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Analysis of The climatic changes in Kermanshah province based on the five criteria of precipitation, temperature, wind, weather phenomena, and horizontal visibility

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Abstract: Score for exposure factor is the sum of scores for the five criteria of precipitation, temperature, wind, weather phenomena, and horizontal visibility. Hourly data on precipitation, temperature, relative humidity, weather condition codes, and horizontal visibility obtained at 23 synoptic stations in the Province, and from those located in an area within a radius of 100 kilometers from the borders of it, since the time they were established up to the end of 2012, was first received from Iran Meteorological Organization. Those stations were then selected that had data related to eight daily measurements in the interval 1990-2010. Based on this, data processing was carried out for nine stations (five in Kermanshah Province and four in neighboring Provinces) within MATLAB environment. The scores for exposure factors for climate change in two five-year intervals were calculated to assess climate vulnerability of Kermanshah Province. In the next stage, the study period was divided into three intervals: the base interval (from 23, 9, 1990 to 21, 9, 2000), the first interval (from 22, 9, 2000 to 22, 9, 2005), and the second interval (from 23, 9, 2005 to 22, 9, 2010). Following that, exposure criteria and markers were determined. It was then necessary to define and measure a broad range of markers because of the temporal-spatial non-uniformity in the climate of Kermanshah Province that results from land location and variety in this Province. In the present research, climatic data was processed in the framework of five criteria that included 29 markers. In general, it was found that Kermanshah Province is faced with increased hazards resulting from current changes in climate.
Keywords: climate change"،" MATLAB"،" exposure"،" Kermanshah

INTRODUCTION

It is obvious that increased vulnerability to natural disasters results from the occurrence of the most important challenge of the twenty first century: climate change, an event scientific controversy over which has ended, and we can now say that climate change is happening and now it is the time to act. The question is how to act. Two strategies have been offered in answer to this question: one intends to reduce the effects of changes in weather and the other to adapt to them. In simpler terms, reduction strategies help to prevent the occurrence of uncontrollable events and adaptation strategies provide assistance in managing unavoidable events (Laukkonen et al., 2009).

According to the reduction strategy, it is possible to reduce the negative effects of climate change through decreasing emission of greenhouse gases, mostly carbon dioxide, as the main factor causing climate change. The level of climate change in future will mainly depend on the selected options of communities regarding emission of gases. Less emission means reduced quantities of heat trapped in the earth's atmosphere, which results in reducing global warming and climate change and their negative effects. The extent carbon dioxide removal from the atmosphere by natural processes is half the quantities of gases emitted in human activities at present. Therefore, emphasis on strategies of stabilizing the present emission levels will not reduce the amount of carbon dioxide in the atmosphere and will only limit the rate of increase of this gas. Based on the scenario of minimal emission (B1), the Earth will face the peak of carbon dioxide emission by 2035 (forty four billion tons per year), and then this rate will start to decline slowly until the end of the twenty first century. However, considering the present rate of emission (34 billion tons in 2014) and the annual rate increase of 9.0 billon tons, it is clear that the peak level of emission will happen ten years earlier (NCA, 2014).

Emission reduction can be achieved by developing international and national policies as guidelines, and through developing general rules and following up of strategies such as increased energy productivity and replacement of present energy sources by low-carbon and carbon-free ones. The nature of these strategies is such that they have greater practicability at the international level. The main areas where these strategies will be implemented are in developed and industrial countries with greatest levels of emission. Instead of emphasizing vulnerability of communities, these strategies concentrate on effects of climate change. Although there are no doubts about the usefulness of reduction strategies, yet the main challenges this method of responding to weather changes faces include non-compliance with the policies, unwillingness and inability of the main perpetrators of emission in implementing necessary measures, and the possibility that new countries will be added to those involved in gas emission. These challenges fade the hope that carbon concentration will reach the level of the year 1950 within the next 100 years. Another challenge is that the increasing trend in temperature and in frequency of severe weather events will not stop due to the inertia in climate systems even if the pragmatic concentration of 400 ppm is achieved (IPCC, 2013). It was under these conditions that other questions besides “How to reduce climate change?” have been raised in the past 10 years such as “What results will ensue if only reduction strategies are emphasized?” and “How can communities manage unavoidable changes?” (Bierbaum et al., 2008; SEGCC, 2007)

Even if we are not able to control climate change, we must reduce vulnerability of communities. Vulnerability refers to the degree of being endangered and incapable of making geophysical, biological, and socio-economical systems overcome the negative effects of climate changeability (IPCC, 2007). Moreover, climate vulnerability, which is the main core of adaptation strategies, can be analyzed and indexed as a function of sensitivity to climate change, exposure to climate change, and of capacity building (De Sherbinin et al., 2007; Smit et al., 2001). The final goal of adaptations is to reduce vulnerability and take advantage of opportunities resulting from changes. Adaptation responses to climate changeability can be short-term or long-term, local or global, single-section or multi-section, spontaneous or planned, and passive or active. It may be possible to utilize spontaneous adaptations in order to prevent damages resulting from gradual changes, but planned, active, and multi-sectioned adaptations are required to confront sudden changes and increased extreme events. If the main goal of responses to climate changeability is to reduce vulnerability of a natural or human system, then vulnerability and adaptation will be raised as a strategic issue since they depend largely on analysis of natural, social, political, cultural, legal, economic, and technological factors and on allocation of human, financial, and physical resources. Strategic planning will be needed to solve such a problem (Pearce and Robinson, 2009).

Adaptation policy, strategy, plan, execution, and facilities must all form parts of a single foundation and, in addition, must not be in conflict with other policies such as emission reduction, sustainable development, and environment protection. In other words, all these factors must be included in one macro policy (UNDP-UNEP, 2011; IPCC, 2012).

The starting point in designing adaptation strategies is to understand and assess environmental factors related to the goal of vulnerability reduction. As presentation of initial numbers does not considerably help in understanding the complexity of the environment and its management and monitoring, continuous efforts have been made, and are continuing, to develop indices (Rennings and Wiggering, 1997). Decision makers have also responded positively to these attempts and thereby are informed of the degree of effectiveness of the decisions they make. Based on this, it is possible to determine the present status of the system in relation to the goal and to evaluate the various stages of the adaptation process by utilizing an index that reveals the various aspects of climate vulnerability. Moreover, vulnerable regions, groups, systems, and sections can be identified based on which to set priorities and allocate resources.

As long as the main attempts made by the community is centered on estimating future hazards resulting from climate change, information reliable for policy makers cannot be provided for them to make decisions on adaptation of communities. In the few evaluations that have concentrated on vulnerability resulting from climate change also, either all aspects of exposure to climate change, climate sensitivity, and adaptation capacity have not been considered or just a list of available options for adaptation has been prepared without paying attention to the possibility of their implementation (Preston and Stafford-Smith, 2009). More importantly, the goal of many evaluations has been merely the measurement of vulnerability rather than reduction of vulnerability and utilization of opportunities.

Meticulous study of the third report of the Intergovernmental Panel on Climate Change (IPCC) up to 2005, has led the evolutionary course of the concept of vulnerability to a direction in which vulnerability measurement is not a goal but a part of designing and evaluating adaptation policies and strategies. In this approach, the main output is measures and facilities related to adaptation that reduce vulnerability and increase utilization of opportunities (Smit and Wandel, 2006). In this framework, climate change increases exposure to climate hazards and extreme events both directly and indirectly that, in turn, increases vulnerability of communities. Of course, climatic factors alone do not determine vulnerability, but non-climatic factors including economic, environmental, social, technological, and political ones also influence the degree of vulnerability through adaptation capacity and climate sensitivity. Therefore, there is a close link between vulnerability of a community and its level of development so that poor people in developing countries are more vulnerable as compared to rich people in developed communities because of their lower level of adaptation capacity. Consequently, one side of the climate vulnerability coin is hazards that, through damaging resources and infrastructure, will have a negative effect on the other side of the coin, the adaptation capacity (which, in turn, lowers the hazard threshold) (Adger et al., 2009; Dessai et al., 2003). Therefore, a chain of community degradation is formed the severance of which will not be possible without designing adaptation strategies. Of course, designing the needed strategies requires measurement of the current vulnerability level on a suitable spatial-temporal scale (NAP, 2013).

The climate vulnerability index has been formed and developed because decision makers have an inclination to using indices, and researchers in the realm of adaptation concentrate on measuring vulnerability. This index was created when economic and social concepts, climate hazards, and adaptation were connected to vulnerability (Adger, 1996). All evaluations were carried out under scenarios of climate change up to the year 2002, but it has been found since then that the output of these scenarios lacks the suitable power of spatial and temporal differentiation required for recognizing the level of vulnerability and for designing adaptation strategies. Furthermore, it was noted that vulnerability is more influenced by climate changeability and extreme events than by changes in the means (Burton et al., 2002).

Calculation of vulnerability index became more comprehensive and of greater value for decision makers when economic, health and nutrition, educational, infrastructure, government, geographical and population, agricultural, ecological, and technological conditions were taken into account (Brooks et al., 2005). Sullivan and Meigh (2005) developed an index to determine climate vulnerability. This index is calculated based on the six components of water resources, accessibility, utilization method, economic-social capacity, the environment, and the spatial background (20 variables altogether). Concentration on the component of water resources and exclusion of important climate elements such as temperature, precipitation, and wind and their related variables can be considered one of the main limitations of this index. Limitation and spatial scale of the required data do not allow measurement of vulnerability at regional (province), local (city), and institution levels.

In fact, from planetary to local scales, there is a significant overlap between regions with unfavorable climate and less developed regions. Such conditions are more conspicuous in a country like Iran in which a high percentage of lands are faced with climate adversities. The increasing exposure to climate changeability in Iran adds 20 percent (3000 billion Rials) to the expenditures in the budget annually to compensate for losses (Deputy for Research, Development, Expurgation, and Publication of Rules and Regulations, 2011, 2012, and 2013). It must be noted that this expenditure is mainly for compensation of incurred losses and does not play a role in reducing vulnerability or in increasing opportunities available to the community. More importantly, the development documents of Iran (the Law for the Fourth Development Plan, 2003) allow the government to spend the equivalent of two percent of the public budget for forecasting, preventing, relieving, reconstructing, and renovating of areas damaged by unexpected events including floods, earthquakes, cold weather, etc. This indicates that reduction of climate vulnerability though adaptation to climate changeability has not received attention to date.

In Iran, most studies related to climate change have concentrated on evaluation of the effects, and mainly the effects of climate change on a specific section (water, agriculture, tourism, etc.,) (Koochaki and Nasiri, 2008; Zarghami et al., 2014; Azari et al., 2013; Babaeian and Koohi, 2012). Although the main part of the first and second report on climate change in Iran was devoted to vulnerability and adaptation (INCC), 2010; INCCO, 2003), yet no references were made in them to assessment of climate vulnerability either so that questions such as “On what basis are adaptation strategies and measures designed?” “How is their success/failure determined?” “Based on what criteria are the need, and the extent of, their modification determined?” still remain unanswered. Fortunately, reports published by two important research centers in Iran (the Center for Strategic Research, 2010) and (The Research Center of Islamic Legislative Assembly, 2013) suggest that decision makers are paying attention to the issue of climate adaptation and to including it in the macro policies of the country. Of course, designing strategies, facilities, and measures for adaptation to climate change will not be possible until a standard assessment of vulnerability with suitable spatial and temporal scales is prepared. If the current situation is continued and climate hazards continue, we will witness annual increases in vulnerability of Iranian communities, institutions, and ecosystems, and hopes for achieving sustainable development will fade with the wastage of natural, human, and financial resources of our country.

METHODOLOGY

Kermanshah Province with an area of 24586 square kilometers and with Kermanshah as its capital is located in mid-western Iran with latitude of from 33˚40´to 35˚18´north of the equator and longitude of from 45˚24´to 48˚7´east from the Greenwich Meridian. It borders on Kurdistan Province to the north, Lorestan and Ilam Provinces to the south, Hamadan Province to the east, shares a 330-kilometer long border with the neighboring country Iraq to the west, and has an average altitude of about 1,200 meters.

Calculation of exposure score

Hourly data related to precipitation, temperature, relative humidity, weather code, and horizontal visibility obtained at 23 synoptic stations in the Province, and at those located in an area within a radius of 100 kilometers from the borders of it, since the time they were established up to the end of 2012, was first received from Iran Meteorological Organization. Those stations were then selected that had data related to eight daily measurements in the interval 1990-2010. Based on this, data processing was carried out for nine stations within MATLAB environment. Figure 1 shows the locations and distribution of the studied stations.

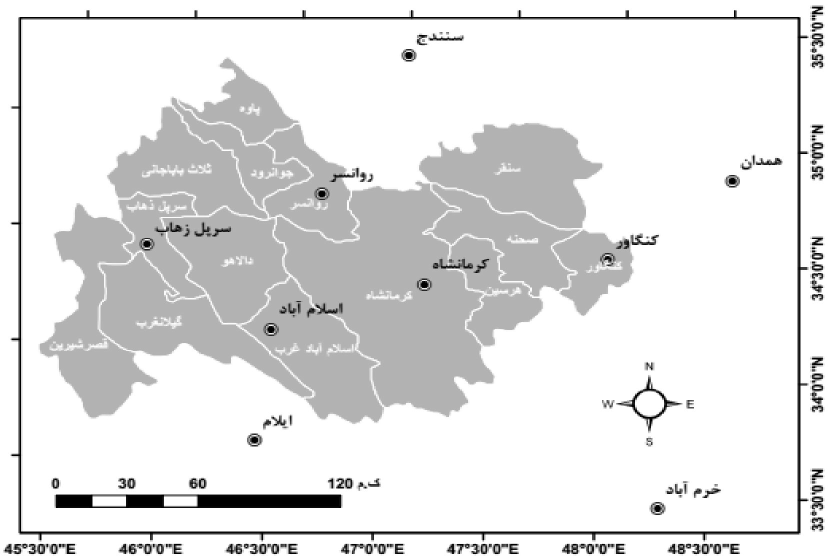

Figure 1: Location and distribution of the studied synoptic stations

The study period was then divided into three intervals, with the beginning and end of each one listed in Table 1. These intervals were selected in a way as to match the water year, the census, and the Five Year Development Plan of Iran.

Table 1: Dates of the beginning and end of the studied time intervals

Name of the interval	Gregorian calendar		Solar Hejri calendar		Length of time interval
	Beginning date	End date	Beginning date	End date	(in years)
The base interval	23/9/1990	23/9/2000	1/17/1369	31/6/1379	10
The first interval	22/9/2000	22/9/2005	1/7/1379	31/6/1384	5
The second interval	23/9/2005	22/9/2010	1/7/1384	31/6/1389	5

Following that, exposure criteria and markers were determined. It was necessary to define and measure a broad range of markers because of the temporal-spatial non-uniformity in the climate of Kermanshah Province, which results from land location and variety in this Province. In the present research, climatic data was processed in the framework of five criteria that included 29 markers (Table 2).

Daily rainfall equal to or exceeding 1 mm was assumed to represent a rainy day. Reduction in the number of rainy days, even if it does not lead to reduced total rainfall, is considered a hazard. If it is accompanied by a reduction in total rainfall, the hazard ratio increases. Increases in coefficient of variation related to climate variables indicate greater instability of the environment that, in turn, reduces influence and effectiveness of programs. If the amount of daily rainfall exceeds the tolerance of biotic and abiotic systems, it will be accompanied by hazards and disasters. Such rainfall events are called extreme, heavy, or critical. The larger the number of this kind of rainfall events is, the greater the exposure to hazards will be (IPCC, 2012). Moreover, the share of this type of rainfall of the total rainfall shows well the degree of hazard the environment faces (Alijani, 2011). All ecosystems are sensitive to consecutive dry days, and increases in the number and length of these dry periods will be hazardous to them (IPPCC, 2012).

Table 2: Factors related to exposure to climate change: 5 criteria and 29 markers

Criterion	Marker	Criterion	Marker	Criterion	Marker

	1.1: Number of rainy days		2.4: Heat waves	3. Wind speed	3.1: Coefficient of changes
	1.2: Amount of rainfall	2. Temperature	2.5: Cold waves		3.2: Number of extreme events
1. Rainfall	1.3: Coefficient of variation of rainfall		2.6: Frost		4.1: Sand storm and dust storm
	1.4: Number of extreme rainfall events		2.7: Early cold	4. Phenomena	4.2: Severe fog events
	1.5: Share of extreme rainfall of the total rainfall events		2.8: Late cold		4.3: Heavy snowfall events
	1.6: number of 15-day dry periods		2.9: Early frost		4.4: Hail events
	1.7: Number of 30-day dry periods		2.10: Late frost		4.5: Thunderstorms
	1.8: Number of 60-day dry periods		2.11: Wind chill		
2. Temperature	2.1: Coefficient of variation of temperature		2.12: Sultry	5. Horizontal visibility	5.1: Horizontal visibility ($\leq 1\ kilometer$)
	2.2: Number of extreme warm temperature events		2.13: Firewinds		
	2.3: Number of extreme cold temperature events				

Since temperature hazards are very extensive and complicated on temporal and spatial scales, their investigation is of great importance in assessing climate vulnerability. Because of this importance, data on temperature was analyzed hourly in the format of 13 markers. Due to consecutive dominance of extreme conditions, heat and cold waves create critical conditions at the time of and several days after their occurrence, and numerous vital and psychological effects will accompany them (CCS, 2011). If two consecutive temperature measurements exceed the extreme heat/cold threshold limit values on the first day and these conditions are repeated the following day, a heat/cold wave has happened. Here, frost events refer to conditions when two consecutive temperature measurements are equal to or lower than 0˚C. In cold weather, if temperature at two meter height is equal to or lower than 0˚C, temperature at ground surface will be very probably lower than 0˚C and conditions will be more prepared for frost. Therefore, 0˚C was selected as the base temperature for frost. The dates for the first and last cold or frost in each year of the base interval were extracted first to determine the number of cold or frost events. The means of the dates of the first cold/frost events and the mean dates of the last cold/frost events were then calculated. Following that, the numbers of cold/frost events before and after these thresholds in the first and second intervals were counted. The three weather phenomena of firewinds, wind chills, and sultry air are considered a damaging factor as they limit human activities and create intolerable conditions. All parts of Iran are faced with at least one of these three weather phenomena. At each station, wind chill index was calculated (Osczevski and Bluestein, 2005) to count the number of wind chill events. If two consecutive wind speed measurements were at least 3 miles per hour and the index value was 36˚F or lower, wind chill had occurred. Sultry events, in this research, happened when two consecutive sultry index values (Rothfusz, 1990) exceeded 90˚F and wind speed was less than five knots. Human activities are severely limited under sultry weather and conditions become favorable for corrosion of metals and proliferation of dangerous microbes and fungi (Hejazi Zadeh and Moghimi, 2007). If high temperatures are accompanied by low humidity and strong winds, very critical conditions will be created. Under these conditions, evaporation and transpiration, wilting, and water needs will increase sharply and social activities and cooling effects of gas coolers will decline to their minimum levels. In the present research, these conditions were indexed under the title of fire winds. If two consecutive measurements of temperature exceeded the extreme hot threshold limit, wind speed was equal to or higher than 5 knots, and humidity was below 20 percent, these conditions constituted a fire wind.

The numbers of hazardous weather phenomena were counted with the help of weather condition codes (Alijani, 2014). Table 3 lists the counted codes.

Table 3: Codes related to hazardous phenomena

Marker	Code of the current weather condition
Sand storms and dust storms	33 - 35.6 – 9
Severe fog events	49, 47, 45, 43, 12
Heavy snowfall events	75.39
Hail events	87-90.27
Thunderstorms	96 – 99,91-94

In this research, relation 2 was first used at confidence level of 95 percent to determine threshold values.
(Relation 2)

Here, sample mean, standard error… represent mean, standard deviation and number of samples in the base interval. Relation 3 was then employed to determine the required thresholds for the rainfall, temperature, and wind criteria.

(Relation 3)

In this relation, the coefficient of changes in the base interval is the marker threshold. After the values of the 29 markers were extracted for each interval, the ratios of the values of each marker in the first and second intervals to those in the base interval were calculated. In this stage, the score of 1 indicates that the exposure did not cause any changes, and scores larger/ smaller than 1 show increases/reductions caused in the exposure. The score for each criterion was obtained from the mean of the scores for its markers, and the score for the exposure factor was calculated by averaging the scores for the five criteria. To make differences between the cities more clear, the scores for exposure factor were multiplied by 10. Finally, based on interpolation, the scores for exposure factor at the nine stations were determined using the kriging method.

RESULTS

The score for exposure factor was obtained by adding the scores for the five criteria of rainfall, temperature, wind, weather phenomena, and horizontal visibility. The map for each criterion was then prepared. In all of the maps, the figures on the maps represent the percentages of change in the scores for the first interval (the figures on the left) or in the second interval (the figures on the right) compared to the base interval, and the colors represent the scores for criteria or factors. Higher numbers mean increased degrees of exposure of criteria and factors to changeability.

The rainfall criterion

Figure 2 shows the score for the rainfall criterion. The degree of exposure of Kermanshah Province to hazards related to rainfall decreased by one percent during 2000-2005 compared to 1990-2000. Of course, this reduction was not significant and was uniformly observed in all cities in the Province (Figure 2, left side).

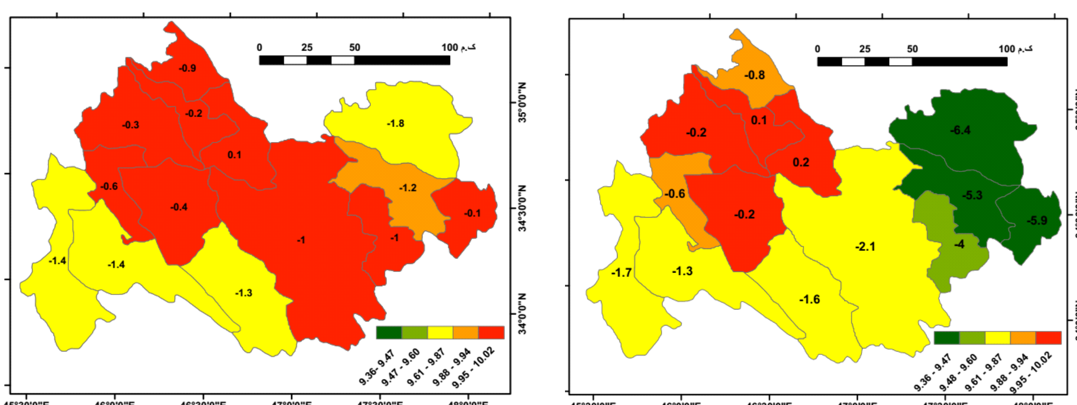

Figure 2: Left: (scores), color (the rainfall criterion), figures on the map show the percentages of change in the first interval compared to the base interval. Right: Scores and percentages of change in the second interval compared to the base interval

The highest score for this criterion was that of Ravansar (10.01) and the lowest (9.82) that of Javanrood. Exposure to hazards related to rainfall declined in the second interval (2005-2010) compared to the base interval. The average rate of change was -2 percent, which was not significant. The degree of exposure in the eastern part of the Province to rainfall hazards showed a greater reduction in this interval. The maximum score for the rainfall criterion in the second interval (10.02) was observed in Ravansar and the minimum (9.36) in Sanghar (Figure 2, right side). Comparison of the two 5-year intervals with the 10-year base period indicated that in Kermanshah Province no tangible changes occurred for rainfall, number of rainy days, number of heavy rainfall events and their share of the total rainfall events, coefficient of change in rainfall, and length and number of dry periods.

The temperature criterion

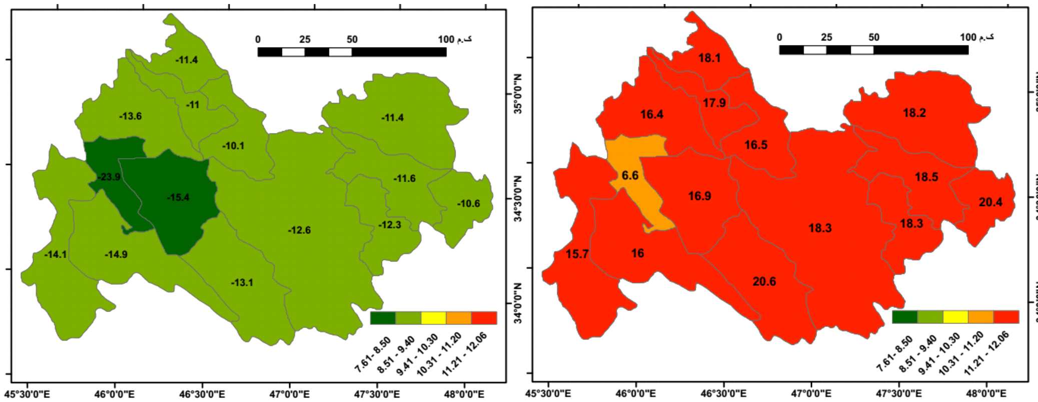

Figure 3: Left (scores), color (the temperature criterion) figures on the map indicate percentages of change in the first interval compared to the base interval. Right: scores and percentages of change in the second interval compared to the base interval

Climate changeability has led to increased exposure to temperature hazards in Kermanshah Province. Figure 3 shows the scores and changes in exposure to these hazards. The means of changes in the temperature criterion in the first and second intervals were -13 and 17 percent, respectively, which indicated the first interval experienced a reduction and the second interval an increase in the degree of exposure. Changes in both intervals were significant and happened uniformly throughout the Province. In the second interval, there were remarkable increases in the number of extreme temperature events and in occurrence of warm and dry conditions in the Province.

Changes in the wind criterion, extreme events

Coefficients of change in wind speed were -0.24 and -5.7 percent in the first and second intervals, respectively**.** In the first interval, the score for the wind criterion increased in the eastern part but decreased in the western part of the Province (Figure 4, left side). The maximum increase in this interval happened in Kangavar and the minimum in Ravansar. In the second interval, the scores for this criterion declined in all cities of the Province except for Kangavar (Figure 4, right side). Therefore, Kermanshah Province was not exposed to the hazard of strong winds, and wind speed even decreased slightly during the second interval.

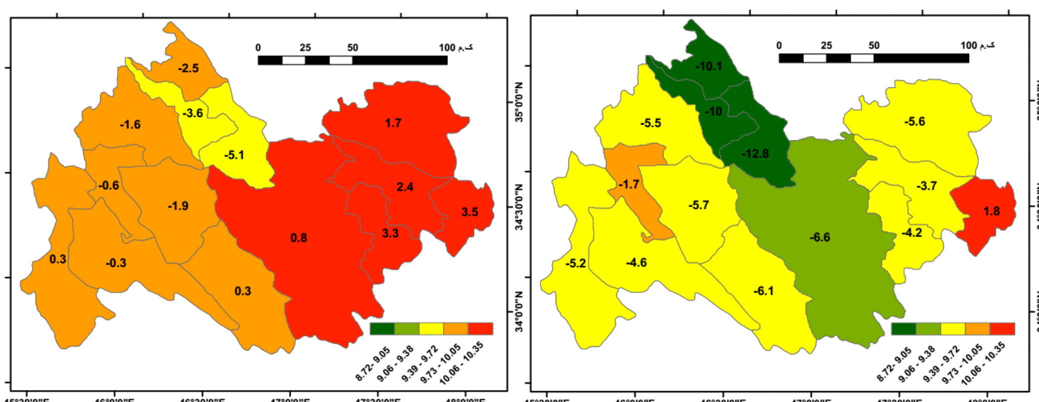

Figure 4: Left: (scores) color (the criterion of wind), the figures on the map are the percentages of change in the first interval compared to the base interval. Right: scores and percentages of changes in the second interval compared to the base interval

The criterion of weather phenomena

Figure 5 shows the scores and percentages of change in the criterion of phenomena on the map of Kermanshah Province

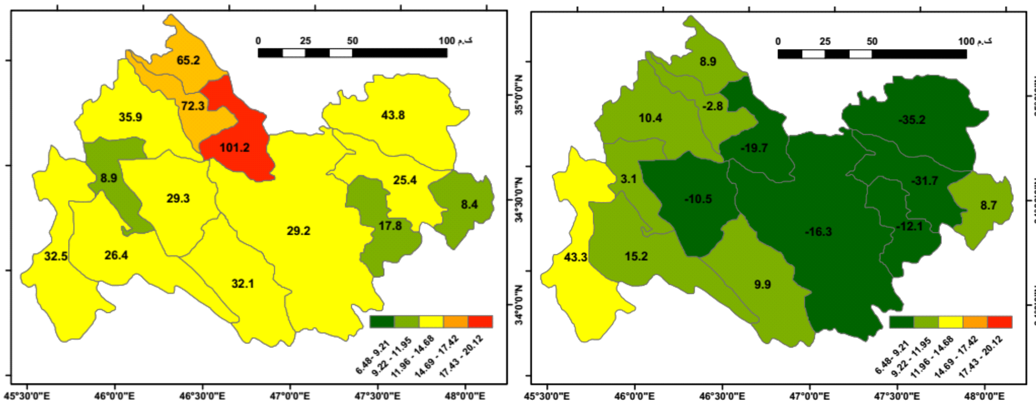

Figure 5: Left (scores) color (the criterion of phenomena), the figures on the map are the percentages of change in the first interval compared to the base interval. Right: scores and percentages of change in the second interval compared to the base interval

The criterion of weather phenomena included six markers that indicated hazardous weather (Table 4). Average changes in the first and second intervals were -2 and 37 percent, respectively. Based on this, we can conclude that sand storm and dust storm, severe fog, hail, and thunderstorm events exhibited the highest increase compared to the other climate hazards. As shown in Figure 5 (the left side), changes in the scores for this criterion were not uniform: they increased toward the western side but decreased toward the eastern side of the Province. Ghasr-e Shirin with the score of 14.36 experienced a 43 percent increase compared to the base interval. This increase was mainly caused by increases in dust storm events. During the first interval, as shown in Figure 5, all cities in the Province faced substantial increases in the scores for this criterion. Here, again, the main factor causing these increases was the rise in the number of dust storms that gradually expanded from the west to the east of the Province. During this interval, Ravansar with the score of 17.2 faced the maximum hazards related to the criterion of weather phenomena. This sudden severe change could be a factor for increased vulnerability of this city.

The criterion of horizontal visibility

The rise in the number of events in which visibility was less than 1000 meters led to increases in the scores for this criterion. The average changes in the criterion of horizontal visibility during the first and second intervals were -3 and 147 percent, respectively. The first interval did not show any significant changes compared to the base interval (Figure 6, the left side). During the second interval, substantial changes occurred, with changes exceeding 200 percent in the western part of the Province, while there were also considerable changes towards the eastern part too. The noteworthy point was that tangible changes related to dust storm expanded from the west to the east of the Province starting from the beginning of the second interval (Figure 6, the right side).

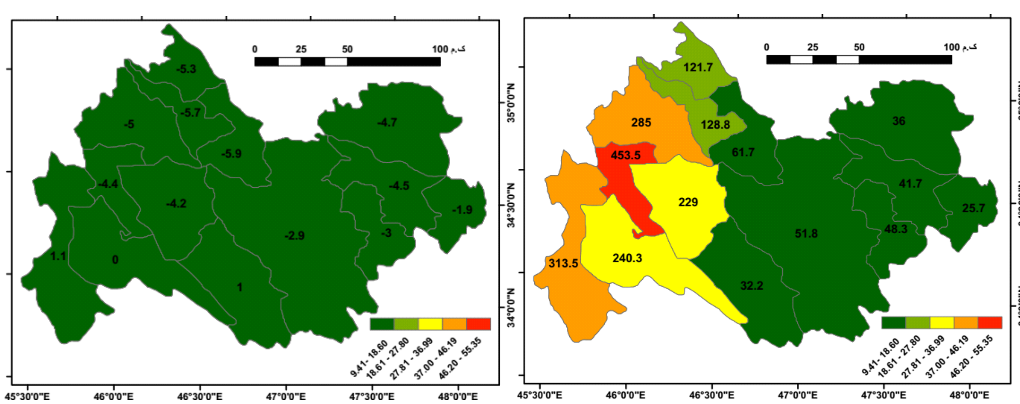

Figure 6: Left (scores) color (the criterion of horizontal visibility), the figures on the map show percentages of change in the first interval compared to the base interval. Right: scores and percentages of change in the second interval compared to the base interval

The score for the exposure factor

Figure 6 shows scores for exposure to hazards resulting from climate changeability in the cities of Kermanshah Province and the percentages of change in each interval compared to the base interval. Based on mean scores for the five criteria, it was found that the extent of exposure to climate hazards in this Province declined -4 percent during the first interval. Of course, these changes were not significant at the alpha level of 0.05 either (Figure 6, the left side). Based on the map of the exposure factor, increases in exposure started in the year 2000 from Ghasr-e Shirin, and intensified and expanded in the second interval. In the second interval, exposure to climate hazards increased by 39 percent in this Province. This extent of change was significant at the alpha level of 0.05 (Figure 7, the right side). The maximum change (93 percent) was observed in Sarplo-e Zahab and the minimum (10 percent) in Kangavar. In general, the extent of exposure was much greater in the west of the Province compared to the east. However, the trend of exposure expansion shows that the Province will face much greater climate hazards in future compared to the past.

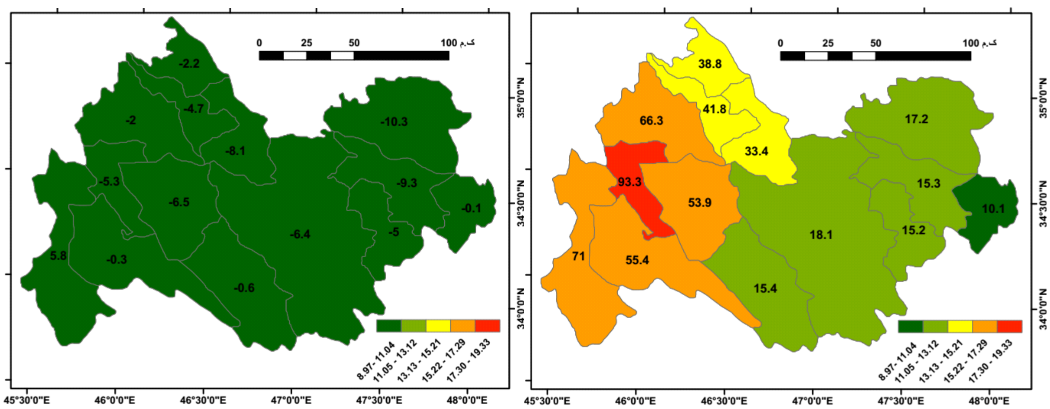

Figure 7: Left (scores) color (the exposure factor) the figures on the map show the percentages of change in the first interval compared to the base interval. Right: scores and percentages of change in the second interval compared to the base interval

Table 3 presents the scores of the exposure factor for each city in the Province. During the first interval, only Ghasr-e Shirin was exposed to climate hazards. However, the extent of exposure in all cities exhibited an ascending trend in the second interval, and they experienced the greatest exposure to climate changeability. In the last row of Table 3, the figures related to this Province confirm that, in general, Kermanshah Province is facing increased hazards resulting from climate change. Of course, the continuation of these increases can be attributed to climate change and we can infer that these conditions are a part of a long-term change and may intensify and expand in future.

Table 3: Scores for exposure factor of cities In Kermanshah Province in the two different study intervals

	First interval			Second interval		
City	Score	Changes	Rank	Score	Changes	Rank
Eslamabad-e Gharb	9.94	-0.64	4	11.54	15.44	11
Paveh	9.78	-2.24	6	13.88	38.83	7
Salas-e babajani	9.80	-2.02	5	16.63	66.31	3
Javanrood	9.53	-4.67	7	14.18	41.82	6
Dalahoo	9.35	-6.46	11	15.39	53.58	5
Ravansar	9.19	-8.14	12	13.34	33.38	8
Sar Pole Zahab	9.47	-5.28	9	19.33	93.34	1
Sanghar	8.97	-10.27	14	11.72	17.21	10
Sahneh	9.07	-9.32	13	11.53	15.31	12
Ghasr-e Shirin	10.58	5.84	1	17.10	70.97	2
Kermanshah	9.36	-6.40	10	11.81	18.12	9
Kangavar	9.99	-0.07	2	11.01	10.08	14
Gilan-Gharb	9.97	-0.30	3	15.54	55.36	4
Harsin	9.50	-5.00	8	11.52	15.22	13
Province	9.61	-3.93	-	13.89	38.95	-

CONCLUSIONS

This research showed that cities in Kermanshah Province are faced with numerous and varied climate stimuli. This level of exposure, which is rapidly increasing due to climate changeability, redoubles the need for quick and high quality capacity building to adapt to and remove climate sensitivity in this Province. Vulnerability will intensify and expand with increases in exposure to climate changeability and, if it is accompanied by slow and low quality capacity building that lacks strategy, it will be impossible to achieve sustainable development. Since rapid reduction in vulnerability through reducing climate exposure is not possible because of its dependence on planetary and time-consuming processes, policy makers and program executors must pay greater attention to increasing capacity and to taking steps for achieving and facilitating climate adaptation. In general, considering the continued increases in climate hazards, they can also be attributed to climate change and we can interpret these increases as a part of a long-term change that may intensify and expand in future.

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