Meteorological Climate Change effect of the Ataturk Dam in Turkey at Eastern Anatolia

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Abstract: In Turkey, the significant amount of energy produced obtained of hydroelectrical power stations. Water constructions such as dam's reservoir in arid and semi-arid regions effects each other with climate and hydrology of environment. Therefore meteorological conditions have to be established and monitored at the hydroelectrical power stations. Droughts are among the most significant natural hazards that might damage human life and property under different meteorological and environmental conditions. The simplest methodology of temporal climate change assessment is the standardized precipitation index (SPI) which is used to quantify the precipitation deficit for several time scales, for example time averaging periods. The SPI is commonly used for the identification of various climate change characteristics such as the rain duration change, magnitude change, and intensity change at different standard truncation levels. The relationships between the drought duration and magnitude are provided in the form of scatter diagrams with the best straight-line fits. These are obtained for different truncation levels. Precipitation based drought description has been extended to triple-variable additionally including temperature and humidity time series. Such contours can be prepared for any base precipitation value but in this study average precipitation value is adopted as the truncation level. In this study is related to construction of the most important main project in the Southeastern Anatolia Project (GAP) area, the Ataturk Dam.

Keywords: Standardized precipitation index, climate change, drought, dam basin

INTRODUCTION

The Standardized Precipitation Index (SPI) is a way of measuring drought that is different from the Palmer drought index (PDI). Like the PDI, this index is negative for drought, and positive for wet conditions. But the SPI is a probability index that considers only precipitation, while Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff).

Weather is the state of the atmosphere at a specific place and time. Climate is a long-term average of weather in an area. Both are influenced by the amount of solar radiation the area receives, by local terrain and nearby large bodies of water, by changing geological and biological conditions and by other factors. Forecasters can often predict weather because of its local and generally sequential nature, but it is difficult to predict the longer-range of atmospheric chaotic motion. Climate predictions can be even harder to make because these factors operate over larger areas and longer periods of time.

Scientific paper

We know that climate has changed in the relatively recent past, but we are unsure about the causes of the change. We cannot yet predict climate change; data and models on which to base these predictions are still incomplete. Accurate climate predictions will soon be as critical as accurate weather predictions, however. Human-induced changes in the quantities of atmospheric carbon dioxide and ozone will lead to climate changes, but we're not sure what these changes will be.

The water resources and the atmosphere are extensions of each other, and human activity has changed the atmosphere as it changed the water resources. By establishing of the Ataturk Dam as important main project in the Southeastern Anatolia Project (GAP) area, pollutants injected into the air by construction phase can have regional consequence for the water resources and for all inhabitants.

Potentially the most destructive atmospheric problems are depletion of the ozone layer, global warming, and acid rain.

Ozone Layer Depletion

Table 1. Average ozone change, 1969-1986 (Smith, R.C., et al., 1992)

Latitude	Summer	Winter	Annual
1. 53^o – 64^{o}N	+ 0.4 %	– 6.2 %	– 2.3 %
2. 40^o – 52^{o}N	– 2.1 %	– 4.7 %	– 3.0 %
3. 30^o - 39^{o}N	– 1.9 %	– 2.3 %	– 1.7 %

Ozon depletion in the stratosphere above various latitudes of the Northern Hemisphere between 1969 and 1986. A 1991 NASA study showed that between 1978 and mid – 1990 the decreases in ozone were about twice the percentages shown here. Ozone is a molecule formed of three atoms of oxygen. Ozone forms naturally when lightning strikes through air; larger quantities are generated spontaneously in the stratosphere. A diffuse layer of ozone mixed with other gases-the ozone layer-surrounds the world at a height of about 20-40 kilometers. Seemingly harmless synthetic chemicals released into the atmosphere – primarily chlorofluorocarbons (CFC s) used as cleaning agents, refrigerants, fire-extinguishing fluids, spray-can, propellants, and insulating foams- are converted by the energy of sunlight into compounds that attack and partially deplete the region's atmospheric ozone. Ozone levels in the stratosphere have decreased by about 3 % over some countries like Turkey since 1969 (Table.1). The amount of depletion varies with latitude and with the seasons because of variations in the intensity of sunlight. This decline in ozone alarms scientists because stratospheric ozone intercepts some of the high-energy ultraviolet radiation coming from the sun. Ultraviolet radiation injures living things by breaking strands of DNA and unfolding average amounts of ultraviolet radiation, but increased amounts could overwhelm those protein molecules. Species normally exposed to sunlight have evolved defenses against defenses. Land plants such as soybeans and rice would be subjected to sunburn that decreases their yields. Even plankton in the uppermost 2 meters of water resources would be affected; recent research in fact indicates an alarming decrease in phytoplankton primary productivity of between 6 % and 12 % in dam lake waters. A 1 % decrease in atmospheric ozone would probably be accompanied by a 5 % to 7 % increase in human skin cancer. Strong ultraviolet light can also suppress the immune system and cause eye cataracts. The quantity of photochemical smog shrouding the urban areas will also increase as ozone levels fall.

Since the building of the Ataturk Dam, the industry at the Southern Anatolia at some cities like Gaziantep, Harran have increased, which results by increasing of emissions of CO_2, methane, and other greenhouse gases. These gases have contributed to a general warming of the district. The surface temperature of the region fluctuates slowly over time. The regional temperature trend has been generally upward in the 18 000 years since the last ice age, but the rate of increase has recently accelerated. This rapid warming may be the result of an enhanced greenhouse effect, the trapping of heat by the atmosphere. Glass in a greenhouse is transparent to light but not to heat. The light is absorbed by objects inside the greenhouse , and its energy is converted into heat. The temperature inside a greenhouse rises because the heat is unable to escape. On earth greenhouse gases-carbon dioxide, water vapor, methane, CFCs, and others-take the place of glass. Heat that would otherwise radiate away from the planet is absorbed and trapped by these gases, causing a rise in surface temperature. Greenhouse mechanism on the water resources:

1. Sunlight penetrating the atmosphere warms the Earth's surface,
2. The earth's surface radiates heat to the atmosphere, and some escapes into space,
3. Greenhouse gases in the atmosphere absorb some of the heat and trap it near the earth's surface,
4. When greenhouse gases-and heat-build up, dam lake water surface temperatures rise and the temperature of the atmosphere increases (Figure.1) (Watson et al.,1990),

Standardized precipitation index (SPI)

The wide variety of disciplines affected by drought, its diverse geographical and temporal distribution, and the many scales drought operates on make it difficult to develop both a definition to describe drought and an index to measure it. Many quantitative measures of drought have been developed in the United States, depending on the discipline affected, the region being considered, and the particu-

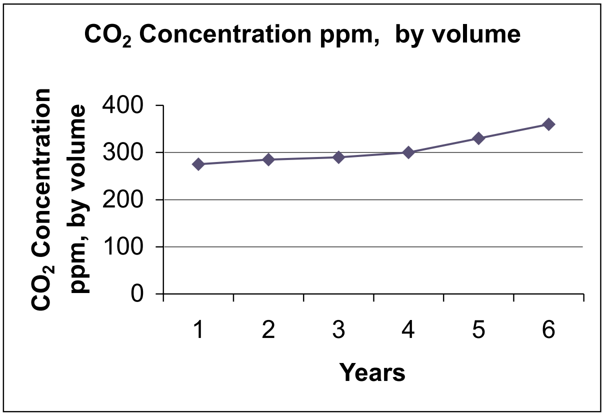

Figure 1. CO_2 concentration increase ppm, by volume (Watson et al., 1990)

lar application. Several indices developed by Wayne Palmer, as well as the Standardized Precipitation Index, are useful for describing the many scales of drought.

Common to all types of drought is the fact that they originate from a deficiency of precipitation resulting from an unusual weather pattern. If the weather pattern lasts a short time (say, a few weeks or a couple months), the drought is considered *short-term*. But if the weather or atmospheric circulation pattern becomes entrenched and the precipitation deficits last for several months to several years, the drought is considered to be a *long-term* drought. It is possible for a region to experience a long-term circulation pattern that produces drought, and to have short-term changes in this long-term pattern that result in short-term wet spells. Likewise, it is possible for a long-term wet circulation pattern to be interrupted by short-term weather spells that result in short-term drought.

The simplest methodology of temporal drought assessment is the standardized precipitation index (SPI) and run analysis which are used to quantify the precipitation deficit for several time scales. In drought analysis, the given time series are estimated as X_1, X_2, ..., X_n , then the standardized precipitation series is given as

$$x_i = \frac{X_i - \overline{X}}{S_x} \tag{1}$$

where $\overline{X}$, is the arithmetical mean of the given series, S_x is the standardized variation. As given in the below Figure (2) the obtained drought periods L_1, L_2, ..., L_m are taken by using the run analysis which are used to quantify the precipitation deficit for time averaging periods.

The drought amplitude is given as the deficit summation under each drought period as M_1, M_2,......., M_m. The cumulative deficit is given as

$$M_j = \sum_{i=1}^{m} \left| X_o - x_i \right| \tag{2}$$

where m is the drought number during the drought period and X_o is the standardized mean level for every drought label. Also the drought intensity can be given as the ratio of drought amplitude to drought period.

$$I_J = \frac{M_j}{L_j} \tag{3}$$

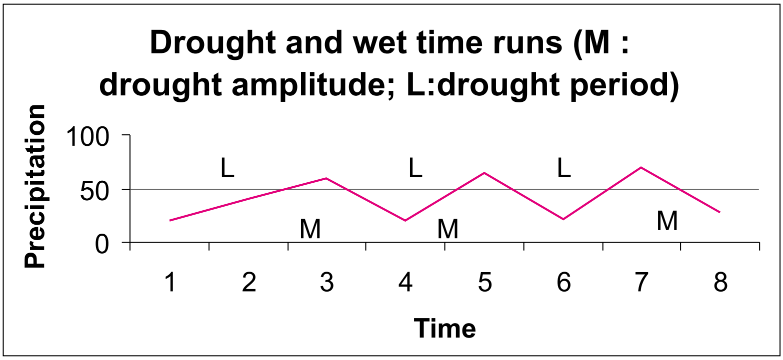

Figure 2. Drought and wet time runs (M_j: drought amplitude; L_j: drought period)

In every cutting point L_{max}, $L_{min,}$ M_{max}, M_{min} and I_{max}, I_{min} can be found as the drought property values. In addition, for understanding of every drought property the statistical parameters (mean, standardized deviation,…. and the others) can be found. The real amplitude, M_r (mm) can be found by opposite of the standardized method as

$$M_r = MS_M + \overline{X}_M \qquad (4)$$

where $\overline{X}_M$ and S_M are the mean of the amplitudes and the standardized deviation, respectively. Taking 9 rain measurement stations to give the drought periods as in Figure 3 and in Figure 4.

Considering the precipitation amounts at Figure 4 the amounts of the 2.value and 3. value lies below the diagram which shows the critical values for the drought periods (Table 2.).

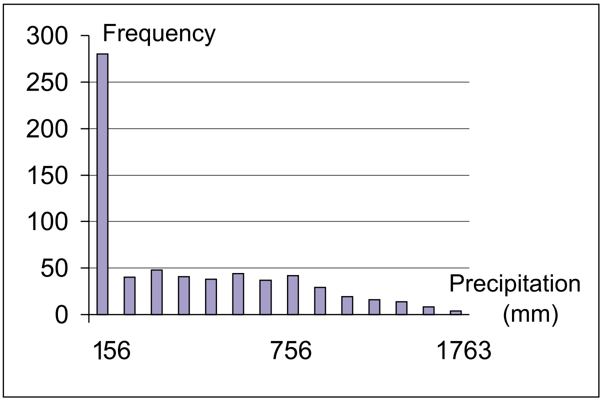

Figure 3. Histogram of Precipitation at Ataturk Dam District before the Dam Building

Table 2. The drought duration, amplitude, intensity, humidity and temperature in the maximum drought period before the Dam Building (Anonymous, 1989)

Cities	attitude	latitude	Month	Ampl.	I=[M/L]	Humidity(%)	(^{0}C)
Adiyaman	38.28	37.75	7	4.06	0.65	81.7	32.31
Diyarbakir	40.12	37.92	13	3.83	0.7	86.0	32.00
Gaziantep	37.37	37.08	7	3.97	0.76	88.4	29.50
Malatya	38.32	38.35	12	6.28	0.7	87.0	29.30
Elazığ	39.22	38.67	15	5.28	0.7	89.0	29.35
Batman	41.17	37.87	5	2.40	0.64	89.0	30.60
Siirt	41.93	37.93	9	3.72	0.62	86.2	30.95
Mardin	40.73	37.3	12	3.05	0.76	86.1	30.57
Urfa	38.77	37.13	16	4.24	0.74	81.0	32.70
		TOTAL:	**96**	**36.83**	**6.27**		

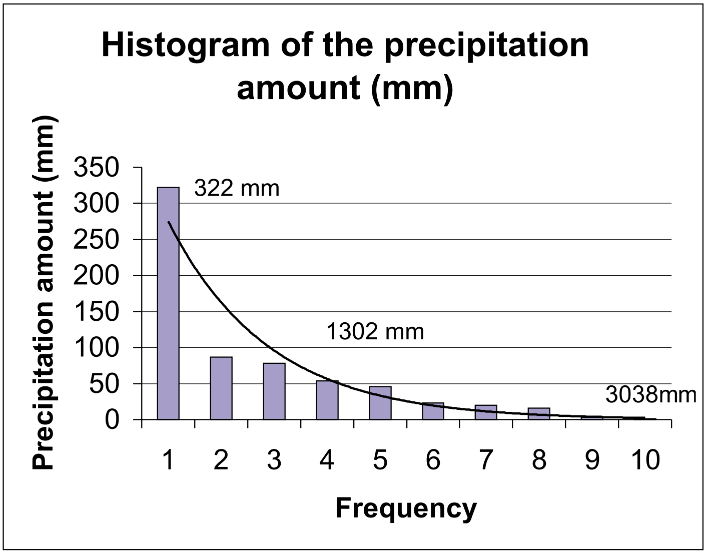

Figure 4. Histogram of Precipitation at Ataturk Dam District after the Dam Building

Standardized Precipitation Index (from National Climatic Data Center, NOAA):

1) exceptionally dry : –2.00 and below
2) extremely dry : –1.99 to –1.60
3) severely dry : –1.59 to –1.30
4) moderately dry : –1.29 to –0.80
5) abnormally dry : –0.79 to –0.51
6) near normal: –0.50 to +0.50
7) abnormally moist : +0.51 to 0.79
8) moderately moist : +0.80 to +1.29
9) very moist : +1.30 to +1.59
10) extremely moist : +1.60 to +1.99
11) exceptionally moist : +2.00 and above

The ***Palmer Z Index*** measures short-term drought on a monthly scale. The Palmer ***Crop Moisture Index (CMI)*** measures short-term drought on a weekly scale and is used to quantify drought's impacts on agriculture during the growing season.

The ***Palmer Drought Severity Index (PDSI)*** (known operationally as the *Palmer Drought Index (PDI)*) attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change almost literally overnight from a long-term drought pattern to a long-term wet pattern, the PDSI (PDI) can respond fairly rapidly.

The hydrological impacts of drought (e.g., reservoir levels, groundwater levels, etc.) take longer to develop and it takes longer to recover from them. The ***Palmer Hydrological Drought Index (PHDI)***, another long-term drought index, was developed to quantify these hydrological effects. The PHDI responds more slowly to changing conditions than the PDSI (PDI).

While Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff), the ***Standardized Precipitation Index (SPI)*** is a probability index that considers only precipitation. The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. The SPI is computed by NCDC for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought.

Time scale

The number of months extending through the end of the current month. Some processes are rapidly affected by atmospheric behavior, such as dryland agriculture, and the rate at which grasses and brush dry out, and the relevant time scale is a month or two. Other processes have longer time scales, typically several months, such as the rate at which shallow wells, small ponds, and smaller rivers become drier or wetter. Some processes have much longer time scales, such as the rate at which major reservoirs, or aquifers, or large natural bodies of water rise and fall, and the time scale of these variations is on the order of several years.

Five quantities are computed as part of the Standardized Precipitation Index procedure. They follow as a consequence of an observation made by Dr. Tom McKee (1993, 1995), State Climatologist for Colorado, that users are interested in one or several among the following types of information:
What is the absolute amount of precipitation?
What is the absolute departure from limatology?
What is the relative departure from climatology?
How frequent are such departures from climatology?
How can this be expressed as a single number comparable across climates?

1. **Accumulated Precipitation -** The total precipitation that has fallen during the indicated number of months, through the end of the month displayed.
2. **Accumulated Precipitation Departure** - The amount by which the indicated accumulated precipitation is above or below the long term average for exactly the same set of months. The local seasonal cycle of long-term average precipitation is automatically accounted for. A departure of 0 indicates totals are exactly equal to climatological values.
3. **Accumulated Precipitation Percent of Average** - The observed accumulated precipitation, over the time scale of interest and extending through the end of the last month indicated, divided by the long-term average precipitation which would be expected to accumulate over the same set of months, and then multiplied by 100. A value of 0 indicates no precipitation at all, and a value of 100 percent indicates that the amount is equal to the climatological average.

4. **Percentile, or "Probability of Non-Exceedance" -** This quantity indicates how often a value of the magnitude observed is seen, its degree of "unusualness". A value of 0 means that zero percent of the other values in the record do not exceed that value, or in other words, that all other values exceed that value, so that the value in question is so low that it seldom if ever occurs. A value of 50 indicates that half of the historical values are higher and 50 percent are lower. A value of 75 indicates that 75 percent of the values are as low as this value, or conversely, that only 25 percent of the values are higher than the given value. A value of 99 means that 99 percent of the observed values are lower, and that this value is in the top 1 percent of all values. Values near 50 are not unusual; values near 0 or 100 are very unusual.
5. **Standardized Precipitation Index** - The SPI was formulated by Tom Mckee, Nolan Doesken and John Kleist of the Colorado Climate Center in 1993. The purpose is to assign a single numeric value to the precipitation which can be compared across regions with markedly different climates. Technically, the SPI is the number of standard deviations that the observed value would deviate from the long-term mean, for a normally distributed random variable. Since precipitation is not normally distributed, a transformation is first applied so that the transformed precipitation values follow a normal distribution.

   The Standardized Precipitation Index was designed to explicitly express the fact that it is possible to simultaneously experience wet conditions on one or more time scales, and dry conditions at other time scales, often a difficult concept to convey in simple terms to decision-makers. Consequently, a separate SPI value is calculated for a selection of time scales, covering the last 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 18, 24, 30, 36, 48, 60, and 72 months, and ending on the last day of the latest month.

Methodology - First, a time series of the precipitation value of interest is generated. Then, a frequency distribution is selected and a statistical fit to the data is determined. The cumulative distribution is formed from the fitted frequency distribution. The percentile for the particular time series element of interest, usually the latest one, is selected from the cumulative distribution. For "ties" (multiple instances of the same value), the upper value is used (probability of non-exceedance). For any other theoretical probability distribution, the analogous point on its associated cumulative frequency distribution can be determined. Here, the normal distribution is used, with mean zero and standard deviation of one, and value in standardized units of a given percentile is found can be readily determined. For the normal distribution, these are exactly the same as units of standard deviations. The Standardized Precipitation Index can be thought of as the number of standard deviations that the precipitation value of interest would be away from the mean, for an equivalent normal distribution and adequate choice of fitted theoretical distribution for the actual data. In effect, the method consists of a transformation of one frequency distribution to another frequency distribution, in this case the widely used normal, or Gaussian, distribution.

In this case, following McKee et al. (1993, 1995), we have chosen to use the incomplete beta distribution (see, for example, Wilks, 1995, p 95-97). This distribution is very robust and can deal with the wide range of extreme climates found in the western United States, especially those where monthly and seasonal precipitation of zero is common and expected. Guttman (1998, 1999) has examined the properties of the SPI in great detail, and has determined that the Pearson III distribution is likely to give essentially equivalent results, and in some instances slightly better. We have not yet modified the code (as of May, 2001) to use the Pearson III, but the incomplete beta distribution in use is quite close.

Precipitation Analysis in Time

The analysis of precipitation variation through time and over space will frequently yield relationships between short-term precipitation intensities and longer-term totals, between intensity and duration, and between intensity, duration and area. Thus, the analysis of the character and organization of precipitation in time and space frequently yields results which span both the temporal and spatial dimensions. Such relationships will commonly exhibit a site or area-dependency, so that temporal and spatial relationships may provide a convenient means of studying the character and organization of precipitation at the ground surface. In turn of course, the character and organization, both in time and in space, are determined by the nature and magnitude of the meteorological processes producing the precipitation, thus providing the all-important link between the two major parts. In practice, of course, no two rainstorms nor any two climates are identical, even over the long term. Many of the techniques involved in the analysis of precipitation character and organization, therefore, are aimed at distilling the considerable variation in precipitation amount over all time and space scales to produce a generalized result which may be used, either for modelling or forecasting, in a particular area or for a specific location. A key feature of the analysis of precipitation in both time and space therefore involves the use of probability theory, and elements of mathematics and statistics.

The study of the character and organization of precipitation in and through time may take a variety of forms. Precipitation is highly variable over a variety of time scales, so that it is first important to identify what may be called the ‘ precipitation climatology ’of a location when precipitation occurs seasonally and within the day, and why such variations are present. The precipitation climatology will be determined primarily by the nature of the prevailing precipitation-producing processes. There is of course considerable global geographical variation in such processes, and also often a marked seasonal and monthly variation in either their nature or magnitude, or both. The influences of process may also extend to daily variation in precipitation and to the diurnal variation in precipitation amount. It is important to ascertain the general nature of precipitation in an area: The normal expectations in amount, intensity and distribution through the year or day, and in particular, to isolate any longer-term trends or oscillations through time. Secondly, the character of precipitation amount (intensity) through time within a typical, or even a particular, precipitation event, be it a temperature frontal depression or a small rain shower over the tropical district. There are some characteristics, which may be used to distinguish a conventional storm from a synoptic disturbance. Commonly for all types of precipitation event it is also possible to characterize them in terms of mathematical relationship between intensity and duration, and in particular to derive a relationship between intensity maximum over a range of durations. Much of the analysis of precipitation data, in common with many hydrological analyses, is concerned with attempting to predict the magnitude or the frequency of events. This may adopt a stochastic approach, where it can be attempt to derive probabilities for events of given magnitude, or a physical approach, through the estimation of probable maximum precipitation (PMP), where a knowledge of precipitation processes is used.

The study of precipitation extremes is afforded by the estimation of the probable maximum precipitation (PMP). It is in fact largely a physical estimate of what might be the greatest possible precipitation given a certain set of extreme atmospheric conditions, notably the moisture content of the atmosphere. It is usually applied with respect to a given area, generally a drainage basin, and includes also estimates for the rate of inflow of moisture over the basin, and the maximum likely amount of that moisture which can be precipitated. The PMP is ‘the theoretical greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year.

Properties of Ataturk Dam and Hydro-Elektrical Power Plant (IRCOLD, 1999)

Location: SanliUrfa
Purpose: Irrigation and Energy
Construction (starting and completion) year: 1983 - 1992
Embankment type: Rockfill
Dam Volume: 84 500 000 m^3
Height (from river bed): 166.00 m.
Reservoir volume at normal water level: 48 700 00 hm^3
Reservoir area at normal water level: 817.00 km^2
Irrigation area: 872 385 ha
Installed capacity: 2400 MW
Annual energy generation: 8900 GWh

Ref: IRCOLD, 1999: Turkish National Committee on Large Dams, “Dam Engineering in Turkey”, Ankara, Turkey.

Drought Management in Turkey

In Turkey at the Southeastern Anatolian Region the water potential like the other natural resources remains constant, despite the fact that the population increased continuously. The natural water supply falls to minimum levels in summer time when the demands are maximum. The periodic droughts in the country causes important problems and necessitates the development of the projects for water storage, to meet the demands in the drought periods. For drought management the state of ground water reserves, surface and ground water relations, water quality, preservation of wetlands and the sustainability of the natural life must be developed. To estimate the magnitude and duration of the droughts beforehand for the operation of the reservoirs, the policies for the drought management must be planned. To meet the valuable results, meteorological, hydrological and ecological investigations, measurements and their analysis must be done precisely. Irrigation plans based on the river basin have been made in order to minimize the effect of drought. To reduce the impact of drought on yield, studies on preventing the planting of crops which consume most water, determining the time that crops requires most water and giving the water to that crops at that certain time, and giving the priority to the crops that requires water most were carried on annually during the drought period.In that drought period some measures such as giving the water to fig will decrease the effect of the drought in the Southeastern Region of Turkey. On the other hand, instead of small basins large river and regional basins must be chosen, also long term precipitation and flow series must be produced, correct runoff coefficients must be determined by investigating the land use, soil quality, soil texture, soil classes, geologic formation and vegetation in the basins by using geographic information systems and minimum, maximum and average flows in the rivers must also be determined. By using the mathematical models the " basin water yields" for the wet, normal and drought periods must be determined for the projects providing technical and economical optimum solutions.

In Turkey the droughts are caused by the absence of precipitation; the severe deficiency in the hydrologic system or in the agricultural and domestic demand areas does not completely match the deficiency caused by precipitation. River flows, snow melt, reservoir levels and changes in ground water levels are the most important parameters for drought processes. A definition can not be found up to now and methods defining coefficients related to drought can not be developed. The risk decreases storage capacity increase and very large and uneconomical structures are needed. For this reason suitable solutions must be developed. In Southeastern Anatolia 75 % of the water resources is being used in irrigation sector. Therefore, the demands in the drought periods can be fully solved by constructing storage reservoirs. This solution is not accepted as a rational solution economically and evaluated as waste of resources. In these periods the demands must be met by making shortages in water supply. But the shortage of irrigation water can cause a decrease in the benefits. In the drought year periods, the magnitude of drought can be estimated with a probability beforehand, so that some proportions of water shortages can be made and as a solution the water required for the minimum production, which will not endanger the plants life, can be given to the plant. During the drought period, the operations which will provide the necessary withdrawal from the ground water requirements must be encouraged. The cost of the storage structures constitutes the most important component of the drought management project. Therefore storage structures become dominant factor in the determination of the project economy. The project design must be determined according to the different conditions of the regions and the principles of the operation studies must be made by the simulations. Also these principles must satisfy the economic criteria as well. In the reservoir operation studies, the average flow of the river on which the dam is built and the variations in this flow must be evaluated as a function of the water withdrawal pattern from the reservoir. The design of the dams and its appurtenant structures must be done according to this criteria.

The measurement of the river flow precisely for long periods is important to obtain reliable results which are the main input for the reservoir operation studies.

For five year drought period the application of the following criteria for the design of the storage reservoirs is evaluated as a rational method:

1. It must meet the 65 % of the annual demands in the most drought year.
2. It must meet the 95 % of the water requirements in the operation period.
3. It must make shortages in the consecutive five years.
4. It must meet the 75 % of the irrigation water requirements in the most critical consecutive five year period.
5. It must provide irrigation water at least during the half of the irrigation period.

Water Resource Development In South-Eastern Anatolia Region (GAP)

The southeastern Anatolia Project is the most comprehensive project ever implemented in Turkey. Beyond the dams, hydroelectric power plants and irrigation schemes on the Euphrates and the Tigris Rivers, Southeastern Anatolia Project, as an integrated project envisages the development of communication, housing, industry, education, health and other services. The objectives for the development of the Southeastern Anatolia region are set as follows:

1. To develop all the land and water resources in the Region, in order to achieve accelerated economic and social development,
2. To alleviate disparity between the Region and other regions by increasing production and welfare levels in the region,
3. To increase the productivity and employment capacity in the region,
4. To meet increased need for infrastructure resulting from population explosion and urbanization,
5. To organize economic and physical infrastructure in rural areas, in such a way as to utilise the resources, in the most useful ways and to direct urban growth in desired directions,
6. To contribute to the national objectives of sustained economic growth and export promotion by efficient utilisation of the region's resources.

Southeastern Anatolia Project is the biggest development project ever undertaken by Turkey, and one of the biggest of its kind in the world. The integrated, multi-sectoral project includes 13 major projects which are primarily for irrigation and hydropower generation, planned by the State Hydraulic Works (DSI). A a large scale and multi-sectoral regional development project, this project comprises the lower reaches of the Euphrates and Tigris rivers within the boundaries of Turkey. The region covers an area of 75 358 km^2 in the upper Mesopotamia. This project aims to develop the water resources of these rivers, which are the two main branches of the Tigris-Euphrates basin (The Shatt-Al- Arab), together with the available groundwater resources in the region. At the border where the branches of the Euphrates and Tigris rivers leave Turkey, the annual average run-offs are 30 billion m^3 and 16 billion m^3, respectively, the total of which corresponds to 25% of the country's average run-off. The project envisages the construction of 22 dams, in which one is the Ataturk Dam, and 19 hydroelectric power plants on the Euphrates and Tigris rivers and their tributaries. It is planned that at full development over 1.7 million ha of land will be irrigated and 27 billion kWh of electricity will be generated annually with an installed capacity over 7500 MW. The area to be irrigated accounts for 19 % of the economically irrigable area in Turkey (8.5 million ha), and the annual electricity generation accounts for 22 % of the country's economically viable hydro-power potential (125 billion kWh). Southeastern Anatolia Project is now one of the most ambitious regional development projects ever attempted in the world. It covers, in addition to the irrigation and hydropower schemes, all the related social and economic sectors including industry, transportation, mining, telecommunications, health, education, tourism and infrastructure. The fundamental development strategy are given as four components:

1. Develop and manage the region's soil and water resources for irrigation, domestic and industrial purposes in an efficient manner;
2. improve land use by encouraging optimal cropping patterns and better agricultural practices;
3. promote private entrepreneurship with emphasis on the agro-industries;
4. improve social services, educational facilities and employment opportunities with a view to keep local population away from migrating to big cities as well as attracting qualified workforce to the region.

Southeastern Anatolia Project Regional Development Administration was established in 1989 to carry on the major function of multi-sectoral planning within a regional perspective. Sustainability goals were determined for strengthening the integrated development process and for the mitigation of the socio-economic disparities in the Southeastern Anatolia region.

Discussion

Over the past decades, increasing climate variability and extreme weather have affected millions of people and disrupted regional economies. Climate change is inevitable and through water it has serious consequences for many sectors, including health and sanitation, food security, energy and nature. Everyone is affected, but the poor and remote are hit first and hardest. It is imperative to increase our efforts towards abatement of greenhouse gases emissions and to initiate actions to better cope with today's climate variability, which is a first step towards coping with climate change. A greater appreciation of climate issues amongst water policy makers and planners, water managers and society is the basis for effective actions in a sector that is essential to all facets of sustainable development. Even though climate is driven by global processes, most adaptation actions will need to be taken at the community, basin, national and regional level. Climate variability and weather extremes will derail achieving the development goals in the next 15 years. Development activities without considering climate change will further increase vulnerability.

Categories of action include infrastructure development, timely warning and forecasting systems, risk reduction, risk sharing and data management, spatial planning and institutional capacity development and reform, based upon community level decision making. To support these actions data are needed from extended observational systems and networks. The Dialogue on Water and Climate (DWC) was launched in 2001 to develop and promote adaptation strategies that help reduce the vulnerability of the poor against the detrimental effects of climate variability and climate change. In many countries and regions the multistakeholder dialogue process has been put in place at the regional, national and basin levels. Through these dialogues a wide range of stakeholders can examine which information is required for awareness raising, what measures can be taken to cope with the effects of climate change, and how climate can best be factored into water resources management policies.

Recommendations

- Enhance policies and measures towards adaptation to the impacts of climate variability and change, along with continuing efforts on further reduction of greenhouse gas emissions.
- Continue the informed multi-stakeholder approach at national, basin and regional level to prepare action plans for adaptation.
- Integrated Water Resources Management should become the inter-sectoral framework under which the water and climate agenda needs to be implemented.
- Develop national, basin and regional capacities (policies, strategies, research and implementation) and secure financial support for preparation and implementation of national water sector adaptation plans.
- Create a " Water and Climate Alliance" as an international umbrella to continue building bridges between the climate and water sector, encourage capacity development to better cope with climate impacts, and facilitate obtaining financial support for national, basin and regional level adaptation plans.
- Enhance efforts to integrate and mainstream the initiatives developed under the Water and Climate Associated Program with related processes like disaster preparedness and management strategies.
- Mainstream the climate variability and change into nartional water and land management policies and management practices.
- Reverse the trend of further deteriorating insitu data collecting and observational networks.

RESULTS

The main objective of the research is to demonstrate the application of modern water resource systems planning techniques that have been well developed in theory to a real water resources planning study in scope of climatic change in Turkey in such a way that the decision-makers are assisted in choosing among alternative development plans for the basin. The ultimate expectation is that the research will help to develop a better understanding of the water resources management in scope of climatic change and to explore the possibilities of integrated river basin management.

The storms themselves are usually considered to be independent of urbanization. That is, the storms are not thought to be greatly affected or changed by the gradual evolution of an urban area.

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