



## THE EFFECT OF ERGONOMICS ON SUSTAINABLE URBAN DEVELOPMENT: A CASE STUDY

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### ABSTRACT

*In this study we attempted to analyze and estimate the effect of ergonomics on sustainable urban development as a case study done in Guilan province of Iran. This is a survey study and participants were 80 experts of the city in environment field selected randomly using Krejcie & Morgan table. Data were analyzed in SPSS software using statistical tests. According to the results, "using appropriate colours in designing" and "human welfare" had the highest and lowest association with sustainable urban development in this province, respectively. Overall, we concluded that ergonomics or Human factor had significant effect on sustainable urban development and infrastructures.*

**Keywords:** Urban planning, Natural studies, Sustainability, Urban development, Survey study, Guilan province of Iran.

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### Contribution/ Originality

The paper's primary contribution is finding that whether ergonomics is effective in sustainable urban development. By surveying participants and statistical analysis, we found out that results support our hypothesis, and ergonomics has relationship with sustainable urban development.

## 1. INTRODUCTION

The extent and intensity of human exploitation of the natural resources of the planet in the 20th century for economic growth have caused significant damages to the atmosphere, vegetation, biodiversity, land and forests, and etc. These non-normative actions and potentially have created serious threats to the survival of the human race and other living species on earth. All of these, especially during the last two decades, have resulted in formation of a new type of development called "sustainable development". The concept of sustainable development refers to this undeniable fact that ecological considerations can and should be employed in economic activities. These considerations include the creation of a favourable environment in which the claim of development to promote quality in all aspects of life is challenged. Sustainable development suggests issues such as: prevention of environmental pollution in urban areas, reducing the production capacity of local, regional and national environment, Supporting recycles, lack of support from harmful development, and eradicating the gap between rich and poor. Sustainable development seeks to build a fairly ideal and utopian city in which contemporary citizens either enjoy a relatively good life or the ability of future generations to meet their needs are not endangered. This means that the present generation in providing economic, social, cultural and political life can be able to provide biological and spiritual needs of all members of society at an optimal level. Sustainable development aims to grow

and develop all spiritual and material conditions of the social, economic and cultural life of humans, especially in urban areas (Navabakhsh and Arjmand, 2009). "High technology can make our lives more efficient and exciting. However, fascination with technology and overly ambitious business expectation can cause us to overlook human factors risks. Neglecting these risks can have serious effects on manufacturers, suppliers and service enterprises. Therefore, ergonomics and human factors will be more important in postmodern era than when it was first introduced in the nineteenth century" (International Ergonomics Association). Ergonomics or human factors engineering is a scientific composition that attempts to design tools, equipment, work environment and jobs with regard to human intellectual-physical abilities, limitations, and interests. This knowledge is formed to increase productivity with respect to the health, safety and welfare of humans on the environment. Also this science is trying to fit environment with user rather than fitting user with environment (Forozanfar, 1999). Ergonomics is the practice of designing products, systems or processes to take proper account of the interaction between them and the people who use them. It is a multidisciplinary field incorporating contributions.

From psychology, engineering, biomechanics, industrial design, physiology and anthropometry (Wikipedia). According to International Ergonomics Association (2014) ergonomics is defined as: "Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." (IEA)

The emergence of ergonomics dates back to the industrial revolution of the late nineteenth and early twentieth centuries. Research work of Frank and Lillian Gilbreth on the ergometer and workshop management was the beginning of ergonomic studies. After World War II, and especially with clarifying the work problems and even losses due to lack of knowledge regarding ergonomics in the workplace, the need for an ergonomic workplace design becomes more evident. Complexity of possible mistakes in various fields such as fighter aircraft, radar and other equipment during the war was related to both engineering and behavioural aspects, and groups of psychologists, engineers, anthropologists and physiologists with each other Began efforts to solve design problems and training. Such efforts, which had begun simultaneously during the Second World War in the United States and the United Kingdom, led to the development of ergonomic science and to be considered in most European countries. In the 1980s, unfortunately, many technological disasters occurred and thereby led to greater recognition of ergonomics among the people. Factory constructors, factory owners, workers, authorities and consequently the general public turned to the ergonomic design. (Sanders and McCormick, 1987)

There are many researches about methods, examples, role and effects of ergonomics in environmental development. Alipour *et al.* (2010) in their research by enumerating ecological network elements and describing its characteristics gave a broad definition so that designers and urban planners consider this issue further in their studies. They presented principles and operational criteria for ecological network design in new developments or in the context of urban regeneration. Salmani and Ahmadi (2010) in a study redefined the concepts of development, sustainability and quality of life, and tried to examine relationship between these concepts. Accordingly, it was shown that the concept of sustainable development was possible by increasing the welfare of the citizens. This will improve the urban structure, and leads to proper and fair distribution of services and facilities to the city.

Attaianese (2011) analyzed the role of human factors in building maintenance in order to enhance sustainability in management of built environment. According to him, maintenance context is a net of interactions among people, as direct and indirect users of built environment, architectonic systems to be maintained, tools and environment. Considering maintainability as a key performance of built environment sustainability, he presented a set of performance indicators and attributes for a supportive and sustainable maintenance. Attaianese and Duca (2012) presented a preliminary survey of some principles driven by human factors/ergonomics discipline, analysing the role they play in the architectural design process, in order to define a design methodology supporting the building designer to create working and living spaces actually fitting the needs of inhabitants. It depicts an iterative process

for architectural design activities including human factors principles. According to Wolf (2003) ergonomics of the city can expand impact and appeal of green infrastructure. Green infrastructure should include ergonomics so that deliver social and environmental services. Ferrão and Fernández (2013) offered a metabolic perspective on urban sustainability, viewing the city as a metabolism, in terms of its exchanges of matter and energy. They provided a roadmap to the strategies and tools needed for a scientifically based framework for analyzing and promoting the sustainability of urban systems. Using the concept of urban metabolism as a unifying framework, they described a systems-oriented approach that establishes useful linkage among environmental, economic, social, and technical infrastructure issues. These linkages lead to an integrated information-intensive platform that enables ecologically informed urban planning. After establishing the theoretical background and describing the diversity of contributing disciplines, the authors sample sustainability approaches and tools, offer an extended study of the urban metabolism of Lisbon, and outline the challenges and opportunities in approaching urban sustainability in both developed and developing countries.

In this paper we want to examine the effect of ergonomics on sustainable urban development by preparing related hypotheses and analyzing their relationship by SPSS software to provide estimation about their effectiveness.

## 2. MATERIALS AND METHODS

### 2.1. Study Area

Guilan Province is one of the thirty-one provinces of Iran. It lies along the Caspian Sea, in Iran's Region 3, just west of the province of Mazandaran, east of the province of Ardabil, and north of the provinces of Zanjan and Qazvin (Fig. 1). Guilan has a humid subtropical climate with by a large margin the heaviest rainfall in Iran. Rasht, the capital of the province, is known internationally as the "City of Silver Rains" and within Iran as the "City of Rain". Humidity is very high because of the marshy character of the coastal plains and can reach 90 percent in summer for wet bulb temperatures of over 26 °C (79 °F). The coastline is cooler and attracts large numbers of domestic and international tourists. Large parts of the province are mountainous, green and forested. (Wikipedia)

"The framework for the traditional houses, including foundations, wall studs and roof frame is of wood. Recent developments have deeply affected building materials and techniques as well as the organization of space. Cinderblock construction (in Persian *boluk*) has replaced timber for wall construction, galvanized iron (*halab*) has replaced straw and rush as a roof covering, and the saddle roof has replaced pointed and hipped roofs. Building operations are no longer in the hands of the traditional specialist: the through-stone builder or layer (*boluksāz*) has replaced the carpenter-joiner (*najjār*), and the iron-roofer (*halabsāz*) has replaced the thatcher (*gālisāz*). The spatial pattern of these new houses, with only one habitable level, is horizontal, no longer vertical or oblique." (Encyclopædia Iranica)

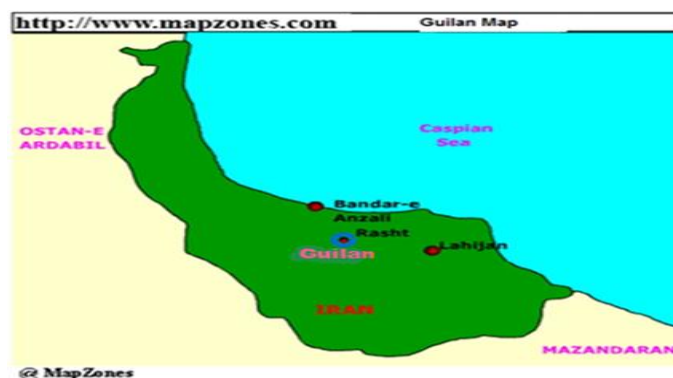


Figure-1. Guilan Province Map

Source: www.mapzones.com

### 2.2. Sustainable Development

Sustainable development is a road-map, the action plan, for achieving sustainability in any activity that uses resources and where immediate and intergenerational replication is demanded. As such, sustainable development is the organizing principle for sustaining finite resources necessary to provide for the needs of future generations of life on the planet. It is a process that envisions a desirable future state for human societies in which living conditions and resource-use continue to meet human needs without undermining the "integrity, stability and beauty" of natural biotic systems (Leopold, 1949). In the early 1970s, the concept of "sustainability" was employed to describe an economy in equilibrium with basic ecological support systems (Stivers, 1976). The use of the term became widespread in scientific circles since the Rio summit in 1992 (Zarrabi and Azani, 2001). The task of the architects in this area is very important because architects indirectly and directly are responsible for 75% of climate change. It aims to provide solutions to the transient patterns of physical, social and economic development that can prevent the occurrence of issues such as: destruction of natural resources, destruction of biological systems, global pollution, climate change, population increment, injustice, and low quality of life now and in the future. It is an aspect of human development and in relation to the environment and future generations. Sustainable development as a process that is necessary for improvement, is a basis for improving the situation and overcome Social and cultural shortcomings of developed societies and should be the engine of balanced, appropriate and coordinated economic, social and cultural progress of all societies especially developing countries. Sustainable development seeks to answer the following five basic requirements: Integration of conservation and development, supplying basic needs of human life, achieving social justice, autonomy and cultural diversity, and maintaining the ecological uniqueness. (Gorji Mahlabani, 2010)

### 2.3. Ergonomics or Human Factors Engineering

The term ergonomics, from Greek *ἔργον*, meaning "work", and *νόμος*, meaning "natural laws" first was used by Polish scientist Wojciech Jastrzębowski in 1857. In practical terms, ergonomics is a knowledge that has emerged from the combination of biology, human physiology, systems and procedures, job design and workplace trying to design tools, systems and workplace based on human physical and mental abilities, limitation and interests. The science aimed at improving the health, safety and welfare of employees at work (Chobineh and Amirzadeh, 2008). The terms "human factors" and "ergonomics" are essentially synonymous. Ergonomics is employing scientific knowledge of information concerning humans (and methods of producing such information) in designing work environment. Ergonomics study human capacities and capabilities, and then applies obtained approach in designing jobs, products, workplace and equipments. (Sadeghi, 2000)

The expression "human factors" is a North American term which has been adopted to emphasise the application of the same methods to non work-related situations. A "human factor" is a physical or cognitive property of an individual or social behaviour specific to humans that may influence the functioning of technological systems (International Organisation for Standardisation). Environmental ergonomics is one of domains of ergonomics which is concerned with human interaction with the environment as characterized by climate, temperature, pressure, vibration, and light (International Society for Environmental Ergonomics). Urban environmental management critically affects sustainability. The increased rate of technological development has created the need to consider human factors in the design section.

### 2.4. Research Hypotheses

In this paper we aim to examine the effect of ergonomics on sustainable urban development. To implement ergonomics in urban development for sustainability, there are important factors. In this study, we examine 5 factors of: functional effectiveness, human welfare, creativity, enjoyable environment, and the use of appropriate colours for the environment. First we provide 5 hypotheses based on these factors and then in section 3 we analyze them.

H1. There is a significant relationship between *functional effectiveness* and sustainable urban development.

- H2. Between *human welfare* and sustainable urban development there is a significant relationship.
- H3. The relationship between *creativity* and sustainable urban development is significant.
- H4. Between *enjoyable environment* and sustainable urban development there is a significant relationship.
- H5. There is a significant relationship between *using appropriate colours for the environment* and sustainable urban development.

## 2.5. Research Method

This research is a descriptive/survey study. We collected information related to literature through library method: searching books, journals, and online websites. Data collection tool was a researcher-made questionnaire in Persian. Participants were 80 human factor specialists in various areas of work and experience who were randomly selected using Krejcie & Morgan table. Data analysis was done by SPSS software. Also to explain and predict the effect of ergonomics in sustainable urban development of Guilan province based on effective factors, multiple regression analysis was used.

## 3. RESULTS AND DISCUSSION

### 3.1. Testing Hypotheses

In order to estimate the relationship between two variables we used Pearson's correlation coefficient. It shows the linear relationship between two sets of data. Results are shown in table 1.

Table-1. Correlation coefficients of research variables

Subject	R	Sig.	N
Functional effectiveness	0.649	0.000	80
Human welfare	0.521	0.000	80
Creativity	0.599	0.000	80
Enjoyable environment	0.724	0.000	80
Appropriate colours	0.763	0.000	80

Source: author's calculations

According to table 1, the following are concluded:

- According to hypothesis 1, since  $r=0.649$  and error level is less than 0.01, we can find out that the relationship between the two variables is significant at the 0.99 confidence level. Also the relationship is on straight line with positive direction. In this regard, functional effectiveness explains 65% of variation in sustainable urban development.
- According to hypothesis 2, results indicate that the strength of association between the variables is high ( $r = 0.521$ ), and that the correlation coefficient is very highly significantly different from zero ( $P < 0.001$ ). Then there is positive and significant relationship between two variables. Also we can say that 52% of variation in urban sustainable development creation is explained by Human welfare.
- According to hypothesis 3, results show positive and significant relationship between creativity and sustainable urban development. ( $r=0.599$ ) with error level of less than 0.01 ( $P < 0.001$ ). Also we can say that 59% of variation in sustainable urban development is explained by creativity.
- According to hypothesis 4, results indicate that the strength of association between the variables is high ( $r = 0.724$ ), and that the correlation coefficient is very highly significantly different from zero ( $P < 0.001$ ). Then there is positive and significant relationship between two variables. Also we can say that 72% of variation in sustainable urban development creation is explained by enjoyable environment.

- According to hypothesis 5, since  $r=0.763$  and error level is less than 0.01, we can found out that the relationship between the two variables is significant at the 0.99 confidence level. Also the relationship is on straight line with positive direction. In this regard, the use of appropriate colours for the environment explains 76% of variation in sustainable urban development.

### 3.2. Multiple Regression Analysis

In this section in order to explain and predict sustainable urban development by related factors, multiple regression analysis was used. One of the terms used in the regression analysis, the lack of correlation between the errors. To determine this, we should use Durbin-Watson analysis where the independence of the error (the difference between the actual value and predicted value by the regression equation) can be identified in this regard, Durbin-Watson statistic was calculated which was  $d=2.102$ . The value of d always lies between 0 and 4. Since  $d < 2$  thus, assuming independence of errors was not rejected and we can use regression analysis.

Because a linear regression model is not always appropriate for the data, we should assess the appropriateness of the model by defining residuals. The residual is difference between the observed value of the dependent variable and the predicted value. The results are shown in table 2.

Table-2. Residual statistical analysis

	Minimum	Maximum	Mean	SD	N
Standardized predicted value	-2.563	2.165	0.000	1	80
Standardized residual	-2.287	2.332	0.000	0.968	80

Source: author's calculations

Generally, residuals are estimation of correct errors in the model. If the model is appropriate for the data; residuals should follow a normal distribution. Standardized predicted value and Standardized residual should have a mean of zero and standard deviation of 1 which in our model it is true. The variables considered in this model all were entered into the model at once by enter method.

Here we present linear regression results of independent variables (functional effectiveness, human welfare, creativity, enjoyable environment, and the use of appropriate colours for the environment) on dependent variable (sustainable urban development)

Table-3. Variables entered/removed-dependent variable: SUD

Model	Variables entered	Variables removed	Method
1	Functional effectiveness, human welfare, creativity, enjoyable environment, and the use of appropriate colours for the environment	-	ENTER

Source: author's calculations

Table-4. Model summary

Model	R	R squared	adjusted R squared
1	0.862	0.742	0.725

Source: author's calculations

According to table 4,  $R=0.862$ ,  $R^2 = 0.742$ , and  $adj.R^2 = 0.725$ . On the other words, the variation in sustainable urban development based on the above variables is equal to 0.74. With accurate counting, degree of freedom for each variable is 0.72. Then it can be said that 72% of variation in sustainable urban development can be explained by mentioned variables.

Table-5. ANOVA table

Source	Sum of squares	df	Mean square	F	Sig.
Regression	12.932	5	2.586	42.607	0.000
Residual	4.492	74	0.061	-	-
Total	17.424	79	2.647	42.607	0.000

Source: author's calculations

As seen in table 5, since  $F=42.607$  which is larger than critical value, we can conclude that there is a significant difference among two variables. Also the Sig. is 0.000 ( $p\text{-value}<0.05$ ) so the test statistic is significant at a confidence level of 99%. Then we can say that there is a significant relationship between effective factors and sustainable urban development.

Table-6. Coefficients

Variable	Unstandardized coefficients; $\beta$	Standardized coefficients; $\beta$	t	Sig.
(Constant)	0.002	-	0.007	0.994
Functional effectiveness	0.249	0.346	5.003	0.000
Human welfare	0.154	0.159	2.609	0.044
Creativity	0.116	0.164	2.218	0.030
Enjoyable environment	0.294	0.276	2.399	0.019
Appropriate colours	0.403	0.328	2.058	0.043

Source: author's calculations

Unstandardized coefficients ( $\beta$ ) are the regression coefficients. Standardized coefficients ( $\beta$ ) are what the regression coefficients would be if the model were fitted to standardized data. In table 6, based on these values and t-statistic, it can be understood that all predictor variables have a pure and significant effect on dependent variable. The component of "Functional effectiveness" has the highest predicted effect on sustainable urban development (0.346). The lowest effected was related to "Human welfare" variable (0.159). The scatter plot of research variables is shown in figure 2.

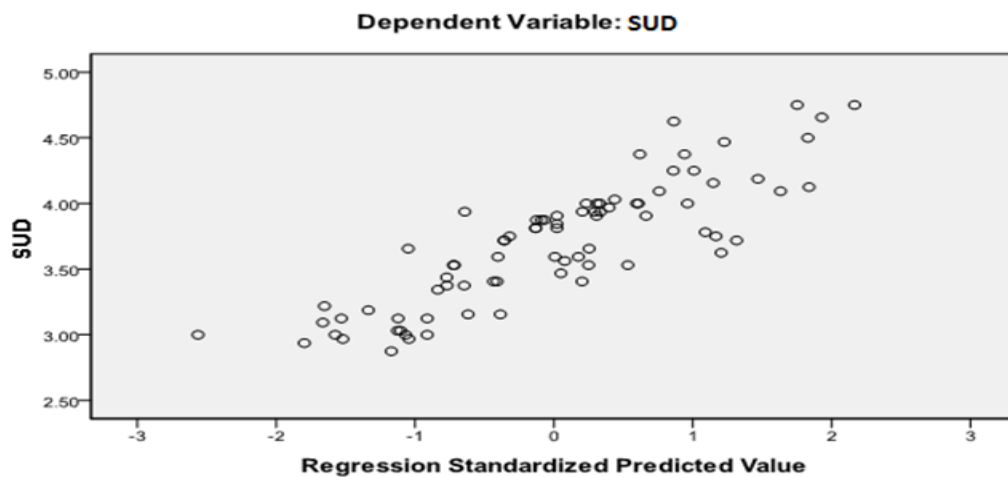


Figure-2. Scatter plot of research variables

Source: author's own drawing

#### 4. CONCLUSION

Given the broad scope of applied ergonomic science, with a comment on this view that this science considers a wide range of industrial systems, the environment, humans and machines, It can be said that one of the ways to consider urban environment and its proper performance, is to gain knowledge and apply ergonomic principles in the design of the urban environment. In this research, we studied the effect of ergonomics on sustainable urban

development. Results of testing hypotheses showed that five factors of functional effectiveness, human welfare, creativity, enjoyable environment, and the use of appropriate colours for the environment have positive and significant relationship with sustainable urban development in Guilan province of Iran. According to the results, the factor of “using appropriate colours in designing” ( $r=0.763$ ) had the highest correlation, and the factor “human welfare” ( $r=0.521$ ) had the lowest association with urban sustainable development in this province. In total, we concluded that ergonomics or Human factor had significant effect on sustainable urban development and infrastructures. Our findings were consistent with the findings of Wolf<sup>8</sup>. For sustainable urban development we must take into account the ergonomic parameters, and use all existing capacities in order to achieve sustainable development.

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