Environmental Resources Research
Vol. 2, No. 1, 2014

GUASNR

Determining Appropriate Provinces for Dew Harvesting in Iran

M. Sarparast[1], M. Hesam[1], H.R. Asgari[1]
[1]Gorgan University of Agricultural Sciences and Natural Resources

Received: June 2013 Accepted: December 2013

Abstract
The fact that water is the most important factor of life on earth is not a new concept. Alteration and reduction in the amount of precipitation, population explosion and contamination of underground water highly pressurize governments to find solutions for water resources. The air moisture is one of the fresh water resources which has not been duly noticed and well exploited. In this study proper places were identified for dew harvesting in Iran based on three important aspects: relative humidity, wind speed and the number of sunny days. The province centres was considered as a whole indicator. Areas with an average relative humidity of more than 70%, wind speed of less than 3 m/s and more sunny days were the best sites for dew harvesting. Based on comparisons and available maps generated using Arc-GIS software, the coastal provinces in the north and south of Iran including Golestan, Mazandaran, Gilan, Bushehr and Hormozgan which comprise about 17% of the total area of the country were identified to be suitable for this purpose. However, Bushehr and Hormozgan provinces were more suitable compared to other regions due to more extended sunny days.

Keywords: Dew harvesting, water quantity management, Iran

*Corresponding author; mehdisarparast@gmail.com

1. Introduction

Generally large water resources are at hand, but man has not attempted adequately to control and exploit them. The atmosphere contains 12900 km³ of fresh water, 98% is as steam and 2% is dense water in clouds (Beysens and Milimouk, 2000). Obtaining this water in liquid form is difficult, and the most important practice is the conversion process to be economical. The primary composition of air is 78% nitrogen, 21% Oxygen and variable water vapour, which depends on temperature and pressure. The amount of atmospheric water is estimated by calculating the actual pressure of air mass (Lawrence, 2005). In determined temperature and pressure, the actual pressure will not exceed a certain extent and without condensation this pressure is called saturating pressure. Relative humidity is defined by Lawrence (2005) as the percent of saturation humidity, which is the ratio of actual vapor density to saturated vapor density. Saturating pressure increases with increase in air temperature and so does the amount of water in air.

Dew point temperature occurs in certain temperatures and the relative humidity is the temperature in which condensation occurs. For example, dew point temperature in 20 °C with 80% relative humidity is 18 °C and with 25% relative humidity is 10 °C (Beysens and Milimouk, 2000). Dew density exists which is a supplementary resource for water shortage in arid places and islands (Beysens *et al.*, 2009).The dew formed by condensation of the atmospheric steam on a cool surface is a result of night coldness (Roman et al, 1973). Examining different opinions for dew collection based on physical processes of condensing atmospheric steam was done by Nikolayev (1996). The feasibility of storing dew was measured by Hollermann and Zapp (1991) in Canary Islands. Al-Nasser and Barakat (2000) predicted and measured the condensation of atmospheric humidity in order to be used for irrigation purposes in small scales. The amount of dew on lapilli's mulches was measured by means of micro-lysimeter (Gonzales *et al.*, 1964) and it was reported that at most 0.59 mm of water would be stored on lapilli's mulches because of night condensation. Kappen *et al.* (1980) found that the amount of measured dew in northern and western slopes of desert lichens was more than in the eastern slopes. The average amount of dew in Negev Highlands measured for 195 days for the period of 17 years was 33 mm and most of dew was formed in a clear morning (Idron, 2000). Idron (2000) claimed that the least amount of dew was related to the windy morning whereas in the cloudy morning the amount of dew was average. Jacobs *et al.* (1999) reported that the amount of dew ranged between 0.1-0.2 mm at night. In examining the effect of mulch in dew absorption for 68 nights in 2001 and 2002, Graf *et al.* (2008) indicated that mulch increases nightly condensation. Lekouch *et al.* (2011) reported that the amount of dew formed in Mirleft region of Morocco was about 18.85 mm in a year. Dew has different roles in agriculture (Wallin, 1967). Whereas little water is obtained from dew formatting processes, such little water plays an important role in growing plants in severely dry conditions (Went, 1955). In natural ecosystems, dew is an important resource of humidity for plants, biological crusts of soil surface, insects and little animals especially in deserts where there is limited water supply (Hamilton, 1976; Broza, 1979; Acostav-Baladon & Gioda, 1991; Jacobs, 1999). Dew measuring instruments hardly indicate a quantity more than 40-50 mm in a year. Nevertheless, in many coastal arid areas of the world farming and agriculture are completed without irrigation and just dew is used. One good example is cultivating grape and other garden crops in Lanzarote Island of Canary Islands (Ribold, 2005). In arid areas where there is temperature and humidity gradient between day and night, conditions are proper for dew formation, but this humidity evaporates very soon before reaching root zone of plants. If there were an approach to transfer this humidity to plant roots before evaporating, most of the desert plants would grow well (Lekouch *et al.*, 2011). Some approaches and techniques have been used in different places of the world of which gravel layers can be cited that are usually used for absorbing dew humidity which increases the soil temperature, and decreases evaporation. Gravel layers cool in the afternoon and remain cold until morning. When steam becomes compressed in the gravels, tiny drops are formed and pass through gravels reaching the soil surface. According to Lekouch *et al.* (2011), this method is used on irrigating vegetables in China. The Deep Root Irrigation Precipitation System (DRIPS) is also used for absorbing dew. The DRIPS is made of a funnel that collects water in the form of liquid and then water drops are transferred under the evaporation surface through tiny grooves of the funnel (Schemenauer *et al.*, 2005).Water researchers and technologists (Schemenauer *et al.*, 2005; Lekouch *et al.*, 2011; Gonzales, 1964) construct equipment for harvesting dew and air humidity especially in semi-arid and arid areas. It is clear that such equipment is more efficient in places where there is adequate humidity or formation of dew. Therefore, the objective of this study was to identify the feasible areas in Iran that can be used for harvesting dew for possible uses.

2. Materials and methods

Data collection was based on the suggestions put forward by Beysens *et al.* (2009) that dew formation is possible if relative humidity is at least 75% in the evening, wind speed is less than 3 m/s and the sky is clear.

Using Arc-GIS, the maps were prepared for three criteria identified to be important for dew formation namely: relative humidity, wind speed and the number of sunny days. These maps were prepared using Inverse Distance Weighted (IDW). Round holes in spots were established and used to increase the correctness of data interpolation. Another indicator of this method is being deterministic and fast which lead to forming a correct output. The system of map coordinates is based on the Universal Transverse Mercator (UTM) projection including 38, 39 and 40 northern zones. Table 1 represents the results of the data for wind speed, relative humidity, and number of sunny days collected from the studied stations over 30 years of accumulated data.

The relationship between dew point and sky emissivity (Esky) was expressed according to Berkeley and Trinity (1980) equation such that: Esky = 0.006349 + 0.73223 Tdp. This latter was expanded by Bordal and Framberg (1982) to Esky = 0.0062 + 0.741 Tdp. The two equation models were finally presented by Clark and Allen (1985) as Esky= 0.0028 + 0.787 Tdp where Tdp represents the temperature of dew point.

Table 1. Averages of criteria involved in dew formation for 30 years in synoptic centres of the studied provinces

Annual Average/ station	Wind speed (m/s)	Relative humidity (%)	Number of sunny days
Shahrekord	1.18	0.46	234
Eastern Azarbayjan	3.08	0.54	168
Western Azarbayjan	1.38	0.6	199
Ardebil	3.85	0.71	143
Esfahan	2.05	0.4	239
Ilam	2.16	0.4	226
Bushehr	3.05	0.75	251
Tehran	2.67	0.41	200
Southern Khorasan	2.62	0.36	255
Khorasan Razavi	2.1	0.55	199
Northern Khorasan	1.54	0.44	150
Khuzestan	2.5	0.43	255
Zanjan	1.9	0.54	195
Semnan	1.38	0.41	231
Sistan & Baluchestan	3.34	0.33	230
Fars	2.31	0.41	244
Qom	2	0.41	233
Qazvin	2	0.51	186
Kordestan	2	0.47	200
Kerman	3.13	0.32	232
Kermanshah	2.52	0.47	204
Kohkiluye & Buyerahmad	1.33	0.32	239
Golestan	1.08	0.47	138
Gilan	1.28	0.82	93
Lorestan	1.64	0.7	242
Mazandaran	1.95	0.83	114
Markazi	1.5	0.46	200
Hormozgan	2.88	0.65	273
Hamedan	1.64	0.53	210
Yazd	3.75	0.3	250

Results

Figures 1, 2 and 3 show the annual average interpolation of relative humidity, wind speed, and sunny days, respectively in Iran.

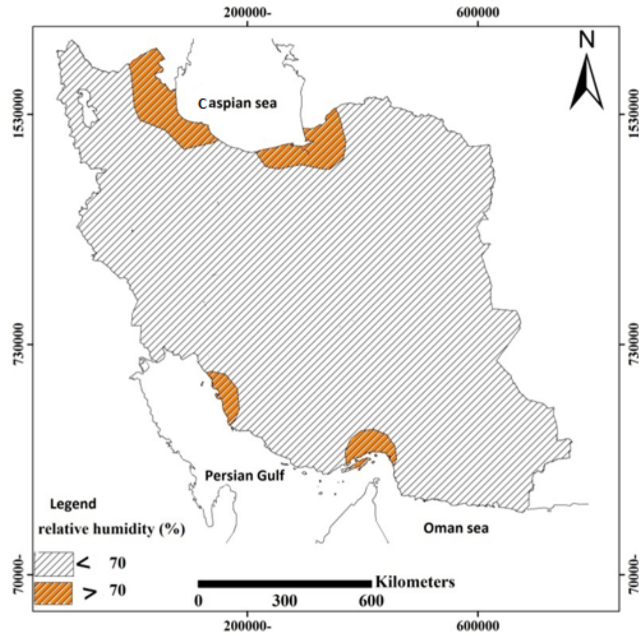


Figure 1. The annual average interpolation of relative humidity

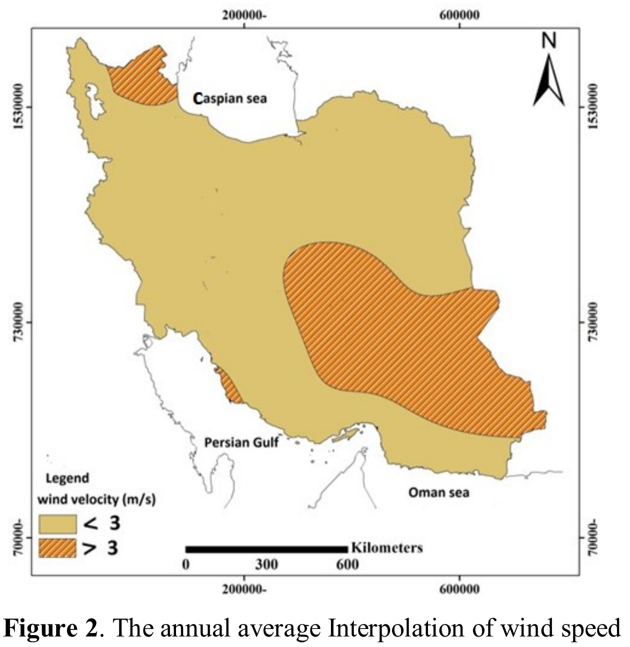


Figure 2. The annual average Interpolation of wind speed

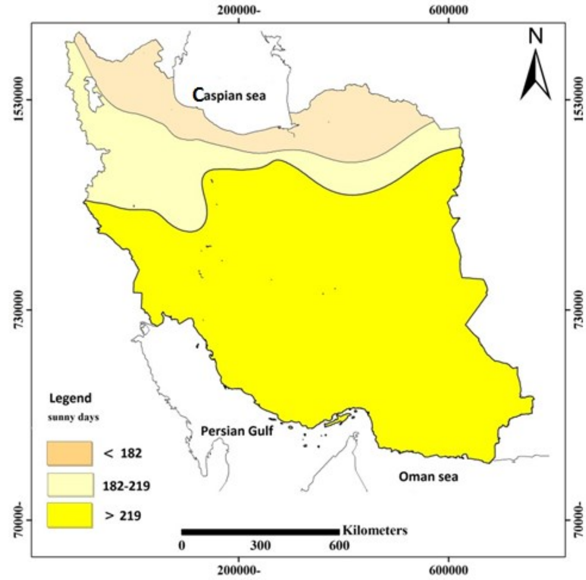


Figure 3. The annual average interpolation of sunny days

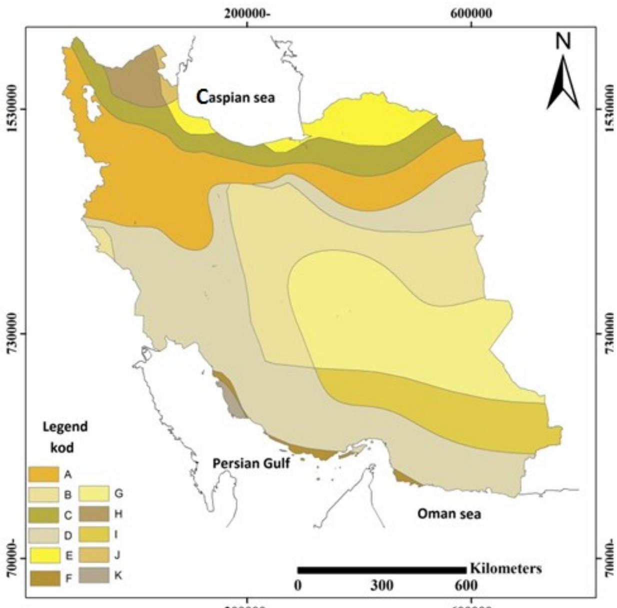
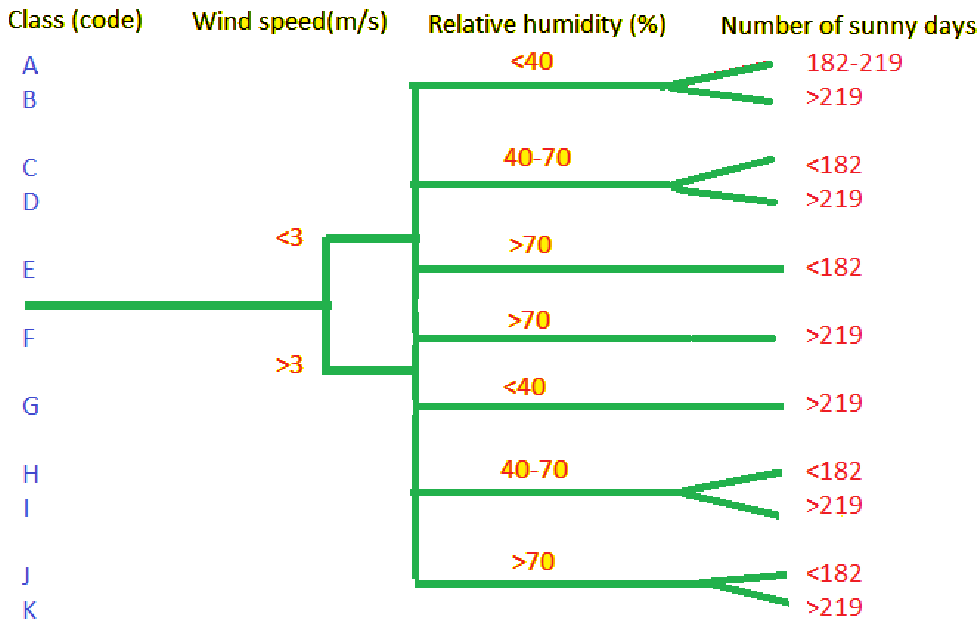


Figure 4. The overlay classes of dew formation

Table 2 and Figure 4 summarize the data collected from Figures 1 and 2. These data identified only the classes with relative humidity more than 70%, wind speed less than 3 m/s and sunny days reported to be appropriate for dew formation.

Table 2. Classification of proper places for dew formation in the province



3.Results and Discussion

The results of the code classes in Table 2 indicate that class F with more than 219 sunny days in a year is mostly favourable for dew formation. In addition, the southern stations including Hormozgan and Bushehr are also located in code class F. On the other hand, code class E for which sunny days in a year is less than 182 ranked second in terms of suitability for dew formation and it included stations such as Golestan, Guilan and Mazandaran. On the other hand, code classes A, B, C and D were identified to be unfavourable for dew formation because of low relative humidity which is less than 70%. Furthermore, the code classes G, H, I, J and K were found unfavourable because of high wind speed which is more than 3 m/s. Based on the code classes used in this study, among the five studied stations only Bushehr and Hormozgan stations favour formation of dew and hence its harvesting because of clearer sky during the year.

The existing immediate solutions of most governments worldwide to the limitations of water in agriculture in the arid regions are construction of water dams or digging of deep wells and underground boreholes. These practices serve to solve water constraints to some extent in the intended areas but drastically may hamper the environment, its surroundings and the existing biodiversity. A study by Ribold (2005) revealed that constructions which involve large dams cause earthquake; deep wells increase underground water depth and may cause contamination of underground fresh water reservoirs. The knowledge and practice of dew harvesting needs little investment because it is a free exploitation which does not destroy the environment. Atmospheric steam remains an answer to water needs of man although at present it is not exploited in a large scale but eventually in future it will turn into practice. Water shortage in the coastal arid regions and inner deserts of Iran is a big crisis. Because these areas are located near the sea and have clearer skies, there is good chance of suitable conditions for dew formation at night. The importance of examining dew as a source of water in natural ecosystems for human activities and use by livestock has been highly noticed, especially in arid and semiarid areas. In these areas, the amount of dew may exceed the amount of precipitation or can be the only source of water for plant use during drought periods. Studies conducted by Gonzales and Halermann (1964) and Graf *et al.* (2008) revealed that absorbing dew from mulch surfaces is a possibility for dew harvesting.

Based on the findings of this study which are similar to the previous findings of Jacobs *et al.* (1999) and Lekouch *et al.* (2011), this study confirms the possibility of dew exploitation in Iran. The findings of this study are also similar to those of Kid Ron (1989) who reported significant influence of sunny hours, presence of clouds and wind to dew formation. Beysens *et al.* (2009) indicated that there is possibility to obtain 17 m^3 of water from an area of 1300 m^2 through dew formation in a year in Mediterranean region of the South Croatia.

4.Conclusion

This study examined three criteria, namely relative humidity, wind speed and the number of sunny days, in which two code classes F and E were identified as favourable for dew formation in Iran. The code class F included stations in Hormozgan and Bushehr and code class E included stations in Mazandaran, Golestan and Gilan which were identified to be favourable for dew harvesting. These stations are located in the Coastal provinces of Iran. To emphasize the credibility of the findings of this study, stations in Hormozgan and Bushehr with more than 219 sunny days in a year have the overall best condition for dew formation. This indicates that these areas can provide good conditions for development of agricultural activities and improve livelihood standards of people.

References

Agam, N., and Berliner, P.R. 2005. Dew formation and water vapour adsorption in semi-arid environments—A review, Journal of Arid Environments. 65: 572–590

Alnaser, W.E., and Barakat, A. 2000. Use of condensed water vapour from the atmosphere for irrigation in Bahrain. Applied Energy. 65 (1–4): 3–18.

Atzema, A.J., Jacobs, A.F.G., and Wartena, L. 1990. Moisture distribution within a maize crop due to dew. Netherlands Journal of Agricultural Science. 38 (2): 117–129.

Awanou, C.N., and Hazoume, R.P. 1997. Study of natural condensation of atmospheric humidity. Renewable Energy. 10(1):19-34.

Berdahl, P., and Fromberg, R. 1982. The Thermal Radiance of Clear Skies. Solar Energy. 29(4): 299-314.

Beysens, D., and Milimouk, I. 2000.The case for alternative fresh water sources. Pourles resources alternatives en eau, Sécheresse. 11(4):1-12.

Beysens, D., Lekouch, I., Mileta, M., Milimouk, I., and Muselli, M. 2009. Dew and Rain Water Collection in South Croatia. Solar Energy. 29(4): 299-314

Beysens, D. 1995. The formation of dew. Atmospheric Research. 39 (1–3): 215–237.

Cereceda, P., Schemenauer, R.S., and Suit, M. 1992: An alternative water supply for Chilean coastal desert villages. Intl. J. Water Resources Development. 8:53-59.

Chen, B., Kasher, J., Maloney, J., Girgis, A., and Clark, D. 2002. Determination of the clear sky emissivity for use in cool storage roof and roof pond applications passive solar research group Engineering. 236: 68181-82.

Clark and Allen. 1985. Assessment of Passive Cooling Rates and Application in the U.S., DOE Contract DE-AC03-TIC31600.

Clark, C.P. 1977. The Estimation of Atmospheric Radiation for Clear and Cloudy Skies, M.Sc. thesis, Trinity University. p:70-80.

Gupta, N., and Learnium, A. 2007. Design of water conservation system through rain water harvesting. Solar Energy. New Delhi, INDIA. 3: 15-16.

Hollermann, P., qnd Zapp, H. 1991. On the estimation and significance of condensation of dew in the eastern Canary, Islands. Erdwissen schaftliche-Forschung. 25:175–196.

Idron, G.J. 2000. Analysis of dew precipitation in three habitats within a small arid drainage basin, Negev Highlands, Israel. Atmospheric Research. 55(3–4): 257–270.

Jacobs, A.F.G., Heusinkveld, B.G., and Berkowicz, S.M. 1999. Dew deposition and drying in a desert system: a simple simulation model. Journal of Arid Environments. 42: 211–222.

Kosmas, C. 2001. Parameters affecting water vapor adsorption by the soil under semi-arid climatic conditions. Agricultural Water Management. 48(1):61–78.

Leibbrand, M., Schemenauer, R.S., and Osses, P. 2003. Community based water harvesting in Yemen. Report by ICS and Fog Quest for the Social Fund for Development in Yemen. pp: 139.

Lekouch, I., Muselli, M., Kabbachi, B., Ouazzani, J., and Melnytchouk-Milimouk, Beysens, D. 2011. Dew, fog, and rain as supplementary sources of water in south-western Morocco. Energy. 36(4): 2257-2265.

Menenti, M., Bastiaanssen, W.G.M., and Van-Eick, D. 1989. Determination of surface hemispherical reflectance with Thematic Mapper data. Remote Sensing of Environment 28, 327–337. A simple simulation model. Journal of Arid Environments. 42: 211–222.

Minnis, P., Mayor, S., Smith, W.L., and Young, D.F. 1997. Asymmetry in the diurnal variation of surface albedo. IEEE Transaction on Geoscience and Remote Sensing. 35 (4): 879–891.

Nikolayev, V.S. 1996. Water recovery from dew. Journal of Hydrology. 182(1–4): 19–35.

Osses, P., and Schemenauer, R.S. 2004. Community based water harvesting in Sadaa Governorate, Yemen. Fog Quest report for International Community Services - Yemen, pp. 45.

Palmier, L.R. 2010.Arid and semiarid development through water augmentation, p 18-25.

Prinz, D. 2002. The role of water harvesting in alleviating water scarcity in arid areas. Keynote Lecture, Proceedings, International Conference on Water Resources Management in Arid Regions. 23-27 March, 2002, Kuwait Institute for Scientific Research, Kuwait. 3: 107-122.

Schemenauer, R.S., Fuenzalida, H., and Cereceda, P. 1988. A neglected water resource: the camanchaca of South America. Bull. of the American Meteorological Society. 69: 138-147.

Slatyer, R.O. 1967. Plant-Water Relationships. Academic Press, London. 80 p.

Wallin, J.R. 1967. Agro meteorological aspects of dew. Agricultural Meteorology. 4: 85–102.

Went, F.W. 1955. Fog, mist dew and other sources of water. Yearbook Agriculture. US Department of Agriculture. 120 p.