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ANN Analysis of Some Social and Economic Factors on Post-disaster Population Growth: The Case of August 1999 Gölcük Earthquake

Afet Sonrası Nüfus Artışı Üzerindeki Bazı Sosyal ve Ekonomik Faktörlerin ANN Analizi: Ağustos 1999 Gölcük Depremi Örneği

ABSTRACT

Disasters date back to earlier times than human history. People who survive in the region where disasters occur migrate to other regions due to factors such as security, shelter, employment, health concerns and psychological problems. It is an important national security problem for the disaster region, which is already negatively affected by the devastating effects of the disaster, to regain at least its pre-disaster social and economic position.

In this study, the effects of some social and economic parameters (Socio-Economic Development Index (SEDI), the number of newly built independent sections for residential purposes, agricultural area, the number of small and large cattle, the number of health personnel and GDP variables) affecting the population of Gölcük after the 7.4 Mw earthquake centered in Gölcük on August 17, 1999 were analyzed by Artificial Neural Networks (ANN). The relevant coefficients were obtained for the selected nonlinear activation function including tangent hyperbolic and logarithmic functions. The reliability of the obtained results was increased by performing ANN analysis twice. Quite high performance values (Rmse, Mad, R2 etc.) were found from these analyses. Then, the effect of the above variables was examined by using Activation function. The variables that had the most positive effect on the Gölcük population were obtained as GDP with 269% and then the number of newly built independent sections for residence with 91.2428%. On the other hand, the variables that had the most negative effect were determined as SEGE with -97.7802% and livestock statistics with -80.4924%.

Keywords: Disaster, Migration, Population, 1999 Gölcük earthquake, ANN activation function.

ÖZET

Afetler insanlık tarihinden daha eski zamanlara dayanmaktadır. Afetlerin meydana geldikleri bölgede hayatta kalan insanlar güvenlik, barınma, istihdam, sağlık kaygıları ve psikolojik sorunlar gibi etkenler yüzünden başka bölgelere göç ederler. Zaten afetin yıkıcı etkileri yüzünden olumsuz etkilenen afet bölgesinin en az afet öncesindeki sosyal ve ekonomik konumunu yeniden kazanması önemli bir ulusal güvenlik problemidir.

Bu çalışmada 17 Ağustos 1999 tarihinde Gölcük merkezli 7.4 Mw büyüklüğündeki depremin ardından Gölcük nüfusunu etkileyen bazı sosyal ve ekonomik parametrelerin (Sosyo-Ekonomik Gelişmişlik Endeksi (SEGE), ikamet amaçlı yeni yapılan bağımsız bölüm sayısı, tarım alanı, küçükbaş ve büyükbaş hayvan sayısı, sağlık personeli sayısı ve GSYİH değişkenleri) etkisi Yapay Sinir Ağları (YSA) yardımıyla analiz edilmiştir. Seçilen doğrusal olmayan tanjant hiperbolik ve logaritmik fonksiyonlar içeren aktivasyon fonksiyonu için ilgili katsayılar elde edilmiştir. İki kez ANN analizi yapılması sayesinde elde edilen sonuçların güvenilirliği artırılmıştır. Bu analizlerden oldukça yüksek performans değerleri (Rmse, Mad, R^2 vb.) bulundu. Daha sonra yukarıdaki değişkenlerin etkisi Aktivasyon fonksiyonu yardımıyla incelenmiştir. Gölcük nüfusuna pozitif yönde en çok etki eden değişkenler %269 ile GSYİH ve ardından %91.2428 ile ikamet amaçlı yeni yapılan bağımsız bölüm sayısı olarak elde edilmiştir. Öte yandan negatif yönde en çok etki eden değişkenler -%97,7802 ile SEGE ve -%80,4924 ile hayvancılık istatistikleri olarak belirlenmiştir.

Anahtar Kelimeler: Afet, Göç, Nüfus, 1999 Gölcük depremi, YSA aktivasyon fonksiyonu.

1. INTRODUCTION

Demography is the scientific study of human population. From this definition, it can be concluded that demography focuses on five aspects of human population. These are expressed as size, distribution, composition, population dynamics, and socioeconomic determinants and consequences of population change. Population size is simply the number of people in a given area at a given time. In this context, population distribution refers to the way the population is distributed in a geographic area at a given time (Bryan, 2004).

The size of a population is of fundamental importance in determining the conservation status of a species. Effective conservation and management actions are needed to protect populations or promote their recovery. These actions usually depend on some knowledge of the status or trends of the population of interest. Different population estimation methods are used for this purpose (Andriolo et al. 2010).

Population projection is the estimation of the future population situation based on the future trends of birth, death and migration data and some assumptions. Population projections help to produce future population policies. Plans and programs are determined according to the projection results. Especially after a disaster that causes migration, the estimation of the population size of a region is of vital importance for the development of the region.

Migration is the act of leaving the place of residence, temporarily or permanently, for different reasons, either compulsorily or voluntarily, and settling in another place. However, in a general context, human migration occurs due to factors such as religion, culture, economy, war, terror and disaster. Humanity has been migrating since its existence. Modern humans spread from Africa to other continents 200,000 years ago. These migrations generally occurred due to forced reasons, a search for food or disasters. People affected by the consequences of disasters such as floods, earthquakes, tsunamis, landslides, desertification and volcanic activities migrated to other, safer places in the hope of living a better life (Varol & Gültekin, 2016).

It is possible to divide the factors affecting the distribution of the population into two as natural and human. Natural factors include water resources, climate and landforms. Human factors include tourism, industry, transportation, agriculture and underground resources, etc. In this context, some important factors affecting the population projection of the disaster area after the disaster are as follows:

- Number of newly built independent sections for residential purposes in the region,
- Socio-Economic Development of the region,
- Agricultural area of the region,
- Number of small and large cattle in the region,
- Number of health personnel in the region, and
- Gross Domestic Product of the region.

These factors are important in terms of reverse migration for the disaster area. Turkey is a country where many types of disasters occur with significant frequency. In addition to many natural disasters such as earthquakes, landslides, floods and avalanches, it can also frequently face humanitarian crises, which we can call human-induced disasters, due to its geopolitical location. The 7.4 magnitude earthquake that occurred on August 17, 1999, the epicenter of which was Gölcük and affected the Marmara Region to a great extent, initiated a process in which intense discussions were held on issues such as the tectonic belt on which Turkey is located, the fault lines in Turkey and the predictability of earthquakes, and rightfully occupied the country's agenda for a long time. A migration movement was on the agenda due to the earthquake (Südaş, 2004).

Artificial Neural Networks (ANN) are the mathematical modeling of nerve cells (neurons) in the human brain in a computer environment. The learning algorithms used in artificial neural networks are different from classical computer algorithms. These algorithms carry the intuitive power of the human brain. For this reason, many branches of science are interested in artificial neural networks. Generally, models created with artificial neural networks are used in time series analysis, optimization, classification, association or nonlinear system modeling (Warner & Misra, 1996). There are three layers in an artificial neural network. These layers are the input layer, output layer and hidden layer, which contain interconnected nerve cells. The input layer allows the artificial neural network to receive data from outside. The input layer consists of

parameters that affect the problem and the number of neurons in the input layer is shaped according to the number of parameters. The output layer allows the information to be transmitted to the outside. The hidden layer is located between the input layer and the output layer. The neurons in the hidden layer do not have connections to the outside environment, they only receive signals from the input layer and send signals to the output layer (Benli, 2002). In addition, the summation function and the activation function are other important elements of ANN (Öztemel, 2012).

In this study, the change in the Gölcük population after the 1999 Gölcük earthquake was examined with Artificial Neural Networks (ANN). For this purpose, some variables related to employment, economic parameters, health and housing were considered as input variables.

2. LITERATURE REVIEW

Natural disasters can affect societies in many ways. One of these is human migration and population change. Disasters act as a "push" factor in the decision to migrate, forcing people to move from one area to another (Bates, 2002; Geipel, 1982; Hunter, 2005). Migration as a coping strategy after a disaster is fundamentally influenced by the social context in which people operate (Hunter, 2005). Demographic characteristics such as economic structure, community infrastructure, population density and rural-urban continuity and other characteristics indicating spatial stratification are also important factors that can reduce the impact of natural disasters on migration (Cutter et al.,, 2000; Myers, 2007). Some of the studies in the literature using deep learning techniques on population analysis of the post-disaster region are given below.

Wu et al. (2021) attempted to analyze population movement using mobile spatial statistics. They analyzed mobile statistical data of the disaster-affected area to extract behavioral patterns from the collected data. For this purpose, they used four different Latent Variable Analysis (LVA) methods, namely Independent Component Analysis (including FastICA and Spatial Color ICA), Non-Negative Matrix Factorization (NMF), and Sparse Principal Component Analysis (SPCA).

Ghaffarian et al. (2021) developed an agent-based model to simulate and explore the PDR process in urban areas of Tacloban, Philippines, devastated by Typhoon Haiyan in 2013. The model differentiated formal and informal (slum) sector households to explore their resilience and different recovery models. Machine learning-derived land use maps were extracted from remote sensing images for pre- and post-disaster and used to inform physical recovery.

Gharib et al. (2022) proposed a mathematical multi-objective model for a disrupted VRP where the affected areas are first clustered (by applying ANFIS). The model aims to minimize the maximum service time, maximize the route reliability and minimize the unmet demand. These points are then prioritized according to the factors affecting reliability (by applying the graph theoretical matrix persistent method). Various vehicles and depots in multimodal (i.e., land and air) transportation were used in temporary shelter distribution operations during the disaster response phase.

Marcelin et al. (2016) examined aid distribution to non-evacuating populations in a post-disaster setting to compare the accessibility of aid for aging with other populations. They used a p-median-based modeling framework coupled to a geographic information system (GIS) to examine the impact of the age of potential hurricane non-evacuees on deciding where to locate relief distribution facilities in Leon County, Florida.

Basu et al. (2018) first derived a principal component regression model to estimate the demand for emergency resources based on situational parameters in shelters. Then, they proposed an opportunistic demand sharing scheme to collect and forward resource demands to the control station using a smartphone-based delay-tolerant network (DTN). Finally, they proposed a demand verification technique based on case-based reasoning to validate these demands and reflect the undelivered demands.

In recent years, there has been a significant increase in the number of people displaced following disasters. Ahmad et al. (2017) They used a mathematical approach combined with the application of Geographic Information Systems (GIS) tools and techniques to measure the social vulnerabilities of displaced populations and visualize movement, thereby drawing attention to the location of significant vulnerabilities. They used a retrospective study approach based on datasets collected from government and non-government organizations working with refugees and internally displaced persons in Pakistan. They applied simple mathematical formulas to calculate and map various types of vulnerabilities such as refugee population, absorptive capacity, unmet needs and overall vulnerability. This approach showed the risks and vulnerabilities of the displaced population.

Lin (2009) used an empirical approach to develop algorithms to predict population shifts after natural disasters.

Parulian et al. (2019) estimated the number of victims affected by the disaster, killed, missing, injured, damaged or displaced. They obtained the data from the National Disaster Management Agency and the Indonesian Central Statistics Agency. The method used to estimate is the Incremental Sequential Order method. This method is a part of the Artificial Neural Network method.

Long-term and long-distance displacement creates a grey area between emergency shelter and permanent housing, raising concerns about vulnerability, housing availability and land development. Levine et al. (2007) began by discussing the transition between response and recovery. They then reviewed literature on social vulnerability, displacement, provision of temporary housing, household return decisions, and disaster-induced land development and housing construction processes.

Cumbane and Gidófalvi (2021) proposed anonymized mobile Call Detail Records (CDRs) as an information source to infer the spatial distribution of the displaced population by analyzing the change of the home cell tower for each anonymized mobile telephone subscriber before and after a disaster. The effectiveness of this method was evaluated using remote sensing-based building damage assessment data and Displacement Tracking Matrix (DTM) from an individual's questionnaire survey after a severe cyclone in Beira city, central Mozambique in March 2019.

Song et al. (2016) collected and analyzed large and heterogeneous data (e.g., GPS records of 1.6 million users for 3 years, data on earthquakes in Japan for 4 years, news report data, and transportation network data) to study human mobility after natural disasters.

Zhou et al. (2023) proposed an optimized BP neural network model considering the spatial characteristics of the influencing factors to evaluate the distribution of the earthquake-affected population. The correlation between the earthquake-affected population and the influencing factors was analyzed using the data of the 2013 Ms7.0 Lushan earthquake. Ten influencing factors, including elevation, slope angle, population density, GDP per capita, distance to the fault, distance to the river, NDVI, PGA, PGV, and distance to the epicenter, were classified as environmental and seismic factors. The correlation analysis revealed that GDP per capita and PGA factor had stronger correlation with the earthquake-affected population. The earthquake-affected population was evaluated using a BP neural network by optimizing the training samples considering the spatial characteristics of GDP per capita and PGA factors.

In this study, the effects of some factors affecting the population change of Gölcük district after the earthquake with a magnitude of Mw=7.4 (Kandilli Observatory) centered in Kocaeli/Gölcük on August 17, 1999 have been analyzed with artificial neural networks. Then, the positive/negative effects of these variables affecting the population were investigated. For these analyses, artificial neural networks activation function was used.

3. METHODOLOGY

Within the scope of this study, some data from the Gölcük district of Kocaeli province between the years 1996-2023, obtained from the Turkish Statistical Institute (TSI) and the Ministry of Industry and Technology of the Republic of Turkey, were analyzed. Thus, some variables affecting the population of Gölcük district after the 1999 earthquake were examined with an artificial neural network (ANN) model. Six features were given as input to the model and ANN model was used to estimate the population. The input variables are as follows, with the population of Gölcük district of Kocaeli province ($\boldsymbol{P}$) as the output variable:

- Newly Built Independent Sections Numbers for Gölcük District (Total) ($\boldsymbol{R}$)
- Socio-Economic Development Index for Gölcük District ($\boldsymbol{I}$)
- Farming Area for Gölcük District ($\boldsymbol{FA}$)
- Animal Husbandry for Kocaeli Province ($\boldsymbol{AH}$)
- Total Medical Personnel for Kocaeli Province ($\boldsymbol{MP}$)
- Gross Domestic Product for Kocaeli Province ($\boldsymbol{GDP}$)

The preprocessing processes, training, testing stages and analysis processes of the proposed model are shown in Figure 1.

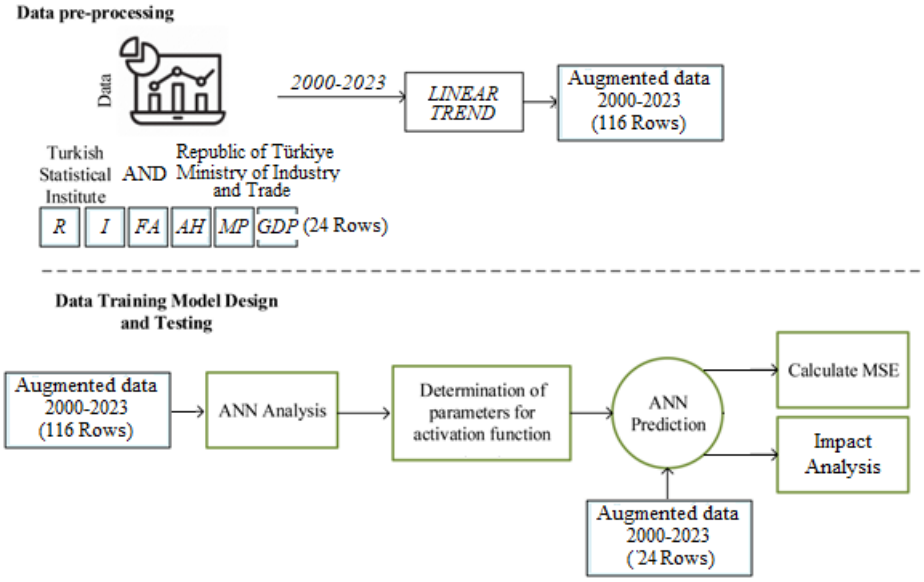

Figure 1. Methodology diagram of analysis.

The first stage of the model is to organize and complete the missing data received from TSI and the Ministry of Industry and Technology of the Republic of Turkey. When the data is analyzed, it is seen that each input parameter contains data from different years. Therefore, the times when all variables are in the same year are taken into account. Since the data were not sufficient for ANN analysis (24 rows), the variables were increased linearly by dividing each consecutive year interval into 5 parts. Using this system, data estimation was made by completing the missing data for each input. Thus, a data set of 116 rows covering the years 2000-2023 was obtained.

In the ANN analysis phase, it was aimed to estimate the population of Gölcük after the earthquake. For this purpose, an original Artificial Neural Network model was designed. A total of 116 data were divided into three as training, testing and validation and used in the training and testing processes of the ANN model. Thus, the process of revealing the model that estimates the Gölcük population with the lowest error rate was carried out.

In the last part of the study, the effect of input variables on the output variable (Negative/Positive) and its level (%) are shown with the ANN activation function.

3.1. Dataset

To analyze the factors affecting the Gölcük population, data are shown in Table 1.

Table 1. Some Kocaeli/Gölcük data (Socio-Economic Development Ranking Research Reports, 2022; TSI, 2000; TSI, 2023).

t	*P*	*R*	*I*	*FA*	*AH*	*MP*	*GDP*	*t*	*P*	*R*	*I*	*FA*	*AH*	*MP*	*GDP*
1996	-	-	1,725715	-	-	-	-	-	-	-	-	-	-	-	-
2000	107615	-	-	-	-	-	-	**2012**	143867	21231	-	9100,5	188560	9838	54819735
2001	-	-	-	-	-	-	-	**2013**	145805	23066	-	8392	213235	10489	64789835
2002	-	-	-	-	-	5133	-	**2014**	149238	24816	-	6506	225852	10798	72878337
2003	-	-	-	-	-	5692	-	**2015**	152607	26593	-	6609	212702	11115	84210995
2004	-	-	1,444	5710	107649	5958	18525149	**2016**	156901	27807	-	6631	210037	11370	92706294
2005	-	-	-	7640	114776	5942	22463361	**2017**	161117	29034	0,978002	6635	219233	12637	117591399
2006	-	-	-	5982	108779	6372	27642201	**2018**	162584	30635	-	6769	214891	13314	148519470
2007	131992	-	-	7282	108354	7684	31349625	**2019**	165663	33288	-	6687	223288	13711	156563068
2008	136513	-	-	7366	115204	7990	35827868	**2020**	170503	35738	-	6955	247383	15599	190334496
2009	136035	-	-	7370	111496	8235	33903826	**2021**	172802	38810	-	6873	236308	16578	308690699
2010	137637	18450	-	7152	134375	8671	38837243	**2022**	175940	40897	0,892002	6658	247289	17357	622576485
2011	141926	19797	-	8428,5	146741	9054	49811684	**2023**	177441	-	-	6906,6	245993	-	-

3.2. Data Augmentation with Linear Trend

The data presented in Table 1 were taken into account for the years 2000-2023 and the missing parts were completed linearly. Later, due to the insufficient number of data for ANN analysis, the data was divided into 5 parts (as ,2-,4-,6-,8) between consecutive years and estimated linearly again. Thus, a data set of 116x7 size was reached, with 6 inputs and 1 output variable. This mentioned data set is given in Table 2.

However, when measuring ANN performance according to some metric values, the unaugmented data set will be taken into account.

Table 2. Augmented data set in 2000-2023.

t	*P*	*R*	*I*	*FA*	*AH*	*MP*	*GDP*	*t*	*P*	*R*	*I*	*FA*	*AH*	*MP*	*GDP*
2000	107615	9119,399564	1,5848575	4426,296497	100589,4518	4422,237	9578609,184		143090,6	20657,4	1,1715704	8831,7	171832,4	9524,4	52816514,6
	108311,4857	9252,557626	1,577814625	4490,481677	100942,4292	4493,313	10025936,17		143478,8	20944,2	1,1644012	8966,1	180196,2	9681,2	53818124,8
	109007,9714	9385,715688	1,57077175	4554,666857	101295,4066	4564,39	10473263,16	**2012**	143867	21231	1,157232	9100,5	188560	9838	54819735
	109704,4571	9518,87375	1,563728875	4618,852037	101648,384	4635,47	10920590,15		144254,6	21598	1,1500628	8958,8	193495	9968,2	56813755
	110400,9429	9652,031812	1,556686	4683,037217	102001,3614	4706,542	11367917,14		144642,2	21965	1,1428936	8817,1	198430	10098,4	58807775
2001	111097,4286	9785,189874	1,549643125	4747,222397	102354,3388	4777,619	11815244,13		145029,8	22332	1,1357244	8675,4	203365	10228,6	60801795
	111793,9143	9928,069557	1,54260025	4811,407577	102707,3162	4848,695	12262571,12		145417,4	22699	1,1285552	8533,7	208300	10358,8	62795815
	112490,4	10070,94924	1,535557375	4875,592757	103060,2936	4919,77	12709898,11	**2013**	145805	23066	1,121386	8392	213235	10489	64789835
	113186,8857	10213,82892	1,5285145	4939,777937	103413,271	4990,85	13157225,1		146491,6	23416	1,1142168	8014,8	215758,4	10550,8	66407535,4
	113883,3714	10356,70861	1,521471625	5003,963117	103766,2484	5061,924	13604552,09		147178,2	23766	1,1070476	7637,6	218281,8	10612,6	68025235,8
2002	114579,8571	10499,58829	1,51442875	5068,148297	104119,2258	5133	14051879,08		147864,8	24116	1,0998784	7260,4	220805,2	10674,4	69642936,2
	115276,3429	10652,89935	1,507385875	5132,333477	104472,2032	5244,8	14499206,07		148551,4	24466	1,0927092	6883,2	223328,6	10736,2	71260636,6
	115972,8286	10806,21041	1,500343	5196,518657	104825,1806	5356,6	14946533,06	**2014**	149238	24816	1,08554	6506	225852	10798	72878337
	116669,3143	10959,52147	1,493300125	5260,703837	105178,158	5468,4	15393860,05		149911,8	25171,4	1,0783708	6526,6	223222	10861,4	75144868,6
	117365,8	11112,83254	1,48625725	5324,889017	105531,1354	5580,2	15841187,04		150585,6	25526,8	1,0712016	6547,2	220592	10924,8	77411400,2
2003	118062,2857	11266,1436	1,479214375	5389,074197	105884,1128	5692	16288514,03		151259,4	25882,2	1,0640324	6567,8	217962	10988,2	79677931,8
	118758,7714	11430,64761	1,4721715	5453,259377	106237,0902	5745,2	16735841,02		151933,2	26237,6	1,0568632	6588,4	215332	11051,6	81944463,4
	119455,2571	11595,15163	1,465128625	5517,444557	106590,0676	5798,4	17183168,01	**2015**	152607	26593	1,049694	6609	212702	11115	84210995
	120151,7429	11759,65564	1,45808575	5581,629737	106943,045	5851,6	17630495		153465,8	26835,8	1,0425248	6613,4	212169	11166	85910054,8
	120848,2286	11924,15966	1,451042875	5645,814917	107296,0224	5904,8	18077821,99		154324,6	27078,6	1,0353556	6617,8	211636	11217	87609114,6
2004	121544,7143	12088,66367	1,444	5710	107649	5958	18525149		155183,4	27321,4	1,0281864	6622,2	211103	11268	89308174,4
	122241,2	12265,17782	1,4368308	6096	109074,4	5954,8	19312791,4		156042,2	27564,2	1,0210172	6626,6	210570	11319	91007234,2
	122937,6857	12441,69197	1,4296616	6482	110499,8	5951,6	20100433,8	**2016**	156901	27807	1,013848	6631	210037	11370	92706294
	123634,1714	12618,20611	1,4224924	6868	111925,2	5948,4	20888076,2		157744,2	28052,4	1,0066788	6631,8	211876,2	11623,4	97683315
	124330,6571	12794,72026	1,4153232	7254	113350,6	5945,2	21675718,6		158587,4	28297,8	0,9995096	6632,6	213715,4	11876,8	102660336
2005	125027,1429	12971,2344	1,408154	7640	114776	5942	22463361		159430,6	28543,2	0,9923404	6633,4	215554,6	12130,2	107637357
	125723,6286	13160,63552	1,4009848	7308,4	113576,6	6028	23499129		160273,8	28788,6	0,9851712	6634,2	217393,8	12383,6	112614378
	126420,1143	13350,03663	1,3938156	6976,8	112377,2	6114	24534897	**2017**	161117	29034	0,978002	6635	219233	12637	117591399
	127116,6	13539,43775	1,3866464	6645,2	111177,8	6200	25570665		161410,4	29354,2	0,974562	6661,8	218364,6	12772,4	123777013,2
	127813,0857	13728,83886	1,3794772	6313,6	109978,4	6286	26606433		161703,8	29674,4	0,971122	6688,6	217496,2	12907,8	129962627,4
2006	128509,5714	13918,23997	1,372308	5982	108779	6372	27642201		161997,2	29994,6	0,967682	6715,4	216627,8	13043,2	136148241,6
	129206,0571	14121,46891	1,3651388	6242	108694	6634,4	28383685,8		162290,6	30314,8	0,964242	6742,2	215759,4	13178,6	142333855,8
	129902,5429	14324,69784	1,3579696	6502	108609	6896,8	29125170,6	**2018**	162584	30635	0,960802	6769	214891	13314	148519470
	130599,0286	14527,92678	1,3508004	6762	108524	7159,2	29866655,4		163199,8	31165,6	0,957362	6752,6	216570,4	13393,4	150128189,6
	131295,5143	14731,15571	1,3436312	7022	108439	7421,6	30608140,2		163815,6	31696,2	0,953922	6736,2	218249,8	13472,8	151736909,2
2007	131992	14934,38465	1,336462	7282	108354	7684	31349625		164431,4	32226,8	0,950482	6719,8	219929,2	13552,2	153345628,8
	132896,2	15152,45095	1,3292928	7298,8	109724	7745,2	32245273,6		165047,2	32757,4	0,947042	6703,4	221608,6	13631,6	154954348,4
	133800,4	15370,51725	1,3221236	7315,6	111094	7806,4	33140922,2	**2019**	165663	33288	0,943602	6687	223288	13711	156563068
	134704,6	15588,58355	1,3149544	7332,4	112464	7867,6	34036570,8		166631	33778	0,940162	6740,6	228107	14088,6	163317353,6
	135608,8	15806,64984	1,3077852	7349,2	113834	7928,8	34932219,4		167599	34268	0,936722	6794,2	232926	14466,2	170071639,2
2008	136513	16024,71614	1,300616	7366	115204	7990	35827868		168567	34758	0,933282	6847,8	237745	14843,8	176825924,8
	136417,4	16258,70306	1,2934468	7366,8	114462,4	8039	35443059,6		169535	35248	0,929842	6901,4	242564	15221,4	183580210,4
	136321,8	16492,68997	1,2862776	7367,6	113720,8	8088	35058251,2	**2020**	170503	35738	0,926402	6955	247383	15599	190334496
	136226,2	16726,67688	1,2791084	7368,4	112979,2	8137	34673442,8		170962,8	36352,4	0,922962	6938,6	245168	15794,8	214005736,6
	136130,6	16960,66379	1,2719392	7369,2	112237,6	8186	34288634,4		171422,6	36966,8	0,919522	6922,2	242953	15990,6	237676977,2
2009	136035	17194,6507	1,26477	7370	111496	8235	33903826		171882,4	37581,2	0,916082	6905,8	240738	16186,4	261348217,8
	136355,4	17445,72056	1,2576008	7326,4	116071,8	8322,2	34890509,4		172342,2	38195,6	0,912642	6889,4	238523	16382,2	285019458,4
	136675,8	17696,79042	1,2504316	7282,8	120647,6	8409,4	35877192,8	**2021**	172802	38810	0,909202	6873	236308	16578	308690699
	136996,2	17947,86028	1,2432624	7239,2	125223,4	8496,6	36863876,2		173429,6	39227,4	0,905762	6830	238504,2	16733,8	371467856,2
	137316,6	18198,93014	1,2360932	7195,6	129799,2	8583,8	37850559,6		174057,2	39644,8	0,902322	6787	240700,4	16889,6	434245013,4
2010	137637	18450	1,228924	7152	134375	8671	38837243		174684,8	40062,2	0,898882	6744	242896,6	17045,4	497022170,6
	138494,8	18719,4	1,2217548	7407,3	136848,2	8747,6	41032131,2		175312,4	40479,6	0,895442	6701	245092,8	17201,2	559799327,8
	139352,6	18988,8	1,2145856	7662,6	139321,4	8824,2	43227019,4	**2022**	175940	40897	0,892002	6658	247289	17357	622576485
	140210,4	19258,2	1,2074164	7917,9	141794,6	8900,8	45421907,6		176240,2	41336,85	0,8886271	6707,72	247029,8	17520,1	749187299,7
	141068,2	19527,6	1,2002472	8173,2	144267,8	8977,4	47616795,8		176540,4	41776,69	0,8852522	6757,44	246770,6	17683,2	875798114,5
2011	141926	19797	1,193078	8428,5	146741	9054	49811684		176840,6	42216,54	0,8818772	6807,16	246511,4	17846,4	1002408929
	142314,2	20083,8	1,1859088	8562,9	155104,8	9210,8	50813294,2		177140,8	42656,38	0,8785023	6856,88	246252,2	18009,5	1129019744
	142702,4	20370,6	1,1787396	8697,3	163468,6	9367,6	51814904,4	**2023**	177441	43096,23	0,8751274	6906,6	245993	18172,6	1255630559

3.3. Normalization of Augmented Data

For the data in Table 2, min-max normalization was applied to the data. One of the most commonly used methods to normalize data is min-max normalization. For each feature, the lowest value is set to 0 and the highest value is set to 1. All other values are then set to be between 0 and 1 in decimal. Thus, the dataset for variable x is created by the formula $x_{norm} = \frac{x - x_{min}}{x_{max} - x_{min}}$ (Sinsomboonthong, 2022; Henderi, Wahyuningsih, & Rahwanto, 2021). In this sense, some results found from the data set in Table 2 for the normalization process are showed in Table 3.

Table 3. Some results for normalizing the dataset.

	t	*P*	*R*	*I*	*FA*	*AH*	*MP*	*GDP*
Min	2023	177441	43096,2280082449	1,5848575	9100,5	247383	18172,6051996622	1255630558,69666
Max	2000	107615	9119,3995641805	0,8751273842	4426,2964974206	100589,451763828	4422,2371601209	9578609,18411894
Max-Min	23	69826	33976,8284440644	0,7097301158	4674,2035025794	146793,548236172	13750,3680395413	1246051949,51254

Normalized augmented data with min-max normalization, is presented in the Table 4.

Table 4. Normalized augmented data.

t	*P*	*R*	*I*	*FA*	*AH*	*MP*	*GDP*	*t*	*P*	*R*	*I*	*FA*	*AH*	*MP*	*GDP*
0	0	0	1	0	0	0	0	0,5043478	0,5080572	0,3395844	0,4176841	0,9424929	0,4853275	0,3710565	0,0346999
0,0086957	0,0099746	0,0039191	0,9900767	0,0137318	0,0024046	0,0051690	0,0003590	0,5130435	0,5136167	0,3480254	0,4075828	0,9712464	0,5423041	0,3824598	0,0355037
0,0173913	0,0199492	0,0078382	0,9801534	0,0274636	0,0048092	0,0103381	0,0007180	0,5217391	0,5191762	0,3564665	0,3974815	1	0,5992808	0,3938631	0,0363076
0,0260870	0,0299238	0,0117573	0,9702301	0,0411954	0,0072138	0,0155071	0,0010770	0,5304348	0,5247272	0,3672680	0,3873802	0,9696847	0,6328994	0,4033320	0,0379078
0,0347826	0,0398984	0,0156763	0,9603067	0,0549272	0,0096183	0,0206762	0,0014360	0,5391304	0,5302781	0,3780694	0,3772789	0,9393693	0,6665180	0,4128008	0,0395081
0,0434783	0,0498729	0,0195954	0,9503834	0,0686589	0,0120229	0,0258452	0,0017950	0,5478261	0,5358291	0,3888709	0,3671776	0,9090540	0,7001367	0,4222696	0,0411084
0,0521739	0,0598475	0,0238006	0,9404601	0,0823907	0,0144275	0,0310143	0,0021540	0,5565217	0,5413800	0,3996724	0,3570763	0,8787387	0,7337553	0,4317385	0,0427087
0,0608696	0,0698221	0,0280058	0,9305368	0,0961225	0,0168321	0,0361833	0,0025130	0,5652174	0,5469309	0,4104739	0,3469750	0,8484234	0,7673740	0,4412073	0,0443089
0,0695652	0,0797967	0,0322111	0,9206135	0,1098543	0,0192367	0,0413524	0,0028720	0,5739130	0,5567640	0,4207750	0,3368737	0,7677251	0,7845641	0,4457017	0,0456072
0,0782609	0,0897713	0,0364163	0,9106902	0,1235861	0,0216413	0,0465214	0,0032310	0,5826087	0,5665970	0,4310762	0,3267724	0,6870269	0,8017542	0,4501962	0,0469054
0,0869565	0,0997459	0,0406215	0,9007669	0,1373179	0,0240458	0,0516905	0,0035900	0,5913043	0,5764300	0,4413773	0,3166711	0,6063287	0,8189444	0,4546906	0,0482037
0,0956522	0,1097205	0,0451337	0,8908435	0,1510497	0,0264504	0,0598212	0,0039490	0,6000000	0,5862630	0,4516784	0,3065698	0,5256304	0,8361345	0,4591850	0,0495020
0,1043478	0,1196951	0,0496459	0,8809202	0,1647815	0,0288550	0,0679518	0,0043079	0,6086957	0,5960960	0,4619796	0,2964685	0,4449322	0,8533246	0,4636794	0,0508002
0,1130435	0,1296697	0,0541581	0,8709969	0,1785133	0,0312596	0,0760825	0,0046669	0,6173913	0,6057457	0,4724396	0,2863672	0,4493393	0,8354083	0,4682902	0,0526192
0,1217391	0,1396443	0,0586704	0,8610736	0,1922451	0,0336642	0,0842132	0,0050259	0,6260870	0,6153954	0,4828997	0,2762659	0,4537465	0,8174920	0,4729010	0,0544382
0,1304348	0,1496188	0,0631826	0,8511503	0,2059768	0,0360688	0,0923439	0,0053849	0,6347826	0,6250451	0,4933598	0,2661646	0,4581537	0,7995757	0,4775118	0,0562571
0,1391304	0,1595934	0,0680242	0,8412270	0,2197086	0,0384733	0,0962129	0,0057439	0,6434783	0,6346948	0,5038198	0,2560633	0,4625608	0,7816593	0,4821226	0,0580761
0,1478261	0,1695680	0,0728659	0,8313037	0,2334404	0,0408779	0,1000819	0,0061029	0,6521739	0,6443445	0,5142799	0,2459620	0,4669680	0,7637430	0,4867334	0,0598951
0,1565217	0,1795426	0,0777075	0,8213803	0,2471722	0,0432825	0,1039509	0,0064619	0,6608696	0,6566437	0,5214260	0,2358607	0,4679093	0,7601121	0,4904424	0,0612586
0,1652174	0,1895172	0,0825492	0,8114570	0,2609040	0,0456871	0,1078199	0,0068209	0,6695652	0,6689428	0,5285720	0,2257594	0,4688507	0,7564811	0,4941513	0,0626222
0,1739130	0,1994918	0,0873909	0,8015337	0,2746358	0,0480917	0,1116889	0,0071799	0,6782609	0,6812419	0,5357181	0,2156581	0,4697920	0,7528502	0,4978603	0,0639857
0,1826087	0,2094664	0,0925860	0,7914324	0,3572167	0,0578019	0,1114561	0,0078120	0,6869565	0,6935411	0,5428641	0,2055567	0,4707334	0,7492192	0,5015693	0,0653493
0,1913043	0,2194410	0,0977811	0,7813311	0,4397976	0,0675122	0,1112234	0,0084441	0,6956522	0,7058402	0,5500101	0,1954554	0,4716747	0,7455883	0,5052783	0,0667129
0,2000000	0,2294156	0,1029763	0,7712298	0,5223785	0,0772224	0,1109907	0,0090762	0,7043478	0,7179160	0,5572327	0,1853541	0,4718458	0,7581174	0,5237069	0,0707071
0,2086957	0,2393902	0,1081714	0,7611285	0,6049594	0,0869326	0,1107580	0,0097084	0,7130435	0,7299917	0,5644553	0,1752528	0,4720170	0,7706466	0,5421355	0,0747013
0,2173913	0,2493647	0,1133665	0,7510272	0,6875403	0,0966429	0,1105252	0,0103405	0,7217391	0,7420674	0,5716779	0,1651515	0,4721881	0,7831758	0,5605641	0,0786956
0,2260870	0,2593393	0,1189409	0,7409259	0,6165978	0,0884722	0,1167796	0,0111717	0,7304348	0,7541432	0,5789004	0,1550502	0,4723593	0,7957049	0,5789927	0,0826898
0,2347826	0,2693139	0,1245154	0,7308246	0,5456552	0,0803015	0,1230340	0,0120029	0,7391304	0,7662189	0,5861230	0,1449489	0,4725305	0,8082341	0,5974213	0,0866840
0,2434783	0,2792885	0,1300898	0,7207233	0,4747126	0,0721309	0,1292884	0,0128342	0,7478261	0,7704208	0,5955471	0,1401020	0,4782641	0,8023183	0,6072683	0,0916482
0,2521739	0,2892631	0,1356642	0,7106220	0,4037701	0,0639602	0,1355428	0,0136654	0,7565217	0,7746226	0,6049711	0,1352551	0,4839976	0,7964025	0,6171153	0,0966124
0,2608696	0,2992377	0,1412386	0,7005207	0,3328275	0,0557896	0,1417971	0,0144967	0,7652174	0,7788245	0,6143952	0,1304082	0,4897312	0,7904867	0,6269623	0,1015765
0,2695652	0,3092123	0,1472200	0,6904194	0,3884520	0,0552105	0,1608803	0,0150917	0,7739130	0,7830264	0,6238193	0,1255613	0,4954648	0,7845709	0,6368093	0,1065407
0,2782609	0,3191869	0,1532014	0,6803181	0,4440764	0,0546315	0,1799634	0,0156868	0,7826087	0,7872283	0,6332433	0,1207144	0,5011984	0,7786551	0,6466564	0,1115049
0,2869565	0,3291615	0,1591828	0,6702168	0,4997009	0,0540524	0,1990465	0,0162819	0,7913043	0,7960473	0,6488599	0,1158674	0,4976898	0,7900957	0,6524307	0,1127959
0,2956522	0,3391361	0,1651642	0,6601155	0,5553253	0,0534734	0,2181296	0,0168769	0,8000000	0,8048664	0,6644764	0,1110205	0,4941812	0,8015362	0,6582051	0,1140870
0,3043478	0,3491106	0,1711456	0,6500141	0,6109498	0,0528943	0,2372128	0,0174720	0,8086957	0,8136854	0,6800929	0,1061736	0,4906726	0,8129768	0,6639795	0,1153780
0,3130435	0,3620600	0,1775637	0,6399128	0,6145440	0,0622272	0,2416636	0,0181908	0,8173913	0,8225045	0,6957094	0,1013267	0,4871640	0,8244174	0,6697539	0,1166691
0,3217391	0,3750093	0,1839818	0,6298115	0,6181381	0,0715600	0,2461143	0,0189096	0,8260870	0,8313236	0,7113260	0,0964798	0,4836553	0,8358579	0,6755283	0,1179601
0,3304348	0,3879586	0,1903999	0,6197102	0,6217323	0,0808928	0,2505651	0,0196284	0,8347826	0,8451866	0,7257476	0,0916329	0,4951225	0,8686863	0,7029894	0,1233807
0,3391304	0,4009080	0,1968180	0,6096089	0,6253265	0,0902257	0,2550159	0,0203472	0,8434783	0,8590496	0,7401692	0,0867860	0,5065897	0,9015147	0,7304505	0,1288012
0,3478261	0,4138573	0,2032361	0,5995076	0,6289207	0,0995585	0,2594667	0,0210659	0,8521739	0,8729127	0,7545907	0,0819391	0,5180569	0,9343432	0,7579116	0,1342218
0,3565217	0,4124882	0,2101227	0,5894063	0,6290919	0,0945065	0,2630303	0,0207571	0,8608696	0,8867757	0,7690123	0,0770921	0,5295241	0,9671716	0,7853726	0,1396423
0,3652174	0,4111191	0,2170094	0,5793050	0,6292630	0,0894545	0,2665938	0,0204483	0,8695652	0,9006387	0,7834339	0,0722452	0,5409913	1	0,8128337	0,1450629
0,3739130	0,4097499	0,2238960	0,5692037	0,6294342	0,0844025	0,2701573	0,0201395	0,8782609	0,9072237	0,8015168	0,0673983	0,5374827	0,9849108	0,8270733	0,1640599
0,3826087	0,4083808	0,2307827	0,5591024	0,6296053	0,0793505	0,2737209	0,0198307	0,8869565	0,9138086	0,8195998	0,0625514	0,5339741	0,9698216	0,8413130	0,1830569
0,3913043	0,4070117	0,2376694	0,5490011	0,6297765	0,0742986	0,2772844	0,0195218	0,8956522	0,9203935	0,8376827	0,0577045	0,5304655	0,9547323	0,8555526	0,2020539
0,4000000	0,4116003	0,2450588	0,5388998	0,6204487	0,1054702	0,2836261	0,0203137	0,9043478	0,9269785	0,8557656	0,0528576	0,5269568	0,9396431	0,8697922	0,2210509
0,4086957	0,4161888	0,2524482	0,5287985	0,6111209	0,1366419	0,2899677	0,0211055	0,9130435	0,9335634	0,8738485	0,0480107	0,5234482	0,9245539	0,8840318	0,2400478
0,4173913	0,4207774	0,2598377	0,5186972	0,6017931	0,1678136	0,2963094	0,0218974	0,9217391	0,9425515	0,8861333	0,0431638	0,5142488	0,9395151	0,8953624	0,2904287
0,4260870	0,4253659	0,2672271	0,5085959	0,5924653	0,1989852	0,3026510	0,0226892	0,9304348	0,9515395	0,8984182	0,0383168	0,5050494	0,9544762	0,9066930	0,3408096
0,4347826	0,4299545	0,2746166	0,4984946	0,5831375	0,2301569	0,3089927	0,0234811	0,9391304	0,9605276	0,9107030	0,0334699	0,4958499	0,9694373	0,9180236	0,3911904
0,4434783	0,4422393	0,2825455	0,4883933	0,6377565	0,2470051	0,3145634	0,0252425	0,9478261	0,9695157	0,9229879	0,0286230	0,4866505	0,9843985	0,9293542	0,4415713
0,4521739	0,4545241	0,2904744	0,4782920	0,6923754	0,2638532	0,3201342	0,0270040	0,9565217	0,9785037	0,9352727	0,0237761	0,4774511	0,9993596	0,9406848	0,4919521
0,4608696	0,4668089	0,2984034	0,4681907	0,7469943	0,2807014	0,3257049	0,0287655	0,9652174	0,9828030	0,9482182	0,0190209	0,4880882	0,9975939	0,9525479	0,5935617
0,4695652	0,4790937	0,3063323	0,4580894	0,8016133	0,2975495	0,3312757	0,0305270	0,9739130	0,9871022	0,9611636	0,0142657	0,4987253	0,9958282	0,9644109	0,6951713
0,4782609	0,4913786	0,3142612	0,4479881	0,8562322	0,3143977	0,3368465	0,0322884	0,9826087	0,9914015	0,9741091	0,0095104	0,5093624	0,9940624	0,9762739	0,7967808
0,4869565	0,4969381	0,3227023	0,4378868	0,8849858	0,3713743	0,3482498	0,0330923	0,9913043	0,9957007	0,9870545	0,0047552	0,5199995	0,9922967	0,9881370	0,8983904
0,4956522	0,5024976	0,3311433	0,4277854	0,9137393	0,4283509	0,3596531	0,0338961	1	1	1	0	0,5306366	0,9905309	1	1

3.4. Design of ANN Prediction Model and Results

The ANN model presented in this study and whose schema is given in Figure 2, was used to estimate the Gölcük population using six different input parameters. The selection of activation functions is critical in network design and facilitates the discovery and learning of complex patterns and relationships found in the data by applying them to the output of each neuron. It also ensures that the network maintains its nonlinear structure. The layers of the network, the number of nodes in the layers and the activation function selected in each layer directly affect the overall performance of the model (López et al., 2022; Hızlısoy et al., 2024). The structure proposed in this study is the activation function network with the tanh and logsig functions that have the highest performance as a result of the tests.

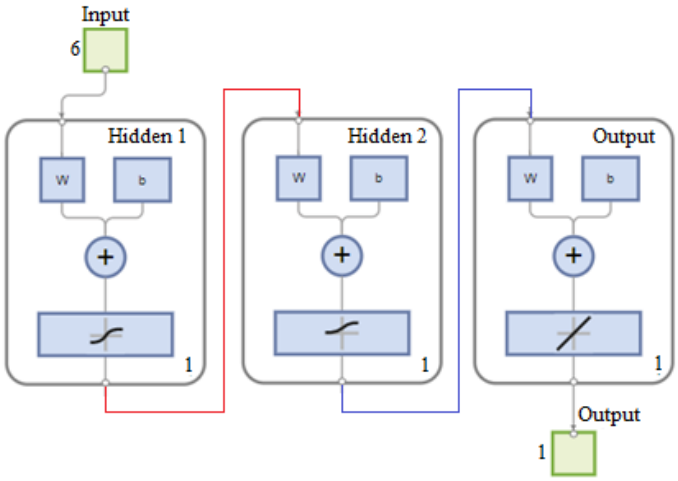

Figure 2. ANN architecture.

Here, the P variable was estimated using six input variables. For estimation, training and testing processes were performed with the data in Table 4. Hyperbolic tangent and logarithmic transfer functions were used as activation functions. In addition, 70% of the data was reserved for training, 15% for validation and the remaining 15% for testing.

The analysis was carried out with the Matlab R2023a program. In the ANN analysis, the ANN program was run twice, as the best and worst. In this way, the results of the analysis were made more reliable.

Table 5. Training progress and state of ANN analysis.

	For the first ANN analysis			**For the second ANN analysis**		
Epoch	0	10000	10000	0	10000	10000
Elapsed Time	-	00:00:09	-	-	00:00:09	-
Performance	0.707	9.73e-05	1,00E-16	0.144	9.03e-05	1e-16
Gradient	1.93	3.55e-07	0	0.315	3.45e-06	0
Mu	0.001	1,00E-09	1,00E+10	0.001	1e-09	1e+10
Validation Checks	0	9.89e+03	1.11e+06	0	65	1.11e+06
Best Validation Performance	5.4976e-05 at epoch 107			0.00010781 at epoch 9935		
R value All Data	0.99946			0.99948		

The resulting model by activation functions of ANN is given as

$$P = b_3 + LW_2 \operatorname{logsig}\left(b_2 + LW \tanh\left(b_1 + IW \begin{pmatrix} R \\ I \\ FA \\ AH \\ MP \\ GDP \end{pmatrix}\right)\right)$$

where coefficients are in Table 6.

Table 6. Coefficients for activation functions.

	b_1	b_2	b_3	IW	LW	LW_2
For the first ANN analysis	-0.3090	-0.3841	1.0077	$\begin{pmatrix} -0.0875 \\ 0.0856 \\ -0.0090 \\ 0.0625 \\ -0.0401 \\ -2.8764 \end{pmatrix}^T$	5.1032	-5.4940
For the second ANN analysis	0.4091	1.9334	-95.3632	$\begin{pmatrix} 0.0653 \\ -0.0471 \\ 0.0061 \\ -0.0399 \\ 0.0137 \\ 2.0479 \end{pmatrix}^T$	7.5958	96.3581

4. RESULTS and DISCUSSION

In this section, the performance of the ANN analysis was investigated by considering the non-augmented and non-normalized 2004-2023 data, where almost all the values of all variables can be reached. The estimation results for Gölcük population (2004-2023) are shown in Table 7.

Table 7. Estimation performances of the proposed models.

		For the first ANN analysis	For the second ANN analysis
Year	Real P value ($x10^5$)	Predicted P value ($x10^5$)	Predicted P value ($x10^5$)
2004	1.2154	1.2078	1.2074
2005	1.2503	1.2443	1.2464
2006	1.2851	1.2846	1.2870
2007	1.3199	1.3268	1.3268
2008	1.3651	1.3545	1.3549
2009	1.3603	1.3633	1.3619
2010	1.3764	1.3799	1.3789
2011	1.4193	1.4272	1.4279
2012	1.4387	1.4347	1.4355
2013	1.4581	1.4636	1.4651
2014	1.4924	1.4868	1.4886
2015	1.5261	1.5305	1.5319
2016	1.5690	1.5563	1.5573
2017	1.6112	1.6034	1.6038
2018	1.6258	1.6464	1.6470
2019	1.6566	1.6568	1.6575
2020	1.7050	1.6841	1.6847
2021	1.7280	1.7324	1.7335
2022	1.7594	1.7589	1.7601
2023	1.7744	1.7637	1.7654

The performance indicators of both ANN models are compared with the actual values and presented in Table 8. According to these results, it can be seen from the metric values in Table 8 that both models are successful in estimating the Gölcük population.

Table 8. Performances of ANN estimation results.

	For the first ANN analysis	**For the second ANN analysis**
RMSE	908.9033	892.9721
MSE	8.2611e+05	7.9740e+05
SSE	1.6522e+07	1.5948e+07
CORRCOEF	0.9986	0.9986
RSquare	0,997244582295095	0,997285962813485
MAD	14748	14764,8

ANN Activation functions obtained with normalized augmented data and having coefficients in Table 6 were taken into consideration. With these functions, the effects of R, I, FA, AH, MP and GDP input variables affecting the P output variable were calculated numerically. The operations performed for this can be summarized as follows. First, P output was calculated by giving the value 0 to all input variables. Then, P output was repeatedly calculated by giving the value 1 to each selected input variable and 0 to all other input variables. Thus, the extent to which each selected input variable changed the P output was calculated both numerically and as a percentage. The obtained etki analysis results are given in Table 9.

Table 9. Impact analysis results.

	For the first ANN analysis		**For the second ANN analysis**	
State Matrix	***P* (Population) value**	**Percentage Change**	***P* (Population) value**	**Percentage Change**
$(\mathbf{0\ 0\ 0\ 0\ 0\ 0})^T$	0.3006	-	0.2672	-
$(\mathbf{1\ 0\ 0\ 0\ 0\ 0})^T$	0.5105	%69.8092	0.5111	%91.2428
$(\mathbf{0\ 1\ 0\ 0\ 0\ 0})^T$	0.0097	-%96.7667	0.0059	-%97.7802
$(\mathbf{0\ 0\ 1\ 0\ 0\ 0})^T$	0.3260	%8.4547	0.2952	%10.4428
$(\mathbf{0\ 0\ 0\ 1\ 0\ 0})^T$	0.0979	-%67.4413	0.0521	-%80.4924
$(\mathbf{0\ 0\ 0\ 0\ 1\ 0})^T$	0.4065	%35.2101	0.3281	%22.7828
$(\mathbf{0\ 0\ 0\ 0\ 0\ 1})^T$	0.9846	%227.5391	0.9871	%269.3488

5. CONCLUSIONS

Previously the input variables were denoted as

- Newly Built Independent Sections Numbers for Gölcük District (Total) ($\boldsymbol{R}$),
- Socio-Economic Development Index for Gölcük District ($\boldsymbol{I}$),
- Farming Area for Gölcük District ($\boldsymbol{FA}$),
- Animal Husbandry for Kocaeli Province ($\boldsymbol{AH}$),
- Total Medical Personnel for Kocaeli Province ($\boldsymbol{MP}$), and
- Gross Domestic Product for Kocaeli Province ($\boldsymbol{GDP}$).

Both ANN analysis results are seen to give similar results in Table 8 and Table 9. Therefore, the results of Table 9 were evaluated according to the second ANN analysis. Here, it can be said that R, FA, MP and GDP variables have positive effects on P output while I and AH variables have negative effects. GDP variable has the highest positive effect (%269.3488) while FA variable has the lowest positive effect (%10.4428). Similarly, I variable has a relatively high negative effect (%-97.7802) while AH variable has a relatively lower negative effect (%-80.4924).

The 1999 Gölcük earthquake had a very devastating effect on the region. The region can only be restored to its pre-earthquake position or to a better position by reconstructing the region and making the social and economic conditions attractive. Different parameters can be examined to see the results of this situation. Perhaps the first parameter that comes to mind and can be measured is the population of the region. In this study, the effects of some social and economic parameters thought to affect the Gölcük population were examined with ANN. Livestock and Socioeconomic Development Index have negative effects on the population of Gölcük district. In particular, the fact that livestock farming is frequently done in places far from industrial zones and where the population density is low is quite supportive with our results. On the other hand, the effect of the GDP value of the region is very high. This is very closely related to the region being an industrial zone. Moreover, the situation that has a high positive effect is the number of newly built independent units for residential purposes. Again, this is another factor that makes the region attractive.

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