Original Article

Effect of Running Sand Natural Hazard on Rural Physical Structure

Akram Khajeh Golstaneh [1]*, Hamdollah Sajasi Qeydari [2], Khadijeh Bouzarjomehri [3]

[1] Master of Geography and Rural Planning, Ferdowsi University of Mashhad, Mashhad, Iran. [2] Assistant Professor of Geography and Rural Planning, Ferdowsi University of Mashhad, Mashhad, Iran. [3] Associate Professor of Geography and Rural Planning, Ferdowsi University of Mashhad, Mashhad, Iran.

Abstract

The instability caused by natural hazards as one of the main goals of sustainable development is the most important challenge in the relationship of a rural man with his/her environment. The present study investigates the effect of running sand natural hazard on the rural physical body. In this descriptive-analytical research, the statistical population included all rural settlements of Zahak city. According to the Zahak Governor's Office, the sample villages included 19 villages most exposed to sandstorms, which a total of 3072 households. A sample size of 292 rural households in 19 sample villages was determined using Cochran formula. Independent and dependent variables were "running sand hazard" and "physical body of rural settlements", respectively. The validity of this study was determined by university professors and experts (from Housing Foundation of Sistan and Baluchestan Province). Cronbach's alpha coefficient was used to calculate the reliability of the questionnaire. The research hypotheses were tested using goodness-of-fit test (X2), simple linear regression test, Friedman test, and one-sample t-test. According to the results, running sand natural hazard had an impact on the physical body of the studied villages. The most important aspect of physical damage to studied villages occurred in the rural infrastructure, and the physical changes mainly affected the form, shape, and physical pattern dimensions.

Keywords: Natural hazards, Running sand, Physical body of rural settlements, Zahak city

Introduction And Problem Definition

Natural hazards as natural phenomena have always existed and will exist throughout life on the globe. Natural hazards occur in the natural environment due to biological, tectonic, seismic, or meteorological conditions and processes [1]. A natural phenomenon in the vicinity of human settlements happens as a threat to people, structures, and to socioeconomic and physical-environmental capitals, and may lead to a crisis. Studies show that the physical, economic, and social impacts of drought in developing countries, including Iran, can be detrimental and even cause famine and complete abandonment of a geographical region. However, the effects of drought do not appear all at once, but they emerge progressively and slowly and are not visible hence the results appear with considerable delay [2]. Thus, such a process results in increasing level of desertification and its adverse effects on human societies in various economic, social, environmental, and physical dimensions.

Running sand is one of various natural hazards that causes many losses each year, particularly in arid and desert regions of the world [3]. In Iran, remarkable areas suffer from the problem of running sand, and the movement of these sands imposes irreparable financial losses annually to places subject to the movement, in addition to the social and health implications for the settlers of these grounds. Accordingly, environmental factors are considered as the cornerstone and a boosting base of physical development from a geographical perspective. Besides, the habitation pattern of rural settlements reflects, above all, the natural environment, such as climate, vegetation, environment, access to soil and water resources, and spatial distribution of climate and soil networks. In fact, physical planning and design are determined in accordance to environmental and climatic conditions considering significant environmental-ecological differences and variations in the territory extent. Hence, it is

Address for correspondence: Mrs. Akram Khajeh Golstaneh, Master of Geography and Rural Planning, Ferdowsi University of Mashhad, Mashhad, Iran.

How to cite this article: Khajeh Golstaneh, A., Sajasi Qeydari, H., Bouzarjomehri, Kh. Effect of Running Sand Natural Hazard on Rural Physical Structure. Arch Pharma Pract 2020;11(S1):69-75.

noteworthy that physical planning and design in macro (network of passages, roads, facility localization, etc.) and the micro (housing design and other needs, type of materials, etc.) dimensions are affected by natural conditions, for which villages and their contexts are no exception. The construction of village physical structure means the village physical texture encompassing (a) houses, b) farms, gardens, and pastures, c) public places and squares, and d) passage network as the communication artery of the rural settlement. The village physical structure includes a set of observable physical dimensions, measurements of the village texture, and the consequences of natural and human factors affecting in an interactive space. It expresses the extent to which the village natural development is influenced by climatic-environmental, economic, and sociocultural factors, which are present and consistent in many villages of the country [4].

In recent centuries, the man-environment interaction has been a topic of interest for researchers in various sciences, including geographers. This is because historical-cultural backgrounds and sociocultural relations have always been able to configure human settlements within the context of environmental conditions [5]. In recent years, however, some rural areas, as one of the human settlements, have been facing a growing trend of rural migration, evacuation of villages, and severe vulnerability from natural disasters such as floods, earthquakes, storms, and so on, the continuity of which has faced the country with numerous and different challenges [6]. The extent of the disaster is extended when rural areas are dominated by drought and its aftermaths (such as the disappearance of flora and fauna, rangelands and farmlands, soil erosion, desertification, and sand movement) as well as its devastating impacts on rural areas, often leading to the evacuation of villages. Following abandonment, the culture of any village is also destroyed as a sign of national civilization. Therefore, given the geopolitical position of the Sistan region, population preservation has played a key role in strengthening the eastern boundaries and preserving the territorial integrity. Because any phenomenon on the Earth has consequences, this phenomenon is also influential on the surrounding human societies, including rural society, and can be a barrier to the realization of rural development. Thus, the hazards of sandstorms can generally influence different aspects of rural life, of which the physical and infrastructural dimensions of villages are among the most important aspects. This study, therefore, investigated the effects of running sand hazards on the physical dimension of villages.

Background Research

Saboori and Seidaei investigated the vulnerability of coastal villages around the Oman Sea to running sand and found that climatic factors, such as lack of vegetation and wind velocity, had the highest weight in identifying vulnerable villages. A combination of weights obtained for criteria, sub-criteria, and gained scores revealed that 17, 16, and 22 villages in the study area, respectively, were in the categories of highly vulnerable, moderately vulnerable, and low vulnerable settlements [7].

In a research on the impact of water and wind erosion on Sustain settlements, it was concluded that the redirection and water depletion of the Hirmand River paved the ground for severe storms along with the movement of dune sands in residential and non-residential areas, and for changes in land use and infrastructure in Sistan plain [8].

Negaresh (2008) investigated on geomorphological analysis of the progress of sand hills in the east of Sustain plain and concluded that the high-velocity prevailing winds in the area caused strong movements of sand dunes very rapidly on the agricultural lands, rural settlements, roads, irrigation canals, utilities, and so forth, leading to a considerable damage to these centers [9].

Materials And Methods

Research conceptual model

In this model, it was attempted to consider the impact of running sand hazards on the village physical structure in physical, infrastructural, functional, service, and semantic dimensions, as well as in terms of modern and traditional management methods.

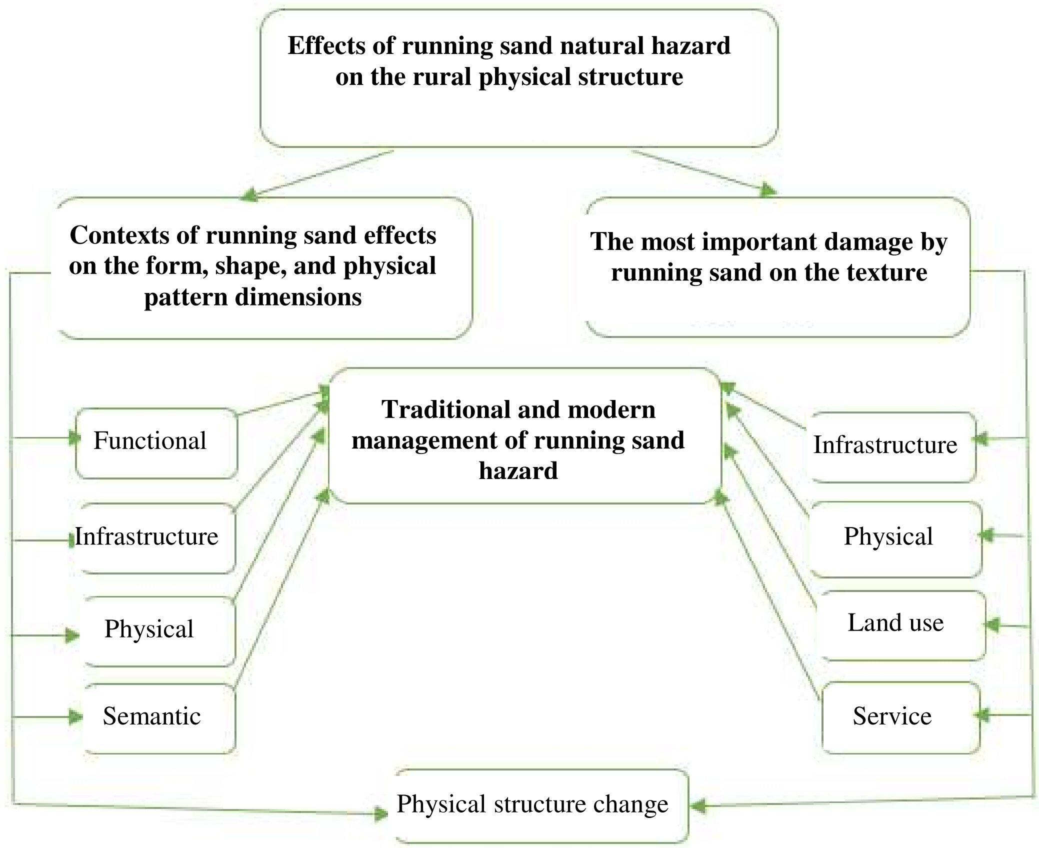

Figure 1: Conceptual model of this research

In this applied study, the descriptive-analytical method was used to investigate the effects of running sand on the structure of Zakak villages. For this purpose, variables and consequently indicators were used to prepare research indicators orally from the viewpoints of experts, officials of related organizations, and rural governors (Dehyar), as well as through field observations and completion of questionnaires at two levels of rural household and rural governors.

The statistical population of the study included all villages of Zahak city. According to 2011 statistics, the city has 141 villages of over 20 households, but the Governor's Office announced a sample size of 19 villages being mostly at risk of running sand, with a total of 3072 households. The size of sample households in sample villages was obtained using Cochran formula with an error of 0.06, yielding a number of 245 samples at the household level with the priority of household headman.

Physical characteristics of running sand affecting the physical body of the villages were studied in this research, and then dimensions were designed to measure the research variables (natural hazard of running sand as the independent and physical body of the studied villages as the dependent variables, respectively).

This study was validated by university professors and experts from Housing Foundation, Sistan and Baluchestan Province. Cronbach's alpha coefficient used to calculate the reliability of the questionnaire revealed a high reliability coefficient, indicating the intrinsic correlation between the variables for measuring the concepts and the necessary and acceptable reliability of the research.

Table 1: The reliability of the questionnaire using SPSS software

Dimensions	No. of items	Cronbach's alphas	No. of questionnaire
Infrastructural	14	0·879	
Physical	11	0·875	
Service	3	0·889	
Land use	6	0·879	
Physical (form, shape, pattern)	19	0·875	292

Functional	9	0·876
Infrastructural	14	0·872
Modern running sand management	11	0·896
Traditional running sand management	16	0·893
Semantic	10	0·878

Source: Research findings, 2016

Data were analyzed by SPSS software to extract the required information. The variables were tested for normality by the Kolmogorov-Smirnov test. The most important damages caused by running sand were investigated by X2 test, and the second and the third hypotheses were tested by regression analysis and t-test, respectively. The effect of running sand on the physical structure of villages was also analyzed spatially by the GIS software.

Results

Testing the hypotheses

This section examines the hypotheses of the present research. Accordingly, it is necessary for statistical tests to determine normal/non-normal distribution of the collected data. Parametric tests can be used to test the hypotheses if the distribution of data is normal, and non-parametric tests are applied in case of non-normal distribution. According to the results of Table 2, the variables do not have normal distribution having a sig. value of less than 0.05. Therefore, nonparametric tests were used to test the research hypotheses.

Table 2: Kolmogorov-Smirnov test

	Dimensions	Statistic	Sig.	Result
Physical damages	Physical	0.110	.000	Non-normal
	Service	0.131	.000	Non-normal
	Land use	0.100	.000	Non-normal
	Functional	0.090	.000	Non-normal
Physical changes	Physical (form, shape, pattern)	0.117	.000	Non-normal
	Infrastructural	0.069	.002	Non-normal
	Semantic	0.092	.000	Non-normal
	Physical	0.105	.000	Non-normal
Management method of running sand	Modern	0.075	.000	Non-normal
	Traditional	0.060	.014	Non-normal

Testing the first hypothesis

The most important hazards of running sand were on the physical texture of the rural settlements in the region. Due to a significance value of p-value < 0.05, it can generally be concluded that the test results show a significant difference, thereby rejecting the H0 (no significant difference between the variables) and confirming the H1 (significant differences between the variables).

Table 3: Results of goodness of fit test (X2) for damages of running sand with error coefficients (a = 0.05)

No.	Dimension	Calculated X^2	df	Sig.	Average
1	Infrastructure	184.551	126	.001	52.81
2	Physical	138.504	104	.013	42.77
3	Land use	79.579	48	.003	23.72
4	Service	49.748	28	.007	11.28

Source: Research Findings, 2016

According to the results, therefore, the sandstorm had more impact on the physical infrastructure of the villages under study. In fact, only the weakness of infrastructure such as water and electricity at the time of the disaster has a great impact on the quality of life, productivity of the economic activities, and actions of the villagers in the region. As shown in the results, the decline in agricultural activity was due to the deterioration and lower quality of the infrastructure.

Testing the second hypothesis

The second hypothesis is formulated as "in terms of physical aspect, running sand mainly affects the form, shape, and pattern of the studied villages". In this regard, simple linear regression was first used to investigate the impact of running sand hazards on research dimensions. Before investigating the impacts of hazard on the research dimensions, the relationships between variables were evaluated with Spearman correlation coefficient (no effect will take place unless there is a relationship between two variables). According to Table (4), running sand hazard is associated with damages to all the dimensions.

Table 4: The relationships between running sand hazards and research dimensions

Spearman correlation coefficient / Independent variables		Running sand hazards		
		Statistic	Sig.	Result
Physical damages to villages	Infrastructural	0.263**	.000	Related
	Physical	0.115*	.049	Related
	Service	0.134*	.022	Related
	Land use	0.120*	.041	Related
Physical changes in villages	Functional	0.213**	.000	Related
	Physical (form, shape, pattern)	0.285**	.000	Related
	Infrastructural	0.214**	.000	Related
	Semantic	0.202**	.001	Related

Source: Research findings, 2016

The effects of running sand hazards on the dependent variables were investigated by simple regression model. Accordingly, the coefficients of determination in Table 5 indicate that the independent variables explain some percentages of the changes in dependent variables. Therefore, a summary of analyzed statistics shows that 75% and 64% of the changes caused by sandstorm hazards are explained by physical and infrastructure dimensions, respectively, and independent variables somehow show linear relationships with dependent variables. Also, the correlation coefficients of the variables indicate that the above linear regression model can be well used for the prediction.

Table 5: Summary of regression analysis statistics

	Dimension	R	R^2	Adjusted R^2	SE
Physical damages to villages	Infrastructural	0.258[a]	0.067	0.064	.67180
	Physical	0.132[a]	0.017	0.014	.69322
	Service	0.113[a]	0.013	0.009	.85842
	Land use	0.166	0.028	0.024	.74076
Physical changes in villages	Functional	0.231	0.053	0.050	.66721
	Physical (form, shape, pattern)	0.280[a]	0.078	0.075	.60092
	Infrastructural	0.210	0.044	0.041	.61978
	Semantic	0.198	0.039	0.036	.78621

Source: Research findings, 2016

A significance level or P-value < 0.05 reveals that the regression model is statistically significant, which rejects the H0 test assuming the non-significance of regression model. In addition, the f value indicates that the independent variable (sandstorm) is able to well explain the changes in dependent variables, thus suggesting the suitability of the regression model.

The t-statistic (0.000) of regression coefficients for independent variables (Table 6) shows that running sand hazards could affect the research dimensions. The highest beta (beta weight) indicates the extent to which the dependent variable is influenced by the independent variable (running sand hazard). Therefore, physical changes with the highest standard deviation had the uppermost vulnerability from the sandstorm.

Table 6: Results of regression coefficients of the sandstorm variable on research dimensions

	Constant	Non-standard coefficients		Standard coefficients	t	Sig.
		B	SE	Beta		
		2.018	0.386		5.223	.000
Physical damages to villages	**Infrastructural**	0.013	0.003	0.258	4.555	.000
	Constant	2.989	0.399		7.499	.000

	Physical	0.006	0.003	0.132	2.269	.024
	Constant	2.793	0.494		5.659	.000
	Service	0.007	0.004	0.113	1.939	.053
	Constant	2.736	0.426		6.424	.000
	Land use	0.009	0.003	0.166	2.865	.004
Physical changes in villages	**Constant**	2.375	0.384		6.190	.000
	Land use	0.011	0.003	0.231	4.040	.000
	Constant	2.078	0.346		6.013	.000
	Physical (form, shape, pattern)	0.012	0.002	0.280	4.959	.000
	Constant	2.529	0.356		7.098	.000
	Infrastructural	0.009	0.003	0.210	3.655	.000
	Constant	2.279	0.452		5.042	.000
	Semantic	0.011	0.003	0.198	3.436	.001

Source: Research findings, 2016

Thus, a statistical significance level less than 0.05 rejects the H0 (physically, running sand does not mainly affect the form, shape, and pattern dimensions of the studied villages) and confirms the H1 (physically, running sand mainly affects the form, shape, and pattern dimensions of the studied villages).

Testing the third hypothesis

The hypothesis is formulated as "the combined application of modern and innovative technologies in the management of running sand hazards seems to be desirable in rural settlements of the study area". Therefore, Friedman test was first used here to determine whether or not the combined modern and traditional methods could influence the management of running sand. Thus, the null and contrary hypotheses are expressed as follows:

H0: The use of modern and traditional methods in combination does not seem to be desirable in the management of running sand.

Contrary hypothesis: The use of modern and traditional methods in combination seems to be desirable in the management of running sand.

According to Table 7, the use of both such materials as stone and brick together with iron, wood, and metal and concrete skeletons (non-native materials) and then native materials have increased significantly. In contrast, reductions are observed in the use of native materials such as clay, mud, and wood.

Table 7: Frequency distribution of materials and dominant housing methods

Dominant materials & methods	No.	Percentage
Native (traditional)	18	6.1
Non-native (modern)	179	60.7
Combinational	95	32.2
No response	0	100.0

Total	292	99.0

Source: Research findings, 2016

Also, the results of Friedman test indicate a difference between the average ratings of traditional and modern methods of running sand management at 95% confidence level, which rejects the H0 assuming the use of combined modern and traditional approaches to running sand management. In other words, modern methods with a mean rating of 1.63 are of priority for managing running sand in the studied villages.

Overall, the mean of respondents (3.534) shows that the indicators of modern methods in the control and management of running sand were higher than the test value (an assumed mean of 3). Moreover, it can be concluded that the modern running sand management is at an appropriate level due to a significance level of $p < 0.05$ and positive values for upper and lower limits of confidence interval. Therefore, the following factors influence the modern management of running sand in order of priority:

1. Exclosure of Lake Hamoon surroundings
2. Tree planting
3. Wastewater management
4. Mulching around the village
5. Supporting and supplying herders' forage need to reduce overgrazing by livestock
6. Implementation of the restoration program for destroyed lands
7. Closure of the windshields
8. Minimization and non-installation of windows
9. House construction with modern materials and architecture
10. Reinforcement of houses
11. Increasing the height of yard walls

This shows that the villagers have taken account of modern running sand control in a wider area of their residence and throughout a region. Consideration of housing and its architecture has been given subsequent priorities for running sand management.

The above results, therefore, reject the H1 and confirm the H0 (suggesting the inappropriateness of the combined method) because the locals mostly try to apply modern practices to deal with running sand. In other words, traditional methods used by villagers to control running sand over the villages and in rural settlements were not effective in the long run. In recent years, therefore, widespread running sand control, such as exclusure of Lake Hamoon to control sediments and mulching around villages, has attracted the attention of local people.

Discussion and Conclusion

Sandstorms, as a natural hazard, can reflect the reaction of nature to human beings who have failed to have a peaceful relationship with nature due to overexploitation of the environment and nature, thereby challenging the future of life on a large scale or in a small village. Therefore, ignorance of the human-environment relationship and insufficient understanding of and confrontation with natural hazard effects have led to increasing natural hazards in the establishment of rural settlements in recent decades. In the study area, local climatic conditions, such as 120-day winds and successive droughts have caused extensive damage to human settlements.

In fact, as most of the villages in the area are located alongside water sources, drying up of Lake Hamun (continued severe winds from late May to late September accelerate evaporation from the lake surface and semi-wells) and other tributaries of the lake driven to rural areas were exposed to the influx of sediment deposited in the lake bottom. This natural hazard has destroyed barren land and reduced agricultural land use in the region, so that Jazinak village had the highest barren land area, the area which reduced by moving towards the north of studied villages. Ali Abad village contains the greatest saline lands and Khamak, Khajeh Ahmad, and Zahak villages have the widest farmlands. The running sand hazard caused physical damage and changes throughout the villages most exposed to this hazard. Therefore, warm and dry climates together with strong winds in the region have caused some of the studied villages (without the rural guide plan) to maintain their irregular and winding passages due to climatic welfare according to the indigenous architecture tailored to the nature. The results of the questionnaire and the statistical tests generally demonstrate that running sand hazard in terms of physical damage and physical changes in the studied villages is related to different infrastructural, physical, functional, and land use dimensions. Overall, the spatial distribution of running sand natural hazard impacts on the 19 villages showed that Amir Nezam village had the highest average damages in infrastructure and service provision. Also, Mohammad Dady was the least affected village by running sand.

At first, Kolmogorov-Smirnov test was used to determine the normality or non-normality of the data obtained from the questionnaire. Since the data were non-normal, nonparametric tests, such as Chi-square test, were used to test the first hypothesis. The research hypothesis, assuming that the physical dimension of the studied villages was mostly influenced by running sand hazard, is rejected due to a significance level of $p\text{-value} < 0.05$. Simple linear regression test was used for the second hypothesis to investigate the effects of running sand hazard on the research dimensions. A significance level less than 0.05 rejects the research H0 and confirms H1 assuming the predominant impacts of running sand hazard on the form, shape, and physical pattern dimensions in the studied villages. The beta value indicates that the highest score (280) was obtained in the same dimension for the changes in the physique of the village, and changes occurred in the other dimensions with subsequent ratings. In the third hypothesis, the results of Friedman test revealed a difference between the average ratings of traditional and modern methods of running sand management at 95% confidence level. As a result, this rejects the H0 assuming the use of combined modern and traditional approaches for running sand management, which does not confirm the third hypothesis of the study.

References

1. Center for Specialized Studies of Urban and Rural Services. An introduction to crisis management with an emphasis on rural areas of the country. Research Institute for Humanities and Social Sciences, Academic Jihad, 2006.
2. Morshedi, A. Sustainable Agriculture in Arid Ecosystems. University of Tehran Publications, 2011.
3. Karimi, M., Yazdani, M. H., Naderi, The impact of 120-day winds on Sistan Security. Journal of Geography and Environmental Planning, 2011; 24, 2.
4. Malek Hosseini, A., Dargahi, M. M. Typology of rural textures in Iran. Zagros Landscape Geography and Urban Planning Quarterly, 2011; 3, 7, 160-184.
5. Hosseini, B., Ziaei, M., Haghshenas, J., Mahdiyar, L., Hosseini, M. Native architecture in Taleghan Valley settlements: A look at Talegan rural housing. Art Knowledge Quarterly, 20117.
6. Razvani, M. R. An introduction to rural development planning in Iran. Qomes Publication, Second Edition, 2008.
7. Saboori, M., Seidaie, E. An analysis on the vulnerability of Oman Seaside Villages to running sand in Lidov district of Jask City. Journal of Rural Research, 2012; 3, 2, 75-96.
8. Sargolzaie, S., Hafezi Moghaddam, N., Lashkari Pour, Gh. R. The effect of water and wind erosions on Sistan settlements. Eighth Congress of the Geological Engineering Society, 2013.
9. Negaresh, H., Latifi, L. A geomorphological analysis of sand dune progression in the east of Sistan plain in recent droughts. Journal of Geography and Development, 2008; 12, 43-60.