhi (near Yamuna Bendh, Okhla and Najafgarh), Faridabad, Mathura and Agra districts contain more than 2,000 ppm, thus being unsafe for irrigation or domestic purposes. Chloride in drinking water is generally not harmful to human beings until a high concentration is reached, although the chlorides may be injurious to some people suffering from diseases related to the heart and kidney. The chloride concentration in Agra, Mathura and at some places in Delhi is quite high due to their large-scale development of pulp and paper, food processing and chemical industry in these areas. Similarly, die abnormally high concentration of SO<sub>4</sub> in Agra and Mathura districts is due to the heavy coal using industries and foundries in this part of the basin. The high concentration of bicarbonates in Agra, Mathura and Delhi is mostly due to the bathing ghats along Yamuna river.

### **5.14 River Water Quality Classification of Selected Catchments in Langkawi Island, Malaysia Using Harkin's Index**

**Mohd Kamil Yusoff, Muda Azizi, Wan Nor Azmin Sulaiman, Mohd Nasir Hassan,  
Mohd Sukri Shafiee**

University Pertanian Malaysia, Malaysia

#### **Abstract**

Keywords: Water catchment, water quality index, classification river.

The study on river water quality was carried out in Langkawi Island, Malaysia and two catchments were selected: Sg. Melaka and Sg. Kubang Badak. Ten water quality parameters were analyzed; DO, EC, temperature, pH, BOD, COD, AN, turbidity, TSS and TDS. The results and discussions presented are based on the sampling and analyses carried out in 1995.

From the study, the rivers were classified into certain classes based on Harkin's water quality index (WQI). The classifications of the rivers were then mapped accordingly to its classes. The results shows that most of the stations located at the downstream experienced serious pollution especially in terms of BOD, COD, TSS and AN. The worst sampling stations are SM1, SM2 and AMI6 in Sg. Melaka catchment as far as water quality index is concerned, the sectors of Sg. Melaka fall into three classes Class I, II and III while in Sg. Kubang Badak Catchment only Class I and II. In general, Sg. Melaka catchment is severely polluted compared to Sg. Kubang catchment. This is due to construction, agricultural and housing activities in the vicinity.

The study concludes that there is a relationship between river water quality and its activities in the vicinity such as construction of the Langkawi International Airport; agricultural such as paddy cultivation and rubber plantations; and discharges of domestic wastes within the study areas are the main impact on the river water quality.

## 5.15 Evaluation of the Impact of Rainwater Harvesting on Water Resource Quality

**I R. Amir Taebi-Harandy**

Isfahan University of Technology, I. R. Iran ,

### Abstract

Rainwater harvesting through the use of rainwater catchment systems in agricultural areas may impact and reduce the water resources quality, especially groundwater. With recognition of the sources of pollution, the quality of the water can be protected. The purpose of this study is to design a thought-provoking checklist to help individuals analyze their own water supplies, and the water agencies to plan and manage the water pollution control.

The designed checklist consists of several short questions along with explanation for some of them. It has four major sections including: (1) basic information about the area, (2) farm's potential, (3) off-site potential, and (4) agricultural chemical potential to pollute the water resources. In the first section, questions about the drinking water supply, sampling, testing, climate, and soils are designed. These questions give insight to the questionnaire to perceive other important parameters for optimization and localization of the area's project. In the second section, all farm's potential in the third section are designed to assess the impact of off-site rainwater harvesting on the area's water quality. The questions in the fourth section are useful to evaluate the agricultural chemical potential in polluting water resources.

Based on the result of this study a checklist is designed. The checklist provides information about potential sources of water resources pollution in farming areas in which the practice of rainwater harvesting is applied. This information can be useful for both individuals and water agencies to control the impact of rainwater harvesting on the quality of area's water resources.

## 5.16 Environmental Assessment of Low-Water Sediments in Rivers of Belarus

**Vladimir Savchenko, Nina Tanovitskaya**

Academy of Sciences of Belarus, Belarus.

### Abstract

Low-water sediment is a specific thin layer of bottom sediment deposited within river shallows under minimal water discharge. Natural features of the low-water sediment composition are illustrated by an example of a 90 km long section of the Berezina river draining the Berezinian Biosphere Reserve. The data obtained have been compared with those available from routine sampled bottom sediments and 2 types of overbank sediments. The investigation has shown that the low-water sediment holds a special place among recent alluvial sediments in origin, mineralogical properties and chemical composition. The data obtained may be used as the geochemical background values for landscapes of Belarus.

The use of low-water sediment allows to expand considerably the temporal and spatial potentialities of the geochemical control and monitoring: geochemical anomalies recognized as a result of the low-water sediment analysis are more extended and well differentiated, show the greater contrast and persistence of anomalous metals. It can be used for the determination of background levels of elements, for distinguishing geogenic and anthropogenic anomalies, for the estimation of the degree of

pollution and for monitoring. Most of known and some unknown sediment anomalies in rivers of Belarus, were detected with anomalous metal concentrations in low-water sediment and showed better contrast and homogeneity. The use of low-water sediment for geochemical monitoring of river systems makes possible highly responsive, representative and time selective assessments. Thus, low-water sediment is suggested as a new suitable and convenient medium for geochemical exploration.

### **5.17 Rainwater Storage and Distribution in Selected Rural Areas of Bangladesh**

**Md. Daulat Hussain, Md. Ahiduzzaman, Thomas Rozario**  
Bangladesh Agricultural University, Bangladesh

#### **Abstract**

This paper describes the present status of rainwater collection systems, storage practices, purification procedures practiced and distribution in three locations of Bangladesh. The three locations are: coastal area in Sundharban forest region, Khulna district forest area in Joydebpur district and hilly areas in Chittagong Hill tracts. This paper also describes the materials used in gutters, rainfall data, method of rainwater collection and storage practices in three locations, cost of water use, cost of storage structure, maintenance status, water use pattern, training on rainwater use, and roof inclination. The constraints, such as, education level, economic conditions, innovation among the users, availability of storage structure, gutters and roofs used have also been described.

### **5.18 Land Use Development Activities in a River Basin and its Influence on the Beneficial Use of Terengganu River Water in Malaysia**

**I. M Azizi, M. K Yusoff, W. N. A Sulaiman & M. N Hassan**  
University Pertanian Malaysia, Malaysia

#### **Abstract**

The physical development of Malaysia has been phenomenal and the pace has accelerated to greater heights in the 1990s. Development is the transformation of land area from its natural state to man-induced land uses. Area in the river basin is not exceptional. Many forested areas have been cleared for plantations, the contractions of infrastructures, building of commercial, urban, industrial and residential centres, mineral and wood extraction; and many others with the aim of increasing economic activities and social upturn. However, these kind of developments in the river basin enhance vast adverse effect on the quality of river water and other river environment. This paper, thus, attempts to provide an existing scenario of land use development in the river basin in Terengganu Malaysia and the nature of environmental crisis that have occurred. It also discusses the need for reviewing existing planning and development policy as to create a healthy integration of environment and physical development particularly in the river basin area.

## 6 WATERSHED MANAGEMENT

### 6.1 Urban Stormwater Management in Australia and Iran: An Opportunity to Share practices

**Dr. B. C. Phillips, A. G. Goyen**

Willing & Partners Pty. Ltd., Australia

**R. A. Ghafouri**

Soil Conservation & Watershed Management Research Center, I. R. Iran

#### Abstract

The effects of urbanization on runoff and its quality including the characterization of pollutant mobilization and transportation by urban runoff is outlined. Emerging best practices for stormwater pollution control in urban centers in Australia under a wide range of climatic conditions are reviewed and compared with current practices in Iran. The opportunities to improve stormwater management practices which respond to climatic conditions are also discussed.

It is concluded that in Australia there is an increasing acceptance of urban stormwater as a source of pollution impacting on the water quality and ecology of receiving waters and of the need to identify mechanisms for reducing impacts around Australia. This awareness is greater for those urban areas adjacent to sensitive receiving waters including estuaries and inland streams or dependent on urban stormwater as a source of water supply.

While the need to control of point source pollution discharges and the upgrading of municipal wastewater treatment plants has been recognized in Iran, to date there appears to have been less recognition of urban stormwater as a source of pollution impacting on the water quality and ecology of receiving waters and of the need to identify mechanisms for reducing impacts around Iran.

The difficulties which are faced by stormwater managers in Tehran and elsewhere in Iran indicate that there is an opportunity to draw on stormwater management experience and practices from Australia to demonstrate the potential benefits of improved stormwater management practices in Iran.

### 6.2 Approaches to Rainwater Harvesting and Retention in Urban Areas

**Dr. Haisheng Mow**

Peking University, P. R. China

**Ms. Huilin Wang**

Alabama University, USA

#### Abstract

China's current conditions of waste problems in urban areas cannot be completely imputed to historical background, natural conditions and the large population. If we have a new concept and philosophy on rainwater management, it is still possible for us to have an ecological balance between society and natural environment. The so-called new concept and philosophy has been proposed and carried out by our ancient people for a long time in China. Just during the past decades of reform and rapid development. They were neglected so that numerous water problems emerged. If each city was

planned and designed with a view of sustainable development, to form a normal circle in urban areas. The water crisis can be lessened and the whole environment will change toward a better future. Based on the author on-site investigation during the field trips in Germany, the technologies such as over flow facilities of combined sewage system, biological treatment plant, different infiltration and retention methods of rainwater, and construction materials being used in Germany are demonstrated in this paper. The possibility of them which could be applied in China were discussed.

### **6.3 Runoff Curve Number, and It's Variability in The Estimation of Storm Runoff**

**Ali Vali-Khodjeini**

University of Tehran, I.R. Iran

#### **Abstract**

The runoff curve number (CN) method, is a simple empirical technique developed by the US. The Soil Conservation Service (SCS), it used for estimating die depth of surface runoff from rainfall events. This technique was originally devised for application in agriculture, and forest watersheds, but later was extended by the SCS to include urban watersheds, and presently is used around the world. However, after four decades of application, it is necessary to review and re-examine it to determine further development.

The purpose of this paper is to review the original intent, development, application, limitations, and present-day interpretations of this method, and assess some remarks in this procedure.

This approach has been applied to the Iranian representative basin, and the curve number of the observed values show that observed CN values deviate from the extracted values from the SCS handbook, for the same catchment characteristics.

### **6.4 Problems and Possibilities Relating to Rainwater Utilization in Botswana**

**John E. Gould**

University of Botswana, Botswana

#### **Abstract**

Water is a scarce resource in Botswana particularly in rural areas which are mainly dependent on groundwater sources, the quality and reliability of which are somewhat problematic. Recent experimental work has confirmed the findings of earlier field based assessments in recognizing the potential for household rainwater collection Systems for improving supplies in rural Botswana. By modeling long term system performance, previous studies have shown that a substantial of domestic water needs could be met by small scale household systems. The possibilities for supplementing community supplies has also been demonstrated through pilot projects involves the construction of large ferrocement rainwater tanks at schools and clinics in several villages. At Zutshwa, a remote community in the Kalaharii desert, another successful pilot project involves the collection and storage of surface runoff from the edge of a salt pan. Several excellent demonstrations of the benefits of using micro -catchments and permanent graded strips to concentrate surface runoff around trees and crops have also been undertaken since 1990. Despite the success of both the pilot projects and

demonstrations, the adoption rates for the widespread usage of these techniques has been slow even though in some instances generous government subsidies have been available. Reasons for the limited replication of most of the rainwater Utilization techniques are discussed in this paper. These include the relatively high initial capital costs of some systems compared to rural incomes, a lack of government commitment to actively promote these systems and poor design or maintenance of systems at many government institutions. Future attempts to encourage broader use of rainwater utilization in Botswana will first need to overcome these constraints and a number of measures and strategies to address these are proposed.

## **6.5 Rainwater Harvesting for Sustainable Development in the Shiwalik Foothills of Northern India.**

**Professor S. P. Mittal, Dr. J, S, Samra**

Central Soil and Water Conservation Research and Training Institute, India.

### **Abstract**

The problems of nearly three million hectares of the Shiwalik hill region of northern India, are assuming serious proportions. Grazing and illicit felling of trees are rampant, which have resulted in degradation of fragile hill eco-system. Consequently, most of the rainwater from the hilly catchments ends in runoff during the monsoons, causing problems of soil erosion, floods and sedimentation,

Among various alternative strategies being developed for rehabilitation, and sustainable development of the region rainwater harvesting from hilly catchments by constructing small earthen dams, have proved to be most promising. This has opened up new vistas of development for the mutual benefit of the people and the hilly catchments. Harvested rainwater, when provided for supplemental irrigation to the farmers' fields, increased the yield of wheat from 0.8 to 4.35, chick pea from 0.84 to 1.2, and mustard from 0.3 to 0.7 t ha<sup>-1</sup>.

The most spectacular aspect of these programs is the community participation in protecting the hilly catchments against grazing and illicit cutting of vegetation. Consequently the grass yield from hilly catchments has gone up from 0.1 to 2.5 t ha<sup>-1</sup>. The number of trees has increased from 72 to 872 ha<sup>-1</sup> in the catchment.

A village based organization, called 'Hill Resource Management Society', has been constituted in project village to manage the common property resources like rainwater and grass. The responsibility of protecting the hilly catchments has been successfully passed on to these societies. This is called 'social fencing'. These programs have already been replicated over 170 locations in the three northern states.

## 6.6 The Conflicts Between Short and Long- Term Economic Gains in Watershed Management

**Mohd Nasir Hassan, Mohd Kamil Yusoff, Wan Nor Azmin Sulaiman, Azizi Muda, Cairul Bariah Zaid**

University Pertanian Malaysia, Malaysia

### Abstract

The development process should concern not only with income enhancement or economic growth, but also the protection of the environment to ensure optimum social welfare improvement. In many cases, these two objectives are conflicting such that some trade-offs have to be made. The use of natural resources for a particular objectives may preclude their use for other objectives. This study demonstrated two conflicting objectives of watershed utilization i.e. Exploitation of timber resources for fast financial and economic gains against its preservation for water supply. The Study uses the opportunity cost approach. Only quantifiable costs and benefits were considered in the Study. The results showed that the benefits of water supply until the year 2020 exceeded the costs with a benefit/cost ratio of 1.05 and an internal rate of return (IRR) of 17 percent which exceeds the normal rate of return for public in Malaysia. The net present value (NPV) of water supply is about RM452 million (USD181 million) 1. On the other hand, the benefits of timber extraction for export are five times higher with a NPV of about RM2.3 billion (USD920 million). The study has shown that if decision marker's objective is short term economic gains, then logging of timber would be chosen. Conservation of the watershed for water supply Purposes generates both smaller and shower returns. The study also indicate that economic evaluation that is based entirely on quantifiable components would favor fast and short-term gains and disfavor longer-term benefits and costs. Important environmental costs due to deforestation such as soil erosion and contamination of rivers and streams and climate change need to be included to obtain the real cost of timber extraction.

Except for the price of timber, all financial figures in this paper are 1994 current prices. The exchange rate for 1994 between USD\$ and Ringgit Malaysia (RM) was USD\$1.00= RM2.5.

## 6.7 Water Yield Estimation of Ungauged Watersheds in Arid and Semi-Arid Regions of Iran.

**Mohammad Khosroshahi**

Research Institute of forests and Rangelands, I.R. Iran.

**Prof, Mohammad Mahdavi**

University of Tehran, I.R. Iran.

### Abstract

In arid & semi-arid regions of Iran, the streams usually are temporary and the number of hydrometric stations are not sufficient for estimating the water yield. In different cases and many areas, we need to have adequate knowledge about water yield of watersheds for different purposes. In most watershed projects in Iran, for obtaining the amount of runoff or deficiency of water flow, the Turc, Coutagne and other formulas are applied, while these formulas have not yet been considered and recommended for all parts of Iran. The use of these models and formulas may bring about many difficulties or wrong calculations for project planners. Reliability of the mentioned models estimating runoff in 29 basins

located in the north-east of Iran (Khorasan ) were tested. The formulas application was not satisfactory except for ICAR ( Indian Council Agricultural Research) formula, which was possible to utilize for Watersheds up to 200 km<sup>2</sup> in area(se±25%), while the area of watershed was determined to be 1000 km<sup>2</sup>.

## **6.8 Hydrological Studies for Determining the Physical Impacts of In-Stream Sand Mining on The Double Swamp Creek, NSW, Australia**

**Ali M. Akhoond –Ali**

University of Ahwaz (Shahid Chamran), Iran

**Wayne D. Erskin**

University of New South Wales, Australia

### **Abstract**

Land use changes often affect the stability of stream channels by altering runoff and sediment yields. However, direct modifications of stream channels often intensify these impacts. The extraction of soil, sand and gravel from flood plains and rivers, is often carried out for construction materials and flood control, but the environmental and physical impacts of such activities can be significant. Double Swamp Creek is a small (11.3 km<sup>3</sup>) sandstone basin drained by an unregulated sand-bed stream, into the Clarence River at Clifden, New South Wales, Australia. The stream bed has been periodically excavated for sand at three different locations over a period of 7 years. The extraction of 6,292 m<sup>3</sup> of sand from upstream, and 834 m<sup>3</sup> from downstream the excavated hole. Cross-sectional changes have been measured in detail for 9 different surveys ( 8 phases ). In order to evaluate the accuracy of computer models for predicting the physical impacts of extraction, the numerical mathematical model, HEC-6 was used to predict bed changes in comparison to the measured changes.

However, HEC-6 require discharge as input data. The stream is ungauged, and the only rain gauge records daily values. Therefore, SFB, a hydrological model based on a water balance method (Boughton, 1984 ), was used to estimate the average daily runoff from daily rainfall. The impacts resulting from historical in-stream mining on this stream were studied to derive general principles for a better management of mining industries. The Cumulative values of sediment storage changes were calculated for 17 cross-sections over the eight time periods. Regressions measured on predicted values of changes in sediment storage, showed significant and meaningful correlation.

## **6.9 The Effect of Soil Management on Reserving and Protecting Rainwater**

**Mr. Zabihollah Eskandari**

Isfahan Research Center of Animal Sciences and Natural Resources, I.R.Iran

### **Abstract**

Soil moisture limitation is one of the main limiting factors in the dry farming and pasture management in the semiarid zone of Iran. Therefore, this research was conducted to study the effects of various types of tillage systems on soil moisture conservation on the zayande-rud river terraces in clay to clay loam alluvial soils. A split plot experimental design was used with 3 replicates and 4 treatments

including moldboard plow (MP), chisel plow (CP), disk plow (DP) and no-till (NT). The soil moisture content of 0-15 cm. and 30-45 cm were determined. A total of 225 soil samples were collected. The results of variance (ANOVA) showed that the tillage and soil depth treatments were significant at  $\alpha=1\%$  level. The highest gravimetric moisture content (23.9%) was related to the chisel plow and the lowest amounts to about 200 cubic meters per hectare. The disk plow and moldboard plow tillage systems preserved less moisture than the chisel plow, respectively.

## **6.10 The Role of Digging of Ditch in The Base of Astragalus on Storage and Infiltration of Rain Water**

**Gholam Hossein Karami**

Shahrood University, Iran

### **Abstract**

To exploit the gum from *Astragalus gossypium* always a ditch is dug on the base of its bush. The dimension of ditches are approximately the same and their volumes fall between 6,000 and 10,000 CC. In the gum exploitation fields, these ditches include a considerable area of catchment area, and due to increasing the depression storage acts as an important factor in storage of rain water and therefore reduce the flood intensity of the region. This research has evaluated the role of above-mentioned ditches in runoff prevention in different areas (from the view of slope and the percentage of *Astragalus* cover), and also their role in increasing of infiltration rate due to surficial breakage, which is relatively compacted.

## **6.11 GIS Applications in Hydrology Computation of Runoff Curve Number.**

**Chandramohan. T.**

National Institute of Hydrology, India.

### **Abstract**

GIS is a tool for storing, analyzing and manipulating layers of spatial data in a computer. The GIS functions for hydrologic and environmental analyses are to manage, automatically and display data in digital form for use as input in analytical computer models. Hydrology is an area which can greatly benefit from integration with GIS. Also it provides a level of automation for hydrological analyses that has not been seen before.

Many computer models in Water Resources use the SCS runoff curve number (CN) methodology to determine rainfall excess. CN value is a function of hydrologic soil group, land cover type and antecedent moisture conditions. GIS overlaying of land features, soil groups and sub-basin boundaries produces a composite SCS Curve number in a fraction of the time of traditional overlay process.

In the present study, a PC based GIS software, MGE PC-1 has been used to store, retrieve, analyze, and display spatial data needed for hydrologic analysis and to compute the SCS curve number for Ghataprabha basin up to Daddi gauging station, which lies in Sindhudurga and Kolhapur Districts of Maharashtra, India.

## **6.12 The Construction Of Contour Banking as a Small Catchment for Multipurpose Crops Production: A Case Study**

**Hamid Reza Gazorypor**

Jihad Engineering Services Company, I. R.Iran

### **Abstract**

In this paper the reserving system of cosmic falling in the soil and the reduction of evaporation in free water level and its effects on dampness of soil for growing almonds in the areas with rainfall of 200 mm is discussed and analyzed.

In this method small catchments are built by a banquette process. Maximum rainfall forms currents which flow toward the lowest point of small pools (penetration zone). A ceramic pipe is laid to collect water and transmit it underground. Soil humidity degree is thus increased by reduction of unsaturated, to dry soil areas. Even if the rate of rainfall is very low, in spring and summer the reserved humidity in the soil can remain throughout the year. If we study this humidity dynamic and search, we may have a plan to reserve as much water as possible, in the soil, to be used for the trees during the period between two rainfalls.

The water gathering rate in a normal small catchment basin is 2-5%. By using this method we can increase the level up to 40%.. Thus this system is one of the ways to increase the level of water in reservoirs.

This program, in addition to performing erosion control on slopes, conserving water and soil, and recharging the underground water table may increase agricultural products and play a role in self-sufficiency plans in the Islamic Republic of Iran. In this system, a water-transferring plan is not required, and the collected water is directly reserved in the soil or reservoirs, which can be used for plants. Furthermore, the possibility of destruction in this system by heavy rainfall is quite low.

In this process it is not necessary to purchase complex machinery, and farmers can easily meet their needs by using local facilities.

## **6.13 Effect Of Different Methods Of Rainwater Harvesting On Renewable Natural Resources**

**Abdolreza Esmali**

Main Office, Natural Resources. Eastern Azerbaijan, I R. Iran

### **Abstract**

In this paper the effects of pitting and contour furrowing on increasing of crop canopy percentage and their significant and positive responses to situation, trend, and capacity of ranges were investigated. Further changes in runoff reduction and sedimentation Control and, hence, increasing of water content on the foot slope of the catchment basin were considerable. Experiments were laid out in split plot design regarding crop canopy status, increasing the capacity of ranges and their trend. With respect to the runoff reduction occurring in the springs of the foot slope of the watershed, data analysis was conducted by direct water collection. Effects of pitting and furrowing on growing and yield of seeds and seedlings were significant as compared to the seeding without water harvesting practices. Increases in seedlings and seeding were 58% and 52% respectively as compared to the conventional

methods of cultivation. The survival rate of seedlings combined ,with water harvesting was 74% in comparison to the 16% of the non-water harvesting plots. Furthermore, the Survival rate of seeds with water harvesting practices was 62% as compared to 10% of the same seeds without having such treatment. Changes in situation, Capacity, and trend of ranges improved from negative to a constant status during a five-year period. Improvement of the ranges' capacity (25%) and isolated seedlings combined with water harvesting practices (19%) and improving of poor ranges towards medium ones are indicative of the significant changes in four determined factors. Obtained changes in sedimentation reduction on the watershed due to the implementation of water harvesting practices was 12% during 3 hours of flash flood with 50 years time interval, as compared to the first year of the experiment Hay yield increases were 38% and 80% in ranges and irrigated plots, respectively. Such increases are very considerable with respect to creating a balance between animals and area of the available ranges, and may influence die motivation of nomads as well. The results of the current study may be used as circulating sample for rangers, and academic activities for scientists and researchers as well.

## 6.14 The Effects Of Turkinests On Qanat Recharge And Flood Control

**Ezzatollah Hosseini**

Jihad-e-Sazandegi of Semnan.I. R. Iran

### Abstract

Due to the dry and warm condition in most parts of Iran, more attention is to collect rainwater, required in; one of the most important of these methods is the construction of Turkinest. The Dozehir drainage area is located in the North-East of Semnan (a city located at the North-East of Iran), with an area of about 11,879 hectares. In this report, the above-mentioned area has been divided into ten parts according to the places of Turkinest constructions, and the field of Turkinest effects, for which three factors have been considered.

Because of Turkinests constructed in the route of tribal migration, it is appropriate that they are fully satisfied by this facility mostly during the Spring and Autumn, when they usually have water. The aqueduct charge of the Dozehir village has been reported to be about 37 liters/sec in 1983, and 42 liters/sec in April 1996. On the other hand, according to village residents, after the Turkinest construction, about 2.2 hectares has been added to the farmlands.

Two methods have been used to show the effect of Turkinest in flood prevention; First the time of concentration for each divided area is obtained, evaluating their peak flood charge, and secondly, the log time is computed and calculated according to the amount of caulk existing and available in reservoirs which delays the time of concentration. In the second method, one of these area is selected and it's flood hydrograph is examined and reviewed before and after the establishment of a Turkinest. During the floods, the maximum charge exists in divided areas, thus the reservoir is in a caulk situation. Thus in an outflow, the hydrograph at the peak of a flood is influenced and it can be reduced. By calculating the time of concentration for each area, and evaluating it's peak flood charge, we can give a precise opinion in determining the place's Turkinest establishment possibilities, and also the amount and volume which can influence the peak flood. It is suggested that in the construction of water gathering reservoirs, the above-mentioned points and localities are to be borne in mind.

## 6.15 Modeling The Effects Of Land Use Change

**Dr. B. C. Phillips**

Willing & Partners Pty. Ltd., Australia

**R. A. Ghafouri**

Soil Conservation &; Watershed Management Research Center I. R. Iran

### Abstract

The recent experience in Australia and elsewhere is that the Successful implementation of catchment management strategies is increasingly dependent on an ability to model the impacts of land use change and in particular urbanization.

The XP-AQUALM package for modeling stream flow, water quality and best management practices ha been implemented under the EXPERT (XP) environment. The package was developed from a range of simple, robust models which have been integrated into a single package. The features of XP-AQUALM include: 1) a rainfall/runoff model, 2) point source and non-point source export models, 3) a gross pollutant trap (GPT) model, 4) a water pollution control pond model, 5) a lake loading model, 6) a river quality and loading model, and 7) graphical user interface and embedded decision support system which combines all the above models in a networked environment.

Two case studies which overview the application of the XP-AQUALM model to a coastal river and land use system and the catchment of an inland lake as part of the formulation or catchment management strategies which were based on ecologically sustainable development principles are presented. The modeling approach including model calibration adopted in response to the differing availability of water quality data and the application of ESD principles to the setting of sustainable loading limits is also discussed. It is concluded that XP-AQUALM is an easy to use, yet powerful tool for the analysis and formulation of integrated catchment management strategies.

## 6.16 A General Over Look To Quran On Benefits Of Water

**Hossein Karbasi**

Fars Research Center for Natural Resources and Animal Husbandry, I, R. Iran

### Abstract

Have you considered the water you drink? (Holy Qur'an, Al-Waqi'ah (The Event): 68). The word is Arabic for water. It has been repeated 63 times in 61 verses of the Holy Qur'an for different Purposes and with varied Connotations. The Qur'an considers water as the substance from which every living thing has been created. ...and made We of water everything alive: (Holy Qur'an, Al-Anbiya (The Prophets): 30), Moreover, water is known for its function in beautifying the environment, in producing food, and cleansing the pollutants, There is every wisdom in the creation of water. Water has a unique .position in Islam and, if available, an adult Muslim has to come in contact with it many times a day. A rinsed body is a prerequisite for ablution, which in turn is a prerequisite for the daily prayers. The essence of life, the cleansing agent, an essential input for food production, the beautifying substance for the planet Earth, moderation and lawfulness in water consumption and the ultimate assurance, are the subject discussed in this presentation.

## 6.17 Fog Capture And Utilization The Coastal Peruvian Desert

**Prop. Mario Falciai, Eng. Elena Bresci**

University Of Florence, Italy

### Abstract

This research aims at testing the sustainable use of the "Looms ecosystem", a natural resource of the peruvian coastal desert, using only available water resource: fog water, results from the first months experimentation, begun in March 1995, on fog collected by Standard Fog Collectors (SFCs, 1 m<sup>2</sup>) are reported. Meteorological and climatological data have been collected for same period. Once the more appropriate location has been chosen on the basins of water capture results, then 20 large fog collectors (48 m<sup>2</sup> each) have been installed on the coastal ridgeline (830 m a.s.l.) at Looms of mejia to collect, water. An hydraulic system made up of two different tanks has been carried out in order to collect, convey and distribute water to the experimental area located around one hundred meters below. A micro irrigation system has been installed for the irrigation of the experimental plots, conducted twice a week.

The obtained results in terms of amount of water captured and plant growth conditions give a first positive answer to the possibility of the potential use of the natural resources represented by fog. Later on, the possibility of plants to sustain themselves by means of the water supply derived from the auto-capturing capacity could be tested and, furthermore, the possibility of using the surplus of water coming from the manmade collectors could be used for development of subsistence agriculture and forage growth.

This will lead to the recuperation in terms of reservation in zones on the coastal hills of Peru, a fragile ecosystem witch is at present undergoing a process of rapid degradation and desertification.

## 6.18 Transmission Loss In Upstream Catchments Of Arid Zones

**A. Teivari**

Soil Conservation and Watershed Management Research Center, I.R.Iran

### Abstract

The loss of Water absorbed into alluvium through the bed material of arid zone streams that is important in flood runoff estimation, has been studied and quantified in several parts of the world. Transmission losses have generally been estimated either by direct measure of the flow at two points of the stream, or by geomorphological, or water content in alluvium studies so far. In the present study, transmission loss in the entire catchment is estimated by analysis of rainfall runoff in three distributed plots within a four square kilometer arid zone catchment, using a period of 1975-1987 observed record and a field survey of stream channel characteristics. Some relationships were found between the volume of overland flow and transmission loss rate that may be used in modeling the catchment flood runoff.

## 7 DESERTIFICATION CONTROL AND SOIL CONSERVATION

### 7.1 Experiences On Water Harvesting In Mexico

**Prof. Dr. Manuel Ana Y A-Garduao**  
Institute of Natural resources, Mexico

#### Abstract

Mexico currently farms 22 million ha of its land, 75% under rainfed conditions. This is a potentially dangerous situation since, given the projected population of 110 million by the year 2000 and an upper limit on farming land of about 25 million ha, the country will have an average of only 0.23 ha per capita at its disposal. If adequate measures are not taken, famine will surely result. In 1980, consumption of corn (*Zea mays* L.), beans (*Phaseolus* sp.), and rice (*Oryza sativa* L.) was 238, 20, and 6.0 kg per person, respectively. In 1986, it was 158, 16, and 5 kg per person; a reduction of 29, 20, and 20%, respectively. Rainfall collection and soil water conservation techniques represent the basic infrastructure for permanent production systems under rainfed agricultural conditions. They increase water availability for plants and reduce drought effects. In situ rainfall collection means the collection, transport and storage of precipitation runoff to the root zone. Collection should be related to social, economic, and ecological conditions. Some important variables are: a) rainfall amount, intensity, distribution and frequency for at least 10 years; b) plant water use, seeding date, plant geometry and plant density; c) soil depth, water storing capacity, runoff coefficient; d) tillage and mulching systems; and e) micro-catchment sizes.

### 7.2 On The Ethics Of Combating Desertification: An Application Of Islamic Approach

**Iqtidar H. Zaidi**  
University of Karachi, Pakistan

#### Abstract

The issue of desertification is indeed of global importance. It is taking place at an alarming rate in almost every country of the world particularly in the third world. Around 35% of the world's land surface is at risk and livelihood of 850 million people who live there are directly threatened. Man's exploitation of the environmental resources through over-cultivation, over-grazing, deforestation, poor irrigation practices, bad management and rural neglect are some of the underlying causes of desertification. The world's nations have been trying to halt the process of desertification but without much success; rather the problem has increased in severity.

For illustration I have chosen the case of Pakistan. It is because the relevant information is readily available for analysis. The magnitude of the problem can be easily gauged by the fact that 14 million tons of soil is eroded away and are brought in the Indus basin each year and which works to shorten the life-span of major reservoirs and reduces their efficiency. Most of the Pakistan falls under the category of dry-land. The type of area which receives very little amount of rainfall. Thus, important question that arises here is how to recover the damaged land and protect the existing good lands from deterioration? It is this question around which objectives of this paper are formulated.

Since there seems to be general consensus of the scholars, private and public agencies that technology alone cannot serve the purpose of development in must provide room for moral and ethical influences. Hence, it is only appropriate to use Islamic Environmental Ethics as a theme to manage desertification hazard in a more sophisticated and useful manner.

### **7.3 Condensed Water As A Source Of Water For Biological Fixation Of Sand Dunes**

**A.Pashaie**

Univercity of Ahwaz, Iran

#### **Abstract**

Our investigations with the help of following methods: 1. Groundwater lysimeters, 2. Statistical analysis of data on the plants grown on the active sand dunes and on the compact sand materials. 3. Measurement of water contents of sand dunes in two different plots with and without mulching. 4. Measurement of temperature variations on the sand dunes. Indicates that:

In the sand dune areas without groundwater and with low precipitation, but with high relative humidity, the condensed water is the only source of water available the growing plants during the hot and dry seasons.

### **7.4 Water Conservation In Biological Point Of View In Dry Conditions With An Emphasis On Sainfoin (Onobrychis Viciifolia Scop.)**

**Dr. S. R. Mir.Hosseini-Dehabadi**

Center of Higher Education (Jihad-e- Sazandegi)

#### **Abstract**

Water conservation can be achieved by increasing water use efficiency (WUE) using a desirable plant. Most of Iran has a climatic condition with insufficient rainfall in summer, while most of the precipitation Occurs in winter or early spring.

Sainfoin (*Onobrychis viciifolia* Scop.) is a native forage legume plant which produces most of its annual production in early season (spring), when soil moisture is more available than summer. Water use efficiency can be increased by having production when vapor pressure differences (vpd) between air and leaf is low. Sainfoin is a desirable plant in dry conditions which is able to increase WUE when soil moisture is available in early season. In addition, it has several useful attributes for adaptation to water Stress, like: osmotic adjustment, root development to depth, and increasing stomatal resistance. The mechanisms of these attributes with an emphasis on sainfoin in discussed here.

## 7.5 Rainfall Erosion Influenced By Slope Length In The Hilly Loess Region, China

**Cai Qianguo**

Chinese Academy of Sciences, P. R. china

### Abstract

Field monitoring of soil loss over a range of slope length was conducted at the Zizhou Station which is located in the hilly areas of the Shanxi Province, the Loess Plateau region. Analysis of the five-year data set which includes 30 storms shows that rainfall erosion is closely related to slope length. While total loss increases with slope length for slope ranging to 60 m, unit area soil loss begins to decrease at slope lengths of 50- 70 m depending on rainfall intensity. The effect of slope length (L) shows a strong interaction with 30 minute maximum rainfall intensity (I30) and the best multiple regression equation for estimating unit area soil loss (Ms) is:

$$Ms = 22.36 + 1.005L - 0.015L^2 + 0.521I + 0.032I^3L$$

According to this result, four belts of differing erosion intensity can be identified on a homogenous loess hill slope: A-belt of incipient erosion; B-belt of accelerating erosion; C-belt of steady erosion; and D-belt of decelerating erosion. The dimension of these belts will vary with the rainfall intensity of individual storms.

## 7.6 Calculating Sediment Discharge Using A Developed Computer Package

**Dr. Mahdi Habibi**

Soil Conservation and Water Management Research Center, Iran

### Abstract

Using 12 methods of sediment load calculation, a computer package is developed in order to estimate the sediment discharge of alluvial channels. The basic language is used for programming with the advantages of Quick-Basic because of its simplicity and greater compatibility with graphic and color outputs. Analytical equations are derived for all the tables and graphs involved in the selected theories. The numerical integration technique is used for determining Einstein integrals and bed load function. The developed package can be regarded as an efficient and powerful tool particularly suitable for practicing engineers.

## 7.7 The Effect Of Soil Type, Shape And Slope Of Rainwater Catchments On River Sediments

**M. Sajedi (I), N. Shams-Kia (II), A. H. Haghiabi(III)**

Soil Conservation and Watershed Management Research Center, Iran.

### Abstract.

It is well known that for every rainwater catchment there is an input flow or 'precipitation', and outputs including surface runoff, Infiltration, evaporation, etc. There is a correlated relationship between the surface runoff hydrograph, and the precipitation hydrograph. The duration, local distribution and

intensity of precipitation, have effects on the Shape of hydrographs, induced forces can be different. In most of the rainwater catchments, the amount of sediment that reaches the affluent streams due to precipitation, can strongly affect the rate of river sediments and quality of water. The type of surface soil is also very important, on river sediments because of its infiltration and resistance against erosion.

## **7.8 Portland Cement For Erosion Control And Rainwater Collection**

**Hassan Rahimi**

Tehran University, Iran.

### **Abstract**

Portland cement has been utilized for improvement of physical, and mechanical properties of soils during last decades. Soil-cement mixtures are now used for several purposes such as road pavement, earth dam slope protection, canal lining, etc. In this paper the results of a research program conducted on the use of Portland cement as a soil-stabilizing agent for erosion control are presented. Three types of erodible soils, namely non-cohesive fine sand, low plastic silt and dispersive clay, were used for the experiments. The results of the tests showed that adding Portland cement to the soil causes reduction in plasticity, reduction in swelling potential, reduction in permeability and increase in compressive as well as tensile strengths, which are responsible for soil erosion. Based on the obtained results, addition of 3 to 5 percent by weight of P.C. prevents the soil surface erosion against a flowing water having up to 3 m/sec. velocity. Portland cement could be added to the soil in the form of dry powder or light slurry. The adverse environmental impacts of P.C. stabilized soils are much less than asphalt emulsion or other chemical additives. The paper will present the physical as well as mechanical properties of different soil samples stabilized, using different P.C. contents and cured under different environmental conditions. The results of special erosion tests conducted in erosion flume and wave generating canal will also be presented.

## **7.9 Rainfall Erosion Indices Of Mazandaran Central Watersheds (North of Iran)**

**Seyed Mahmoud Reza Behbahani**

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### **Abstract**

To determine the Rainfall erosion indices of Mazandaran central watersheds in the North of Iran, the automatic rainfall data were analyzed. Rainfall erosion index values were computed by adding the kinetic energy of rain having intensity greater than 20 mm per hour (modified Hudson index) using energy equation of Wischmier and Smith. The average annual, wet-season rainfall iso-erosivity maps together with isoerosivity maps at 50 and 80 percent probability of occurrence were produced for universal soil loss equation and for designing erosion control measures with desired probability level. The potential distribution of rainfall erosion index curves for five locations in the watershed was produced for selecting proper crop management factors. Annual average rainfall erosion indices for different stations: Behshahr, Nozarabad, Sari, Babol and Noshahr (Korkorsar) were 1600, 2100, 1200, and 4400 meter-ton per hectare respectively. Erosive rain is concentrated on the wet-season in the regions of Behshahr and Babol but for Nozarabad and Sari locations it is uniformly distributed within

the year. The result of the Study also indicated that erosive rain increased from Babol toward western side of the region and reaches its maximum level at Noshahr were 80 percent of erosive rainfalls on wet-season. Analysis of total and erosive rainfall indicated that the amount of erosive rain is not related to the total rainfall. On the average 80 percent of annual erosion occurred in the wet-season where as 20 percent annual erosion occurred in dry season at Noshahr areas, that means the erosion that occurred in dry season maybe negligible. Two types of variation of erosion in Mazandaran central watersheds were observed from analysis of both annual and monthly pattern. One is due to seasonal differences in the ability of rainfall to cause erosion. The other one is due to location differences in distribution of erosive rainstorm to cause erosion. Therefore both types of variations of erosion potential should be considered in designing the proper erosion control measures in Mazandaran central watersheds north of Iran.

## **8 RENEWABLE NATURAL RESOURCES AND COMMUNITY PARTICIPATION**

### **8.1 Afforestation By Rainwater Harvesting And Evaluation Of Different Species: A Case Study**

**A. Najafi A. Barzghar-Ghazy,**

Research Center in Natural Resources and Domesticated Animals I. R. Iran

**A. Javanshir, M. Moghaddam**

Tabriz University, I. R. Iran

#### **Abstract**

In order to determine the most suitable site preparation method and select adaptable species for the purpose of afforestation under rainfed conditions, an experiment was laid out for the first time on the southern slope of the Oan-Ebn-Ali mountain in Tabriz, Iran in the spring of 1994. The site is characterized with the poor soil, prolonged dry period, hot summer-, cold winter, and severe wind throughout the year, and hence, one of the problematic environments in semi- arid regions.

The experimental design was a nested split-split plot with three replications. The main plots involved five types of water catchment methods: 1) perlite -plastic sheet on the soil surface, 2) rice bran + plastic sheet on the soil surface, 3) only plastic sheet on the soil surface, 4) plastic sheet on the bottom of the pit+ plastic sheet on the soil surface, 5) deep pit + plastic sheet on the soil surface. Two sub-plots consisted of trees and shrubs. Species within each sub-plot were represented as nested sub-plots (10 shrubs and 5 tree species). Four seedlings were planted in each plot

Crescent form banquettes were prepared in the experiment to catch the runoff water. Water harvesting area for a tree species was about 15-20 m<sup>2</sup>, and for a shrub species was around 10-12 m<sup>2</sup>. Percent survival of the seedlings was measured from 1994 to 1996. The height was also measured in 1995, 1996, and the relative height growth was calculated using the two-year data. Only the data obtained in 1996 -used in the analysis of variance for percent survival. Analysis of variance did not indicate any significant differences between water harvesting methods during these Preliminary years, in terms of percent survival and relative growth. But the differences among tree And shrub species were significant for both studied characteristics.

Among trees, *Pinus nigra* var. *austriaca* showed the highest relative height growth (79.43%). The relative growth of *Pistacia atlantica* and *Pinus ponderosa* were also appreciable (58.95% and 58.90% respectively). These species are resistant to wide range of temperature variations, drought, and severe winds. Among the shrub species, *Purshia tridentata*, with relative growth of 33.92% acquired the first position. Next, *Anygdalus orientalis* (2), *A. orientalis* (1), *A. communis*, *Pinus fasciculata*, and *Halozylon persicum* ranged from 21.8 to 29.85% in terms of relative height growth. The percent survival for all five-tree species was unexpectedly high. It was 97.55% for *Pistacia atlantica*, 96.55% for *Pinus ponderosa*, 90.45% for *Robinia pseudocacia*, 89.4% for *Juniperus chinensis*, and 73.47% for *Pinus nigra* Var. *austriaca*. Six shrub species acquired survival rates of above 84%. These species were: *Rosa canina* (99.24%), *Amygdalus scoparia* (98.06%), *A. orientalis* (2) with 93.3%, *A. orientalis* (1) with 92.4%, *Purshia tridentata* (88.30%), and *Halozylon persicum* (84.73%). In general, the range of variation for 11 species (out of 15 studied species) was from 73.47% to 99.24%.

This unexpected preliminary result based on three years of data regarding the problematic environment of the Oan.Ebn.Ali mountain, is very promising. It might be attributed to the choice of resistant species against unfavorable climatic and edaphic conditions, application of proper site preparation techniques such as construction of crescent banquettes, and covering the soil surface of the pits with plastic mulch. These techniques may have played an important role in the regulation of water balance through the catchment of runoff water, prevention of weed growth, and suppression of evaporation. Although we have obtained very promising results from these preliminary years of experiment, for a general recommendation, the study should obviously be continued for several more years.

## 8.2 Floodwater Spreading For The Establishment Of Wooded Range Land

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**Hamid Messbah**

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### Abstract

Soil erosion, which is a consequence of mismanagement, has drastically decreased the carrying capacity of desert rangeland. Inadequate precipitation and its uneven distribution make reclamation of such land immensely difficult. However, occurrence of floods in eroded watersheds is a fortunate happening which has to be advantageously utilized.

Runoff from a 3290-hectare watershed in the Bid Zard areas, about 190 km SE of Shiraz, Iran, was spread on 269 hectares of denuded rangeland. Sedimentation of the nutrient-rich suspended load and irrigation with floodwater have increased the forage yield from 187 KgHa<sup>-1</sup> of control to 604 KgHa<sup>-1</sup> in the treated area. The height and DBH of the six-year-old *Eucalyptus camaldulensis* Dehnh. and *Acacia salicina* Lindl. trees were 8.17 m and 11.93 cm; and 6.57 m and 15.14 cm respectively. These species have the potential to yield 10.14 and 13.13 m<sup>3</sup> of total wood (stems and branches) per year at the age of six if planted at 3x3 m spacing. Moreover, these trees provide fodder for a limited number of livestock in the lean years.

### 8.3 Adaptability And Growth Rate Of Various Conifers Conditions In Arasbaran Region Under Rainfed

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#### Abstract

In order to rehabilitate abandoned forestlands, and prevent soil erosion in sloping areas, 12 conifer species were planted under rainfed conditions. Sufficient solar radiation and adaptability of conifers for poor nutrient environment were two reasons for selection of these species. The experiment was conducted in 1994 in two locations. The experimental designs in Kalaleh (northern slope) and Hareh Sar (southeastern slope) were repeated in simple rectangular lattices with four replicates, and triple rectangular lattices with three replicates, respectively. Thirty-six seedlings were planted in each experimental plot. Seedling interval distance in Kalaleh and Hareh Sar were 2x3.5 and 2x3 m, respectively. Planted Species included: *Pinus pinea* L., *Cupressus sempervirens* L. var. *horizontalis*. *Pinus eldarica* medw., *pinus nigra* Link var. *austriaca*, *Pinus Sylvestris* L. (Yugoslavian origin), *Cupressus arizonica* Green, *Picea abies*, *Pinus nigra* Link var. *pallasiana*. *Pinus nigra* Link var. *caramanica*, *Pinus brutia* Ten *Larix decidua* Mill, and *Cedrus atlantico mamett*.

Survival rate in 1994-96, height and diameter of seedlings were measured during 1995 and 1996. Then the relative height and diameter growth rate of the species were calculated. Since *Cedrus atlantica* seedlings were not available at the beginning of the experiment, plantation of this species was completed in 1996. Statistical analyses of relative growth rate of height and diameter were therefore conducted as randomized complete block design in each location. Since the effects of incomplete blocks for survival rate in both locations were not significant, the final analysis for this character was also conducted as a randomized complete block design in 1996. Furthermore, combined analysis of data of two locations for all of the characters were done and means were compared using Duncan's test. There was significant differences between the two locations with respect to the survival rate and relative growth of plant diameter. The mean percentage of the survival rate and relative growth of diameter in Kalaleh (northern slope) and Hareh Sar (southeastern slope) were 92.71, 36.92, and 64.24, 21.56, respectively. Even though differences between the locations, in relative growth of plants were not statistically significant, the relative height growth in the northern slope was 6.91% higher than that of the southeastern slope (26.4 compared to 19.49). There were significant difference among species within each of the location, and in the average of two location, with respect to the survival rate and relative height growth. There was not any significant differences among species with respect to the relative diameter growth. Species of *pinus eldarica*, *Cupressus arizonica*, *Pinus nigra* var. *pallasiana*, and *Pinus brutia* observed the highest percentage of the survival rate based on the location's average. Except the *Picea abies* and *Cedrus atlantica*, the survival rate or other species ranged from 90 to 100% in the location of Kalaleh. On the other hand, in Hareh Sar, only the *Pinus eldarica*, *Cupressus arizonica*. *Pinus nigra* var. *austriaca*, and *Pinus brutia* showed the survival rate greater than 90%. With respect to the relative height growth, *Pinus nigra* var. *austriaca* was exclusively different than other species and stayed in first place with the percentage of 46.71 in Kalaleh, 74.47 in Hareh Sar, and a mean of 47.1 as compared to all other species. Kalaleh was superior to Hareh Sar because it was located on the northern slope which provides sufficient moisture content, solar radiation, and better regulation of water balance.

## **8.4 A Survey Of Planting Four Species Of The Eucalyptus, Based On Reserves From Precipitation, On Mulch Covered Sandy Hills In The Khuzestan Province**

**Najaf Najafi, Hassan Saleh Shooshtary**

Natural Resources and Animal Husbandry Research Center, Iran

### **Abstract**

The vigorous rise in the rate of population growth in the world, mostly in the developing countries, and the limitations on agricultural lands and products call for man to bring about a quest for a new resources by the year 2000 in order to meets the various demands.

The Khuzestan province is located in the south of Iran, which has an area of sandy plains exceeding 350,000 ha. This is infact 3.5% of the entire state and 29.5% of the entire agricultural land of Khuzestan. The sand encroachment by wind over the agricultural lands, roads, pipelines and residential areas is a serious economical problem in this area. Sand dunes extend from the northwest to southwest of Ahwaz in the Khuzestan province, in the form of tapes. These include some sporadic expansions consisting of over 68 varieties. The two important sand dunes are those located in Albajy with an extent of about 9,000 ha; and that in the southwest of the Karkheh river of 115.000 ha.

Research proves that afforestation offers a permanent solution for the sand dune area problem. Selection of a suitable plant spices for this purpose is crucial for successful afforestation. As a result, four eucalyptus species were selected in further investigations. The samples of soil, climate, and ground water were collected and analyzed for several parameters using standard procedures. In this study, petroleum mulch is used for soil conservation, especially preventing wind erosion and also based on reserves of precipitation for plants species such as the eucalyptus.

After more than 6 years of cultivating four eucalyptus species, the investigation conclusively demonstrated the Eucalyptus Camaldulensis 9616 as superior (adaptation and growth) to other species in the sand dunes of the Khuzestan province.

## **8.5 Investigation On The Adaptability Of Coniferous And Broad Leafed Trees Under Rainfed Conditions Around Tabriz Area**

**Mohammad Ali Sarcarat**

Research Center of the Natural Resources and Domesticated Animals, I. R. Iran

### **Abstract**

In order to create parks and recreational areas around cities, it is essential to recognize adaptable and resistant tree species to arid climate in rainfed conditions. On this basis, a research study was conducted to determine the adaptability of some broad leafed and coniferous trees in rainfed conditions situated in Elgoli, around Tabriz area. The experiment was conducted as a randomized complete block design using five different species in four replications within four years. Studied species included: Cupressus arizonica Green (Arizona cypress), Pinus nigra (black pine), Pyrus amygdaliformis L. (wild Pear), Cupressus arizonica, Fraxinus rotundifolia mill (ash tree), and Robinia pseudacacia (false acacia). Twenty-five seedlings were planted in each experimental plot. Data related to the percent of survival rates of species were collected in yearly bases. Height and diameter of

seedlings were measured precisely, and relative growth rate of height and diameter were calculated in yearly bases as well. Analysis of variance of collected data for the survival rate during four years was conducted as split plot in time. Collected data related to the survival rates were normalized prior to the analysis using  $\sin^{-1}$  transformation. Even though there was a significant difference among species with respect to the percent of the survival rate, it is worthwhile to indicate that all studied species have acquired high rate of survival and have been adaptable to the rainfed conditions. That interaction between year and species was also significant with respect to the survival rate, but a significant difference was not obtained among years with respect to this character. The comparison of the relative height and diameter growth rate of the studied species revealed that black pine had higher relative growth as compared to the other species. Arizona cypress and wild pear acquired second rank after black pine. The relative growth rate of ash trees and false acacia were the least. The overall results within four years of experiment were indicative to this fact that all studied species were adaptable to the rainfed conditions in the Elgoli location.

## 8.6 Study Of Tree Dry Farming By Surface Runoff

**Mohsen Bany Asadi, Ahmad Anseri, Farang Khosraviyan, Ali Zangi**

Natural Resources and Animal Husbandry Research Center, I. R.Iran.

### Abstract

In order to study the possibility of dry farming on mountain slopes (10%), several quadrat plots have been made and separated from each other, by the boundary. A pit has been dug at the lower corner of each plot, and filled with soil and method fertilizer. Planting takes place during the end of winter, with irrigation in fixed intervals. This method was evaluated by the comparison of trees grown in three plots with different dimensions (three main samples), and five productive or unproductive tree species (five secondary samples) by randomized complete block design (RCB). During the experiment, a monthly measurement of the moisture of the soil in different depths is conducted.

## 8.7 Evaluation Of The Biomass Of Mixed Cropping Of Wheat-Grass And Alfalfa Using Rainwater In The Arasbaran Region

**Anoshirvan Najafi, Shahrokh Mohseni, Aziz Javanshir, AkbarAbdi Ghazijahani**

Natural Resources Research Center And Domesticated. Iran

**Seyed Abolghasem Mohammadi**

University of Tabriz, Iran

### Abstract

In order to rehabilitate the eroded pastures in semi-arid regions, to improve less fertile dry land, to increase the diversity and sustainability of agro-ecosystems, to prevent the wind and water erosion of soil, and produce suitable rainfed forage yield, a research study was conducted on the mixed cropping of agropyron and alfalfa grass. Positive interaction among these species not only may affect the quality and quantity of forage and the optimal use of environmental factors, can inhibit surface runoff by increasing organic matter content, and hence soil infiltration rate. The current study was initiated in the experimental station of Tatar located in Arasbaran following mixed and row cropping of alfalfa and wheat-grass. The experimental station is situated within the north latitude of 39°1', and east

longitude of 46°50'. The altitude of the station varies between 300 to 700 m with the annual precipitation ranging from 350 to 400 m.

The experiment was laid out under rainfed conditions as a randomized complete block design with the five treatments in four replications. Treatments included pure cultivation of alfalfa, a combination of 75% alfalfa and 25% agropyron, a combination of 50% alfalfa and agropyron, a combination of 25% alfalfa, and 75% agropyron, and pure cultivation of agropyron. The area of each plot was 10.5 m<sup>2</sup> (2.10 x 5 m), that by eliminating marginal rows, ultimate harvested area of each plot reduced 7 m<sup>2</sup>. The cultivation and harvesting data were October 28th, 1995 and June 30th, 1996 respectively.

Obtained results from analysis of variance revealed significant F values among treatments with P < 0.05. Cultivation of pure agropyron produced the highest yield during the first year of experiment. The obtained yield from the treatment of (75% agropyron and 25% alfalfa) ranked second place after the treatment of pure agropyron. Rest of the treatments produced less yield as compared of 25% alfalfa and 75% agropyron. The higher yield of pure agropyron and mixed cropping at the first year of experiment as compared to the pure cultivation of alfalfa, might be related to the adaptability of agropyron to dry conditions and the further application of 50 kg ha<sup>-1</sup> of urea.

## **8.8 Role Of Precipitation In Concentration Of Nutrients In Rhizosphere Vicinity Using Crescent Contour Bundings**

**Syrous Azarabadi**

University of Tabriz, Iran

**Anoshirvan Najafi**

Research Center in Natural Resources and Domesticated Animals Research Center, I. R. Iran

### **Abstract**

Plant growth is affected by several parameters, but only a few of them may be controlled. Some of the controllable parameters are the moisture content and level of essential nutrients absorbed by plant roots. These parameters are provided from soil and might be controlled through soil management.

Crescent contour bundings have been constructed in some young soils of the region. The area of watershed ranged from 10 to 20 m<sup>2</sup>. Soils collected sufficient moisture content, and the rate of evaporation in studied soils reduced to minimum using some of the conventional methods. Increasing the concentration of nutritional elements and the moisture content of the rhizosphere, increased the rate of adsorption of essential elements.

Results revealed that the movement and diffusion of ions were indicative in the vicinity of rhizosphere. In other words, the relative concentration of nutrients in the vicinity of rhizosphere increased the amount of exudates and hence, the activities of microorganism, changed the soil pH and ultimately enhanced the adsorption rate of soil cations and anions.

## 8.9 Tree Growth Response To Climatic Variables In Mixed Regression Model

**Hamid Djalilvand, Benoit Cote**

McGill University, Canada

### Abstract

The responses of red pine (*Pinus resinosa* Aiton) and Norway spruce (*Picea abies* L. Karst) to climatic variables were studied at the Morgan Arboretum of McGill University on the West Island of Montreal (45°25' N, 73°57' W). This study was done to examine climatic variables in the growth year as well as previous year by individual, second degree, combined and mixed statistical models. The best-mixed models were found for two species and explained 82% and 85% of red pine and Norway spruce growth respectively. Partial R<sup>2</sup> of current year annual evapotranspiration explained 43% of the total variance for Norway spruce growth while partial R<sup>2</sup> of current year's August evapotranspiration explained 33% of the total variance for red pine growth. The most decisive periods for Norway spruce growth were the current and previous year's evapotranspiration (R<sup>2</sup>=0.43). For red pine, the most important factors were current August evapotranspiration and previous September precipitation (R<sup>2</sup>=0.41). The analyses showed that evapotranspiration was associated with the two species' growth to a greater degree than precipitation. We concluded that red pine requires warmer conditions than Norway spruce.

## 8.10 Investigation Of Edaphic Forests In Yazd Province

**Alireza Karimi Noghipoor**

University of Tarbiat Modarres, I. R.Iran

**Mohammad Hossein Djazirei,**

Organization of Forests and Rangelands, I. R. Iran

**Mohammad Djafari**

Tehran University, Faculty of Natural Resources, I. R.Iran

### Abstract

In this study three regions are selected in different latitudes in Yazd province (south, central and north) and the Edaphic Forest Formations are studied in these areas.

This survey showed that precipitation and air humidity decrease and also temperature, evaporation from south (Harat-Marvast) to north (Kavir Siah-Kooh) due to that diversity and density of plant cover, increasingly has been reduced in the area of Harat-Marvast, with species diversity, more than 22.5% of plant cover in this area.

In comparison to Harat-Marvast, Kavir of Dar-an-Jeer (Bafgh) with six plant species, and Kavir of Siah-Kooh with five plant species, have formed 6.5% plant cover in the area.

In studied areas, in general, two typical association of tamarisk were observed:

.Salsolo-Tamaricetum association. This association has reached plant cover density and diversity with low salinity and calcareous. This plant association has been seen in Harat-Marvast.

Halostachiete-Tamaricetum association. This association, with lower species diversity and cover density, was located on very saline content, with gypsum and calcareous in areas of kavirs in Dar-an-Jeer (Bafgh) and Siah-Kooh.

## **8.11 Comparing Different Methods Of Precipitation Reserve And Their Effects On The Establishment Of Canopy Cover**

**Aziz Orsham**

Natural Resource and Animal Husbandry Research Center, I. R. Iran

### **Abstract**

Due to relatively low precipitation, improper time distribution of precipitation, heavy potential for evaporation and transpiration and also sharp reduction in soil moisture in arid and semi-arid regions, it appears to be difficult to confirm and establish an effective canopy cover in order to conserve and prevent the erosion of the soil, To compare the effects of precipitation reserve methods on the establishment and production of canopy cover, in this study, and also to assess the sediment runoff on each geological formation of Aghajari and Gachsaran, from the third era of geology, sensitive to erosion in Khuzestan province, 3 block of 20x24 m were built. In each block of six blocks, four plots of 4x10m were built where the treatment of each block consisted of rectangular pits along with biological actions, contour furrow with biological actions, biological actions without the methods of precipitation reserve, and a control plot where no methods of precipitation reserve or biological actions were used.

The dimensions and distances of furrows and pits were designed relative to the maximum or 24 hour precipitation in the region and lower end of plots were connected to the collecting tanks of the sediment runoff. To perform biological actions, Medicago, Onobrychis and Amygdalus species were used in the form of sowing and seeding. On the basis of desert observations and quality results, the methods of precipitation reserve have had an important impact on the establishment and production of canopy cover. The amount of the sediment runoff has been decreased heavily in the mentioned treatments because of the water conservation and infiltration into the soil.

## **8.12 Extention Work And The Role Of Women In Water Catchment Rehabilitation**

**Dr. Jessica Calfoforo- Salas**

Kahublagan Sang Panimalay (Community Movement) Foundation, Philippines

### **Abstract**

In 1991, a study of a natural Waters catchment was conducted by Kahublagan Sang Panimalay (Community Movement) Foundation to determine the feasibility of supplying the increasing need of potable water to some half a million inhabitants or Ilolio City and the irrigation of 3000 hectares of farmland. The water catchment, with an area of 6150 hectares was found to be unprotected due to deforestation of the watershed in 97% of the land area.

The study further presented alternatives for rehabilitation. This paper discusses how the decision was implemented. The local council decided to use community-based reforestation to contain the 2000 poor household living in the periphery of the~ water catchment area.

The government agency in Charged of forest management made available funds for the rehabilitation of the Water catchment and contracted out the administration of the project to the local government. The same agency also contracted the Kahublagan sang Panimalay to do the community organization and extension work in support of the reforestation.

The paper describes the Strategies used by Kahublagan to accomplish its objectives of not only reforesting the 6150 hectares but also having a marked change in attitude among the people who are using the water catchment for their livelihood. Problems met and how they were shared in the paper

Most importantly, the paper also shows how the women in the watershed participated in the reforestation project and what was the impact of their involvement to the raising of women consciousness and dignity.

### **8.13 Participatory Rainwater Harvesting, Storage And Recycling: A Case Study At Rel Majra Village, India**

**Dr. Jagir Singh Samra**

Central Soil and Water Conservation Research and Training Institute, India

#### **Abstract**

Socio-economic, gender and participatory issues are being realized more important than the biophysical measure for sustainable rainwater management by the stakeholders. The recent achievements made by the Central Soil and Water Conservation Research and Training Institute in demonstrating the relevance of community participation revolutionized the concept of bottom up approach in resource development, conservation and management in India.

Institutionalized management of harvested rainwater at watershed level triggered the process of participation. The major components of this integrated management consisted of: bio-remediation of non-arable lands and drainage lines, use of local skills and materials, diversification of common and private land uses. Improved agro-techniques on farmlands, livestock development and community involvement increased incomes from private property resources and provided a base for livelihood support system to rural people. Equitable sharing of natural resources, the concept of social fencing of the catchment against grazing and tree felling were the key elements of the program. The results strongly suggest the adoption of community driven "bottom up" approach for managing rainwater on sustained basis as an alternative to traditional "top down" approach. However, the role of an external agency as a facilitator for setting up local institution and for resolving various conflicts is an important consideration.

### **8.14 Rainwater Catchment Systems And Indigenous Knowledge Systems: An Exploration With Iranian Nomads**

**Dr. Mohammad Hossein Emadi**

Rural research Center, I. R.Iran

#### **Abstract**

The government of Iran has placed considerable resources into provision of advice and services to improved the natural resources status of Iranian rangelands by improved range management, watershed management and rainwater harvesting projects. Efforts have traditionally been attempted

through the use of technology transfer and centralized planning without considering the valuable indigenous knowledge of nomads. On the other hand, the nomadic pastoralists of Iran have been able to achieve a sustainable “balance” between their ecology and their economy through their indigenous knowledge. This balance has certainly changed over recent decades, the nomads now being held responsible for very significant degradation of the rangelands by the officials.

The aim of this paper is to illustrate the indigenous knowledge of a group of Iranian nomads about their environment and explore its role in the process of rainwater harvesting and watershed management projects.

The main argument of this paper is that there is a need to shift from technology transfer model to collaborative issue management model" which considers local people's views, values and knowledge in the process of development activities.

The method adopted by the author in preparing paper has involved the inductive analysis of primarily qualitative data collected in Iran during 1991-93 with a group of Qashqai nomads in Fars province.

## **9 SUSTAINABLE AGRICULTURAL DEVELOPMENT**

### **9.1 Aquifer Management: A Key To Food Security In The Deserts Of Iran**

**Sayyed Ahang Kowsar**

Fars Research Center for Natural Resources and Animal Husbandry, Iran

#### **Abstract**

Erosion, conversion to nonagricultural uses, salinization, inundation and toxification decrease the cropland area of the world by about 12 million hectares (Mha) a year. Most of mankind shall be doomed in about 100 years if this trend continues. Debris cones, coarse alluvial fans and colluvia may be reclaimed if an artificial recharge of groundwater is performed on them. Aquifer management, which is the rational use of all resources related to aquifers, offers a proven alternative for surviving in deserts. Iran has succeeded to work on 14 Mha on a small scale and plan, and will be happy to share the experiences gained with any other country that can duplicate her endeavors.

### **9.2 The Growth And Yield Of Grape Vines When Influenced By Micro-Catchment Water Harvesting In A Dryland Region**

**R. Sepaskhak, A A Kamgtr-Hagigi, S A A Moosavi**

Shiraz University, Iran

#### **Abstract**

The Micro-catchment Water Harvesting (MCWH) technique has been practiced in several parts of the world, including Iran; in order increase crop production on dry lands. However, its effects on plant growth and yield have not been studied effectively. This research has been conducted in order to Study the influence of MCWH on vegetative growth, yield, and yield per cluster of dry land grape vine for six years in a semi-arid region of the Fars province, Iran.

The experimental sight was located on a gravelly loam soil (54% gravel), with an average slope of 5-6%. The MCWH system consisted of small plots of 6.7x2.0 m<sup>2</sup>, confined by small ridges (20-25 cm in height). Trees were located at the lower end of the slopes of the plots, and hence the runoff is directed towards the trees. The annual rainfall varied between 244 and 548 mm, and mostly occurred during November to late April. The study area had a low runoff potential. The annual runoff varied between 13.5 and 42.5 mm. The average increase in the soil water content, at a depth of 0-120 cm in the MCWH plots, were 4.2 -9.9% with respect to the control during the different years. The average increase in the grape yield, and yield per cluster were 36.4 and 26.5% respectively. Furthermore, a multiple regression equation has been given in order to predict the grape yield per tree as a function of annual water infiltrated under the tree (rain and runoff), rainfall in April (the Persian month of 'Ordibehesht'), and the average monthly temperature in February (the Persian month of 'Bahman') of the previous year. Even though the runoff potential of the MCWH system was low in the study region, this system has increased the vegetative growth, grape yield, and the yield per cluster, due to the increase in the soil water content. Therefore the MCWH, without any surface modification, was effective in increasing the growth and yield production in this study area.

### **9.3 Role Of Supplemental Irrigation Using Harvested Rainfall On The Various Phenological Stages Of Dry Farming Wheat Crop**

**Fathali Kalantari**

Agricultural Research Center, Eastern Azerbaijan

#### **Abstract**

Plant growth is affected by climate, variety and gene characteristics of plant, and soil properties. This paper emphasizes on climatic conditions, namely precipitation and its effects on crop cultivation. In the temperate zone, water is not a limiting factor for cultivation. In such a region, the amount of precipitation exceeds evaporation and water requirements of plants, but in arid and semi-arid areas, the amount of evapotranspiration is more than that of effective rainfall, and hence, moisture can be considered as a limiting factor for plant yield. In these regions, in order to obtain a satisfactory yield, irrigation is necessary. About 16% of cultivated lands of the world are equipped with different facilities of irrigation, and based on statistical data, 40% of the total agricultural yield is produced in these Regions (1). This fact indicates the importance of irrigation as a valuable factor in agricultural production, especially in arid and semi-arid regions. Obtained results from conducted experiments in the Middle East and North Africa reveal that the effects of all limiting factors in agriculture (soil, plants, fertilizers, and agricultural techniques) are a function of available moisture content (1). The effect of irrigation in plant production and harvested water through precipitation as an important and mostly available water resource, may guide us in water consumption and increasing agricultural products. In some parts of the world, in spite of adequate available moisture, misuse of such resources, has violated a guaranteed agricultural yield. Providing an adequate water supply not only reduces a farmer's risk, but may also gain additional results:

1. Increasing Crop Yield
2. Improving Crop Quality
3. Usage of Optimal Rainwater Towards Increasing the Area of Uncultivated Lands
4. Minimizing Water Erosion

Using supplemental moisture content during vital Stages of plant growth may considerably reduce yield loss. One of the main resources for the completion of irrigation is different kinds of runoff resultant from rainfalls. Collection of runoff waters may be conducted as follows:

Harvesting and preserving runoff water resulting from seasonal rainfall through the construction of dams and reservoirs in farms.

Using of runoff water through the application of domestic and cheaper facilities (i.e. pumping), may enhance their applicable potentials. Application of surplus rainwater from supplemental irrigation considerably affects crop yield. The International Center for Agricultural Research in the Dry areas (ICARDA) in Syria, reported that by adding 1/3 of required water to the annual precipitation in wheat, crop yield doubled during 1985-1986. Dry farming wheat yield increased 2.5 times with the same treatment during 1986-1987. The amount of precipitation during these two years was almost identical (2). Furthermore, by increasing 1000 m<sup>3</sup>ha<sup>-1</sup> of irrigation water to annual precipitation in Eastern Azerbaijan, dry farming yield of wheat increased by 70% Mirnezami (1978) studied the degree of correlation between precipitation and wheat, yield, and found the correlation coefficient ranging from 0.928 to 0.981 in six regions of the country (5). Hashemi (1973) found a linear correlation coefficient of 0.78 between rainfall and wheat yield in all agricultural lands of the country (6).

## 9.4 History Of Rainfed Agriculture In Turkey

**Prof. Dr.Mehmat Aydin. Rec. Ass. Seref Kilic**

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### Abstract

Turkey, like most other Mediterranean countries, is an arid and semi-arid country. Turkey is also experiencing a population boom.

This increase in population has led people to boost agricultural production by cultivating marginal land. In fact, until 1970, increases in food crop production were caused mostly by increases in the area of land that was cleared and cultivated.

After 1970, with the help of more sophisticated techniques and more modern equipment, farmers aimed to conserve the moisture in the soil profile and protect greater yields by controlling the time of tilling how many times a year soil was disturbed, and how deeply soil was cultivated. For a time, these new farming practices appeared to resolve Turkey's agricultural production problems. Between 1970 and 1990 while the area cultivated in wheat increased by only 9% wheat production increased by 90%. Nevertheless, Turkish farmers had much to learn about contending with periods of low rainfall, such as in 1989, when wheat production declined by 20% from the year before. By the early 1990s, the increasing rate of production clearly showed that it was time to establish new guidelines for sustainable agriculture in the nation's dry regions. Indeed, lack of rain during the growing season on the Central Plateau and other semi-arid regions of Turkey poses the greatest challenge to the nation's agriculturists.

To address the pressing need for water the Turkish government launched the Southeastern Anatolia Development Project in 1987. The project covers an area of 74,000 km<sup>2</sup>, roughly equal to one-tenth of Turkey's land surface. The project consists of 13 subprojects on the Euphrates and Tigris rivers.

## 9.5 Determining Spatial Variability Of Ground Water Levels For Sustainable Irrigated Agriculture

**Rema Devi, H. R. Patel**

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### Abstract

Much of the world's food production is dependent on irrigation. Irrigation plays a particularly important role in developing arid and semi-arid regions of the world. However, large-scale extension of irrigation in such area has created some problems. Irrigation without manmade drainage, often raise, the water table to the upper layer of ground water, leading to salinization, which further impairs plant growth and make soil impenetrable.

Worldwide, one tenth of the irrigated lands suffer from water logging and as a result, productivity has fallen due to land degradation. Improving irrigation, efficiency could help reverse the inevitable decline in irrigated land. However, there are some limitation to irrigation efficiency, taken in the context of canal irrigation. Even when economic and other constraints are taken care of in these cases, inadequate information on ground water levels reduces the efficiency of these management measures. Ideally, landaus and water resources management can put land and water to the best and most sustainable uses by conjunctive use in irrigation, by harnessing the excess around water, by provision of drainage etc. Spatial analysis of around water levels, which provides more reliable information can lead to improvement in the efficiency of these management measures.

This paper focuses on the use of Kriging techniques for optimal prediction of ground Water levels. Kriging uses the semivariogram or error processes to arrive at optimal estimation. It takes into account the effect of both distance and direction. Semivariogram analysis involve an assessment of spatial distribution of a parameter (such as ground water levels) by comparing measurement between individual sample location. The variability between the locations is assessed according to the radius of influence and regional characteristic. The plot between variance and separation distance is called a semivariogram. Thai analysis is used to interpolate ground water levels at unassembled locations using the Kriging algorithm.

The area chosen for study is a part of the command area a major canal project in a semiarid region; the command area has suffered water logging extensively in the twenty years, since canal irrigation was introduced on a large scale in 1973. PC ARC/INFO 3.2 GIS is used for extracting the information from the command area map for the spatial analysis.

## 9.6 Influence Of Runoff Irrigation On Soil And Plant Nutrients

**Johannes Lehmann, Wolfgang Zech**

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### Abstract

In many tropical dry lands, low and variable rainfall severely limits crop production. In arid and semi-arid regions, runoff is reported to increase and stabilize crop production. Runoff however, may adversely affect the nutrient status of the soil.

The present study was made on a runoff irrigation system with *Acacia saligna* and *Sorghum bicolor* in the semi-arid zone of northern Kenya. This examines the effect of irrigation water on soil nutrients and studies the influence of trees, and organic and chemical fertilizers on some aspects of nutrient cycling. The nutrient contents of the soil under runoff irrigation and rainfed agriculture were compared before and after irrigation. Foliar nutrient contents of good and poor growing Sorghum were compared outside and inside the irrigation system, in order to identify the nutrients, which are limiting crop production. Net nitrification was measured with and without irrigation using resin cores. Nutrient leaching was estimated by analyzing the soil solution obtained by suction cups. A fertilization experiment was conducted applying leaf manure and chemical fertilizers.

N deficiency accounted for most of the yield depression. Foliar N contents of Sorghum are lower under runoff irrigation than under rainfed agriculture. This can be explained by the lower soil NO<sub>3</sub> content and the lower net nitrification in the Irrigated plots. The total soil N Content decreased more than 10% within one-year after establishing the runoff irrigation system. N fertilization increased the total grain yield by 4.5 times. Under the tree canopy, N losses are lower than that in soil without vegetation cover.

Leaching of nutrients, especially N, is the main problem limiting crop yield in the studied irrigation system. Runoff irrigation can only be successful if the available nutrients are kept in the system, or if additional nutrients can be provided. Trees, with their continuous and deep root system, can recover nutrients and make them available for the annual crop when the leaves are used as green manure.

## **9.7 Management Of Rainwater And Its Recycling For Increasing Crop Productivity In Bhal And Coastal Belt Of Gujarat (India)**

**A. Das, V.V. Sonani, P.T. Patel**

Regional Research Station (Bhal and Coastal Zone), India

### **Abstract**

A study was undertaken at the Regional Research Station (Bhal and Coastal Zone), Arnej of Gujarat Agricultural University over a catchment area of 40 hectares on the management of rainwater and its recycling for increasing crop productivity in the region. Bhal and Coastal Belt of approximately 1.2 million hectares, falls under semi-arid climate and suffers from various crop production related constraints like scanty, erratic rainfall, brackish groundwater, saline/sodic vertisol and vertic inceptisol with poor drainage, low or no outfall and water logging. Thus, exploration of maximum applicability of rainwater to crop production would be of utmost value for the region. Techniques followed for rainwater management consists of four steps:

- Collection of rainwater in different plots of the catchment to desired extent and time through (a) improved techniques of deep ploughing and harrowing during summer and (b) making 45-60 cm high bunds around each plot of the catchment
- Land shaping and development of graded raised and sunken bed system.
- Harvesting of excess rainwater from different plots of the catchment into a dugout pond located at the lowest contour point in the catchment and connected through a network of drainage channels to plot outlets.
- Recycling of harvested rainwater as “life saving” Or “limited” irrigation to different crops during post rainy periods.

The bund making and improved technique of deep tillage arrested 25-28% more moisture in the soil profile over the conventional practice and resulted in 20.1% and 18.0% increase in grain yield of wheat and gram respectively. Step 2 revealed that cotton crops on 6m wide raised beds during monsoon and wheat on 6m wide sunken beds during post-rainy seasons are the best sequential crop combination for higher harvesting of 1.20, 2.47, 1.42, 2.07, 1.67, 2.33 and 0.85 ha meter of rainfall in the dugout pond during 1989.95 out of 568.1, 877.5, 386.2, 620.5, 530.3, 876.2 and 405.3 mm of rainfall respectively. Results from Step 4 revealed that one 50 mm irrigation increased 67.5, 56.0, 41.9, 42.9, and 38.9% grain yield over those of rainfed respectively for wheat, gram, mustard, safflower and dillseed, while three irrigations each of 50mm produce 177% more grain yield of wheat than rainfed.

## 9.8 “In Situ” Rainwater Catchment For Crop Use

**Seyed Majid Hashemina**

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### Abstract

Seldom is precipitation sufficient and adequately distributed to enable crops in achieving full yield potential. Furthermore, runoff from a sloping terrain found in dry land agriculture could seriously intensify this problem. Retaining rainwater ‘in situ’ using surface storage enhancement techniques, have long been used in many areas to compensate for non-uniformity and inadequacies in amount and distribution of rainfall, and to reduce the risk of crop failure and stabilized crop yields at economic levels.

Basin tillage, also known as furrow diking, tied-ridging, basin listing, row-damming or micro-basin tillage, is a soil and water conservation practice that increases the storage of precipitation, thereby potentially reducing storm runoff and increasing soil water storage and availability to crops.

This paper reviews the historical development of the technique, describes different types of equipment used for construction the basins, and discusses the impact of this tillage method on crop yield and soil erosion. In addition, new surface storage enhancement implements are introduced, including the one designed and manufactured by the author.

## 9.9 Correlation Between Rainwater Use And Agriculture Sustainable Development Of Loess Plateau Of China

**Huang Zhanbin, Shan Lun, Wu Pute, Zhang Zhengbin**

Chinese Academy of Sciences and Ministry of Water Resources, P. R. China

### Abstract

Rainfall is a main water resource of farming in Loess Plateau of China. The annual average precipitation (443 mm) is  $2.757 \times 10^9$  m<sup>3</sup>, which is about 9.2 times amount of annual surface water and groundwater used at present. Because of different distribution on time and space, easy loss and more changing of rainfall soil and water loss and serious drought, rainwater use rate and the efficiency are very low. There are some advantages for collecting rainfall on Loess Plateau, and to develop rainwater harvesting agriculture is a key link between soil and water conservation and production. The history of rainwater harvesting is very long in Loess Plateau, also there are many ways, such as small

reservoirs, dams, pools, well or cellars, and terraces separated by slope land, etc. The problem is these ways have not formed a system, and shortage of some key advanced technologies, such as materials for protecting from water loss in collecting, storing stages, and good methods of irrigation with high efficiency exists. Presently, the Chinese government has paid a great deal of attention to rainwater harvesting on agriculture sustainable development

## **9.10 Feasibility Of Honeybee (*Apis Mellifera L.*) Rearing In The Kowsar Water Spreading Station**

**Bahman Eilami**

Fars Research Center- for Natural Resources and Animal Husbandry, I.R. Iran.

### **Abstract**

To find the feasibility of honeybee rearing in a flood Spreading system, a twenty honeybee colonies (*Apis mellifera*) was studied for one year from 1995 to 1996. Having determined the flowering time and flowering period of the different species of Eucalyptus and Acacia trees, the production characteristics of the colonies were recorded monthly, and the produced honey chemically analyzed and compared with the international Standard criteria. Various species of the Eucalyptus and Acacia planted in the flood spreading system flower in a 12-month season, therefore, enough nectar and pollen are available for honeybees throughout the year. In spring the yield and production characteristics of the colonies were good. Although the amount of nectar and pollen abounded in summer, the colonies were carried to the cold regions, because the temperature and pest population were high in the experimental site. In fall and winter the honeybees collected the nectar and pollen of the trees which bloomed in these seasons. Comparing the experimental honey with the standard criteria indicated it was a honey of suitable quality.

## **9.11 Rainwater Management For Sustainable Production In Indian Arid Zones**

**R. K. Goyal, P. R. Ojasvi, J. P. Gupta**

Division of Resource Management, Central Arid zone Research Institute, Jodhpur, India

### **Abstract**

The Thar desert in western Rajasthan is characterized by low (100-400mm/year-1) and erratic ( $CV > 50\%$ ) rainfall, high wind speed (20-40km/hr-1), intense solar radiation, and high potential evapotranspiration (1842mm/year-1). Soils in this region are mainly sandy with low water holding capacity. This complex leads to frequent droughts and consequently crop failure. For the survival of human and animal populations, a system must be employed to conserve the meager rainfall received in this region. Over a period of time people in this region had evolved methods of rainwater conservation for domestic and agricultural use. Some of the most viable techniques of moisture conservation for imparting stability in the crop production are contour bunding, contour furrowing, mulching and Khadin cultivation. Other moisture conservation measures which have been found useful and adopted in this region are micro-Catchment, subsurface barrier, tanks and soil amendments. These methods, therefore, have been studied and structurally improved for better moisture conservation. This paper present the results of techniques recommended for various farming situations in this region.

## 9.12 Scarcity of Natural Resources and Its Implications for sustainable Development

**Alfred Boryor Tetteh**

University of Ghana, Ghana

### Abstract

The idea of sustainable development has much popular appeal, but conflicts with centuries of economic theory about how limited land and natural resources had constrained the growth of economies and population. Much of that doctrine, especially that in the Methusian tradition, is contradicted by historical experience, but the modern threat of environmental degradation raises new questions about whether growth can be sustained. Many of these new problems result from biases in economic organizations and institutions so-called environmental resources.

Today's concern about sustainable development has deep root in economic doctrine. Repeatedly, and especially since economic and population growth continues, we will run out of essential natural resources. Sometimes the danger has been seen as impending global starvation as expanding populations exhaust the world's food production capacity. Sometimes a particular country may be threatened with depletion of some natural resource on which its economy critically depends.

The world's fresh water resources are now facing an unprecedented crisis. Despite the fact that less than 1% of these resources are renewable, water extraction greatly exceeds replenishments and demand is increasing significantly as the world's population grows. To make matters worse, usable stocks are being polluted as urban areas expand and agriculture intensifies, increasing the marginal cost of supplying water.

This study analyzes the crucial intervention between the growing demand for groundwater and the socioeconomic effects of its depletion and degradation. An underlying hypothesis is that the depletion and degradation of groundwater resources will create conflicts between the ways the water can be used and between the people who use it. The main issues being examined include:

- a) links and interaction between socio-economic demographic and hydrogeologic conditions;
- b) management of depleting and degrading sources; and
- c) strategic geo-political issues arising from the scarcity and management of groundwater and rainwater harvesting and storage.

## 9.13 Agricultural Reuse Of High Salinity Wastewater Through Drip Irrigation

**Dr. Iqbal Ali**

Ned University Of Engineering And Technology, PakiStan

### Abstract

Field investigations at pilot scale were carried out to take into account all the aspect of reuse of chlorinated secondary effluent of high salinity from an activated sludge treatment plant for growing tomato using two systems of irrigation. The performance of sprinkler and drip systems was compared on the basis of the yield obtained. Saline water (<3400 mg /l) was found suitable for agriculture reuse with drip system producing as much as 6.55 to 7.77 time higher yield as compared to sprinkler system,

The foliage damage due to sprinkling water was the main cause of low production in case of sprinkler System. No traces of fecal coliform was observed in either case. There was no problem of excessive salt deposition in the root zone of drip system. However, periodical washing of soil either naturally through rains or sprinkling of sweet water was found necessary to wash down the salts below the root zone particularly in sprinkler system.

Overall the superiority of drip system was for the secondary treated wastewater in terms of yield, health hazard, high salinity. Water and energy observation was established over sprinkler system. The use of drip system utilizing the chlorinated secondary effluent of high salinity is recommended without going in for tertiary treatment.

### **9.14 Documentation Of Soil Fertility: An Experience From Irrigation Resource Inventory Of North-East Tanahun And East Chitwan Valley, Nepal**

**R.N. Yadav**

Tribhuvan University Institute Of Agriculture and Animal Science, Nepal

#### **Abstract**

The Irrigation Management Systems study Group (IMSSG) at the Institute of Agriculture and Animal Sciences (IAAS), Rampur, Chitwan recently completed a resource inventory of more than 250 farmer managed irrigation systems residing in east Chitwan (Inner Terai) and north-east Tanahun during May 1992-December 1993. One component of the study focused on the farmer's perception of their soils, specifically soils related data such as soil fertility changes and the farmers' practices to fertility management. An inventory checklist was utilized to facilitate the farmer's interviews. Evidence from both of these areas shows the occurrence of high degree of spatial variation in soil types even within an irrigation system boundary. Loamy or gravelly loam in the river basin of Tanahun district and loam to clayey in East Chitwan valley were found to be the dominant soil textures. A comparison of soil fertility changes over time showed 73% of the irrigation systems, maintained or improved their soils in Tanahun in contrast to 21% maintained or improved soil fertility in East-chitwan. The farmers in both of these areas were found to have developed their own soil classification systems using certain criteria that relate to the need of soil and water management practices. In Tanahun, there is greater dependency on organic manuring and silt collection for fertility management, whereas higher chemical fertilization predominates many of the irrigation systems in East-chitwan.

### **9.15 Pilot Irrigation Systems For On-Farm Water Management At Jibrin, Nattalah And Jimah Areas Of The Sultanate Of Oman**

**Emad Abdel Majid**

Ministry of Agriculture and Fisheries, Sultanate of Oman

#### **Abstract**

Irrigated agriculture in Jibrin and Natallah areas are experiencing acute shortage of irrigation water. As a result the majority of date palms and other crops are stressed, and some of the date palms have dried up. As Jibrin possesses the most important and beautiful fort, it is therefore become imperative to save most of the nearby date palms from dying and to preserve and keep the beauty and the

historical touch. This has been achieved by transferring irrigation water from Jimah ground water wells to Jibrin area using buried pipeline, balancing tanks, booster pump station and modern irrigation systems.

In the meantime, a pilot project of smallholdings farms has been established at Jimah with the surplus water after meeting the requirements of Jabrin and Nattalah. An Irrigation Pilot Project using pipe networks and modern irrigation systems has been constructed to serve about 60 hectares of the irrigated agriculture lands in Jabrin, Nattalah and Jimah. The project is considered unique in controlling, distributing, managing and utilizing the irrigation water efficiently and as per requirements. Using this integrated approach in agriculture development will result in water savings and accomplish higher productivity with less agriculture inputs.

## **9.16 Feasibility Of Developing Small Catchments Based On Rainwater Harvesting Tanks For Small And Marginal Farmers In Bhal And The Coastal Belt Of Gujarat (India)**

**P. T. Patel, J. B. Raol, A. Das, V. V Sonani**

Gujarat Agricultural University, India

### **Abstract**

Feasibility of developing a rainwater harvesting tank based on small catchments of 10 ha, coupled with the prevailing soil agro-climatic data over the last 37 years of that and the coastal belt of Gujarat has been worked out for its possible implementation by the small and marginal farmers of this region for increasing/sustaining crop productivity. The groundwater of Bhal and the coastal belt is brackish in quality so rainwater harvesting is the key solution for increasing productivity of crops through supplemental or life saving irrigation by the farmers who have an average holding of 10 ha of land.

The total yield capacity, runoff coefficient, runoff and average water yield per year are estimated to be 1 ha-m, 0.20, 9.0 cm and 0.90 ha-m, respectively. While the earth calculation of such model tanks in terms of different parameters like average area, average length, width and area at bottom, are of tank (ground), earth work (cut), earth work for bund (fill) and gross area for construction are estimated to be 2857 m<sup>2</sup>, 53.45 m, 49.08 m, 2408.4 m<sup>2</sup>, 2790.5 m<sup>2</sup>, 3899.1 m<sup>3</sup>, 3130.1 m<sup>3</sup> and 0.50ha, respectively.

This experiment conducted on the micro-pond at this station revealed that evaporation and seepage loss accounts for about 35.54%, which holds true and corroborates with the results of existing farm ponds at this station.

Out of 9000 m<sup>3</sup> of the water yield, by subtracting the evaporation and seepage loss plus another 15% (irrigation efficiency related) a total of 4931.19 m<sup>3</sup> of water per year will be available for irrigation, which in turn brings 9.5 ha of land under one 50 mm supplementary irrigation area which can fetch about Rs. 45,000/ additional income to the farmers. Our findings on wheat revealed that one 50mm supplemental irrigation brought in more than Rs. 4500/ha as additional income over rainfed crops. The total cost of a model tank, inclusive of the main channel, valves, etc., is estimated to be Rs. 164,000/-. The tank, once made, will last a long time and farmers will be highly benefited and will be able to recover the initial investment within 4 years.

## 9.17 Burkina Faso Experience On Rainwater Harvesting For Drought Proofing Of Rainfed Agriculture

**L. Some Inera**

Burkina Faso

### Abstract

Agriculture in a sahelian Country like Burkina Faso is strongly dependent on rainfall. Whereas since the beginning of the 70s deteriorating climatic conditions have been observed in this region. This has particularly resulted in a low and/or a bad space-time repartition of rainfall. Giving that it is impossible to efficiency modify the climate, one must try to manage in the best possible way the entire rainfall.

In Burkina Faso, several research and development institutions have been dealing with this problem since the beginning of drought in the Saheil in 1973-74, which unfortunately persists today.

This paper summarizes what have been done in Burkina Faso as appropriate technologies for rainwater harvesting.

Several techniques including; flat ploughing, earthing up and tied ridging have been compared to the traditional non-soil tillage in a pluri-annual and multi-local agronomic trials conduced with respect to all the agro-climatic conditions of the country.

Some other rainwater catchment systems have been experimented particularly in the north of the country to make available for supplemental irrigation on rainfed crops or watering of animals.

## 9.18 Full Utilization Of Rainfall Runoff As An Effective Way For Development Of Water Resources In Arid And Semi-Arid Regions Of China

**Zu Zhenhua, Wang Kailin, Song Guanchuan**

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### Abstract

The city of Xuzhou is located between 33°43' N to 34°58'N and 116°22'E to 118°40'E, northwest of the Jiangsu province, bounded on the junction of the Shandong, Henan and Anhui provinces. From east to west, the city is about 210 km long. The Beijing-Shanghai railways criss-cross here, and the Beijing-Hangzhou canal obliquely passes through it. The city of Xuzhou has a developed highway traffic and is one of the most important communication hubs in the northeast of China.

Five districts and six counties are under the jurisdiction of the city government, with a population of 8.51 million. The city has 9.06 million mu of cultivated land, and 6.74 million farmers.

Xuzhou also does not have water resources. Under normal conditions, the water quantity is 1,600 million m<sup>3</sup> short. During dry years, its shortage is as much as 4000 million m<sup>3</sup> annually, which has seriously restricted the development of farm production. In this regard, the full utilization of the indigenous rainwater to develop irrigation agriculture is an important area of study for the Water Conservation Department. This study will have much benefit for local residents as to improving their standard of living.