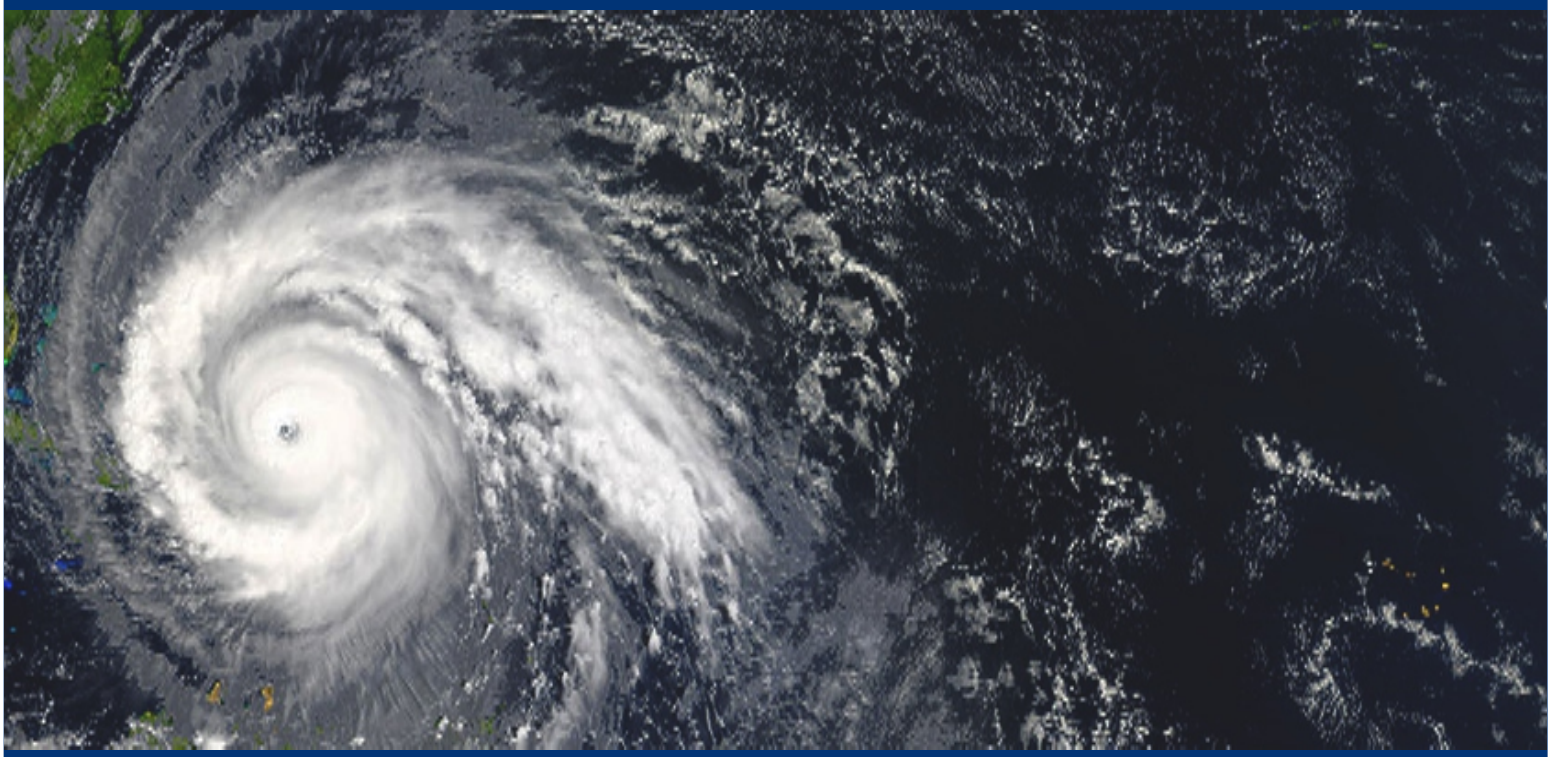
DISASTER SCIENCE AND ENGINEERING



VOL: 8, NO:1, 2022

ISSN: 2149-7249

For more info, you may visit
www. disasterengineering.com

DISASTER SCIENCE AND ENGINEERING
EDITORIAL BOARD
Volume: 8, Issue 1, May 2022

DISASTER SCIENCE AND ENGINEERING

2022, Volume 8, Number: 1
Page: 1 - 10
Received: 17 January 2022
Accepted: 13 Aprile 2022

Pro-Environmental Behaviors, Pollution Control Attitudes and Environmental Knowledge of Secondary School Students

John C. Matthias[1], Aşkın Kiraz[2], Hüseyin Gökçekuş[3]

[1]Near East University; johnmatthias04@gmail.com
[2]Near East University; askin.kiraz@neu.edu.tr; ORCID 0000-0002-2350-8291; Phone Number +905338341757
[3]Near East University; huseyin.gokcekus@neu.edu.tr

Abstract

This study assessed the level of pro-environmental behaviors, pollution control attitudes and knowledge among a sample of 424 secondary school students within Abuja the capital city of Nigeria. The data for this study was collected using three tools: environmental attitude test, environmental knowledge test and pro-environmental behavioral scale. The study data were analyzed using Ms. Excel computer program. Pearson correlation coefficient was used to compare individual responses on environmental knowledge with environmental attitude to see if both responses correlate with one another. According to the study results, the environmental attitude of the students was high, and results also showed their environmental knowledge to be also high while their pro-environmental behaviors were found to be moderate. It also reviewed that female student exhibited better pro-environmental behaviors, while the male students gave a better attitude to environmental related issues. The result displayed a very strong positive correlation value of 0.807 between environmental knowledge and environmental attitude, meaning the higher the environmental knowledge, the better their attitude towards issues of the environment and vice versa.

Keywords: Environment, Environmental Knowledge, Pollution Control, Pro-Environmental Behaviors

1. Introduction

Over the years, there has been a steady increase in human activities around the globe, such as industrial production, resource exploitation, and private consumption on the environment which results in the degradation of the ecosystem, threats to future generations (Decamps, 2000). As a result of the increase in environmental problem such as ozone layer depletion, the rise of sea levels, global warming, natural resource exploitation and numerous health hazards from the activities of man, society is becoming aware and more sensitive to things about the environment (Bearer, 1995). Scholars all over the globe have continually called for environmental awareness to create a room in which the environment can be saved by humans from further harm.

Nigeria's capital was moved to Abuja in the year 1991 by General Babangida due to the fact that its former capital, which was Lagos state was not only congested but was also perceived to be prone to attacks since it's by the sea border and as well suffered from slum and environmental pollution. Ever since Abuja was made the capital, it has been facing serious environmental problems from the consequences of rapid growth on human population from the influx of people from across the nation looking for greener pastures, urbanization, and industrialization (Obiadi & Onochie, 2018). These consequences include wastewater disposal problems, poor air, and water quality, and a polluted environment from improper waste management and disposal practices among its inhabitants (Babayemi & Dauda, 2009). Some of these environmental problems of waste management in developing country is as a result of no recycling policies created in their countries which contributed to the accumulation of waste and as a result caused the inability of waste management authorities to cope with the volume of solid waste generated and at the same time caused the overstretching of waste management facilities (Nnaji, 2015).

Corresponding author: askin.kiraz@neu.edu.tr

Navaro and Vincenzo (2019), revealed in their study that more than 250,000 tons of waste is generated in Abuja per year and Abuja had only four major disposal site they manage which was shut down in the year 2005 due to poor management of the facilities which led to the contribution of air pollution and land pollution from the leachate that flowed to the surface in the rainy season period. Meanwhile, Adeyemi (2011), in their study revealed that population growth and construction boom is the major problem causing environmental pollution in Abuja, as this generates over 3000 tones of solid waste daily, of which eventually ends up not properly disposed. In addition, (Babayemi, Ogundiran, & Osibanjo 2016) lack of awareness among populace who are still tied to traditional and cultural practices, preindustrial norms contribute to the environmental problems the country is facing.

According to Akinyele, (1994), Poverty implies as a distinct form and levels of deprivation, which inflict crucial constraints on traditional human functioning and existence. Poverty is undeniably associated to lack of control over resources including capital, knowledge, land, skills, and social connections. (United Nations, 1996). And Nigeria being a 3rd world country has about 40% of its population living in Poverty, although the statistics for 2021 has not been estimated but it was projected to increase by 5% according to The Nigerian National Bureau of Statistics report on poverty and inequality between September 2018 and October 2019.

Nigeria as a country is facing daily increase on environmental consequences as a result of polluted environment, such problems include flooding of the environment whenever there's a heavy rainfall due to waterway blockages from the indiscriminate dumping of domestic waste into it, food contamination from the dirty environment and wrong application of fertilizers by farmers on their farmlands to improve crop production for food for the ever-increasing population of the country (Imam et al. 2008; Adedeji and Eziyi, 2019).

These environmental problems cannot only be solved through law enforcement by the government as to the sustainability of the environment, therefore this can also be solved by finding out the levels of environmental knowledge, attitude and pro-environmental behaviors of students as this would help create basis for more environmental education that would help them be more environmentally friendly people with positive decisions tomorrow.

1.1 Background

Environmental knowledge, attitude and pro-environmental behaviors are determined by various factors. Haron, et al. (2005), in their research found out that factors that determines how high or low levels of environmental knowledge were education, income levels of households, and as well gender. Results from their study also indicated that households' sources of environmental knowledge were from newspapers, television, and radio. And they also noticed that the higher the level of education, the higher the level of their environmental knowledge. Ibrahim and Babayemi (2010) investigated university of Ibadan undergraduate students' knowledge and attitudes toward environmentalism, results from their investigation showed a positive, significant and strong relationship between knowledge and attitude towards environmentalism and there was significant differences in the scores of knowledge and attitude toward environmentalism between Subgroups of Gender, in which Males had significantly better knowledge of environmentalism than their female counterparts, Insignificant differences were recorded across religion-subgroups as regards knowledge of environmentalism, although the Christians had a significantly better attitude towards environmentalism and lastly, Significant differences were recorded across field of study subgroups as regards knowledge of environmentalism. Respondents in the field of health sciences, science and technology as well as those in humanities and arts had the best better and worse knowledge of environmentalism respectively while Insignificant differences was recorded across field of study subgroups as regards attitudes towards environmentalism. They suggested the earnest need to update undergraduates' environmental knowledge such that their attitudes may also improve.

Purpose of the study: This study aims at ascertaining the level of Pro-Environmental behaviors of secondary school students, and their attitudes towards controlling environmental pollution as well as their knowledge on the consequences resulting from environmental pollution. The research will help lay the foundation for environmental awareness activities in schools and their locality.

Research Question: For the purpose of this study, we are going to answer the following questions
1) How is the pro-environmental behavior of the secondary students differing in respect to Gender (Boys and Girls) and Schools (Government-owned and Private Schools)?
2) How are the attitudes towards environment differ in respect to Gender (Boys and Girls) and Schools (Government-owned and Private Schools)?
3) What is their level of knowledge on the consequence of our actions to the environment?

4) Is there any correlation between their environmental knowledge and environmental attitudes?

Significance of the study: Since there has been an increase of environmental problems caused by the daily activities of a man to fend for his family, destroying ecosystem to erect infrastructures like railways, roads, and buildings. These problems have gotten the attention of scholars around the world and they are calling for more environmental awareness among people and this study will help in understanding the level at which the students behave pro environmentally, attitude towards the environment, and knowledge about the consequences of environmental pollution in Abuja, it'll also help to improve the attitude towards the protection and proper use of natural resources, and it would also help create room for further research.

Limitation of the study: This study interest is limited to only secondary school students of both private and government-owned within the 2020/2021 academic year calendar in Abuja.

2. Methods

2.1 Study Area

Abuja is Nigeria's administrative and political capital, located center of the country (as seen in Figure 1). The land area is 8,000 square kilometers, bordering Kaduna to the north, Nasarawa to the east and southeast, Niger to the west, and Kogi State to the southwest. It lies in latitude 7° 25' N and 9° 20° North of the Equator and longitude 5° 45' and 7° 39' (www.fct.gov.ng). Abuja belongs to the Guinea forest-savanna mosaic area in the West African subregion. The terrain of Abuja is gently undulating, with a height of 305m in the west and 610m in the east (Abuja-Citiserve, 2004).

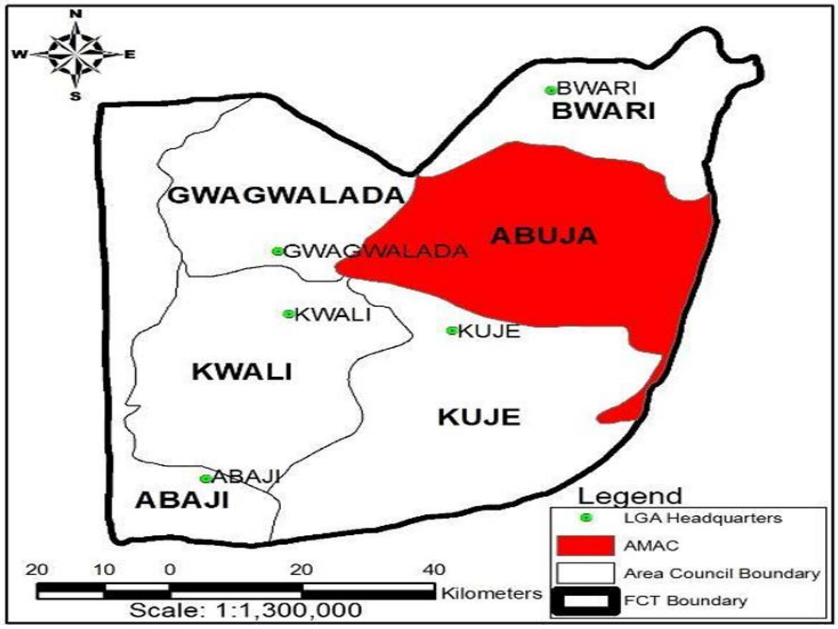


Figure 1. Map of Abuja showing Abuja municipal area council

2.2 Study Area Population

Abuja is composed of six municipalities, including Abaji, AMAC, Bwari, Gwagwalada, Kuje, and Kwali. These municipalities are further subdivided into districts and areas. Abuja has a population of 1, 406,239, the city's population has been growing by 20%-30% per year, making it the fastest growing city in Africa according to the National Population Commission (NPC, 2012), it is also considered to be the eight most populous cities in Nigeria. The inhabitants of Abuja are mainly people of different cultural groups who migrated from other parts of Nigeria.

2.3 Methodology

The data for the study was collected primarily with the help of questionnaire containing 19 questions on environmental attitudes, 18 questions on environmental knowledge and 21 questions on pro-environmental behaviors, and administered it to students from both private owned and government-owned schools in the six Municipals of Abuja. 400 students were initially targeted for this study but at the course of receiving the data, we noticed that 424 students

responded to the questionnaire, so we made use of the 424 respondents for the study, and Secondary data was collected from data sources like books and journals.

2.3.1 Margin of Error details

Confidence level %	Sample size	Population Proportion %	Population Size	Margin of Error %
95	424	0.03	1406239	0.16

2.4 Scoring of the Scale and Classification

The attitudinal level towards the environment and knowledge of environmental issues of the students who participated in the study was obtained using the "five-point Likert scale" and interpreted. The scoring and grading adopted for this study is as follows.

Table 1 Scoring and grading of the scale material for environmental attitude

Likert Description	**Scale**	**Value Range Allocation**	**Value/Level**
Strongly agree	5	849-1060	Very high
Agree	4	637-848	High
Neutral	3	425-636	Average
Disagree	2	213-424	Low
Strongly disagree	1	212	Very low

Table 2 Scoring and grading of the scale material for pro-environmental behaviors

Likert Description	**Scale**	**Value Range Allocation**	**Value/Level**
I do it very often	5	849-1060	Very high
I do it	4	637-848	High
I sometimes do it	3	425-636	Average
I barely do it	2	213-424	Low
I never do it	1	212	Very low

Significant difference between groups was tested using one-way analysis of variance (ANOVA) to see if there is any significant difference in their response in respect to school and gender.

2.5 Data analysis

The data collected in this study was quantitatively analyzed using the computer software excel for windows, and the analysis was based on the research objectives. Reasons why we chose a quantitative method for the purpose of this study is that it is fast in obtaining information and more scientific, and secondly, we are trying to check levels and also the correlation between variable of environmental knowledge and environmental attitude scales. Quantitative method of research according to Dźwigoł (2018), is a method that is designed to determine how many people think, react, or behave in a specific way, and is also the best choice for large sample sizes.

2.6 Ethical Consideration

Informed consent was obtained from the participants before administering the questionnaires to them, and data was kept encrypted in a laptop.

2.7 Demographics properties

The findings based on the demographics properties of the questionnaire which includes gender, age, school and location is shown in table 3 below.

Table 3 Distribution of sample

	Frequency (N=424)	**Percentage (%)**
Gender Female	212	50

Male	212	50
Age		
14	78	18.4
15	126	29.7
16	103	24.3
17	117	27.6
School		
Government School	212	50
Private school	212	50
Location		
AMAC	91	21.5
Bwari	72	17.0
Gwagwalada	87	20.5
Kuje	53	12.5
Kwali	64	15.1
Abaji	57	13.4

Table 3 above shows that 50% of the respondents numbering about 212 were females and 50% which is about 212 were males. The majority (29.7%) of the respondents were students who are 15 years of age, while students who were 16 and 17 years of age was 24.3% and 27.6% respectively and the age with the least number of respondents were students of whom were 14 years as at the time the survey was carried out. According to the table above, distribution of sample according to schools shows that 50% of the respondents numbering about 212 were students from government-owned schools while the remaining 50% which is about 212 were students from private schools. According to table above showing distribution of sample according to locations, it shows that 21.5% of the respondents numbering about 91 were students living within AMAC, 72 students which are about 17% of the total respondents were living within Bwari, 87 students which are 20.5% of the respondents lives within Gwagwalada, 53 students live in Kuje, 64 lives in kwali and 57 lives within Abaji council.

3. Results

The following session contains the findings based on the research questions earlier mentioned.

3.1 Pro-Environmental Behavior

In order to access level of Pro environmental behaviour of the students, a total of 21 items was used and table 4 below shows the distribution of students' response according to gender and according to school as well.

Table 4 Pro-environmental behavior of the secondary students differing in respect to gender (boys and girls) and schools (government-owned and private schools).

Items	**Male**	**Female**	**Private school**	**Government owned school**
1	527	498	559	466
2	457	480	457	480
3	746	723	696	773
4	654	612	596	580
5	591	473	547	517
6	552	547	535	564
7	508	541	512	538
8	558	662	655	565
9	372	479	447	407
10	340	429	375	394
11	855	736	736	670

12	480	522	448	554
13	623	591	651	563
14	426	543	490	479
15	514	413	499	528
16	602	577	669	510
17	624	636	612	648
18	743	766	695	814
19	640	559	604	595
20	773	813	838	749
21	677	616	625	668
AVG	**579.6**	**581.7**	**583.1**	**574.3**

On comparing the response given by the students on pro-environmental test, it was seen on table 4 above that the female students exhibited a more pro-environmental behavior with an average score of 581.7 than their male counterparts that had an average score of 579.6. meanwhile, students from the government owned schools had an average score of 574.3, scoring above students from private schools that had an average score of 583.1. On relating the results to the Pro-environmental scale on Table 2, we found out that the level of the students' pro-environmental behaviors is within average on the scale.

3.1.1 Significant difference of the students' responses.

This session shows the significant difference of the students' responses on pro-environmental behaviour based on their gender and as well as their schools and it is shown in table 5 below.

Table 5 Significant difference of student's response on pro-environmental behavior in respect to gender and to schools

	Source of Variation	SS	Df	MS	F	P-value	F crit
Gender Pro-environmental Behaviors							
	Between Groups	50.38	1.00	50.38	0.00	**0.95**	4.08
	Within Groups	595646.10	40.00	14891.15			
	Total	595696.48	41.00				
Schools Pro-environmental Behaviors							
	Between Groups	806.10	1.00	806.10	0.06	**0.80**	4.08
	Within Groups	508049.52	40.00	12701.24			
	Total	508855.62	41.00				

As seen on table 5 above, there was no significant difference found on students' response on Pro-Environmental behavior responses when compared to gender and schools because the P-values for both were all above 0.05.

3.2 Attitudes Towards Environment

A total of 19 items was used to assess the level of students' attitude towards the environment and table 6 below shows the distribution of the students' response according to gender as well as school.

Table 6 Difference in student's response to questions on environmental attitude scale according to gender and according to schools

Items	**Male**	**Female**	**Private school**	**Government owned school**
1	739	787	718	808
2	916	902	858	903
3	840	739	804	895
4	662	734	693	703
5	679	766	681	460
6	667	712	737	642
7	596	575	648	523
8	670	543	636	577
9	833	860	828	865

10	818	758	812	764
11	555	636	552	639
12	802	806	843	777
13	783	836	828	793
14	584	603	593	561
15	770	840	809	801
16	668	735	653	750
17	855	746	786	815
18	873	798	825	746
19	915	808	861	866
AVG	**748.5**	**746.5**	**745.5**	**730.9**

On comparing the response to the questions from the students, it was seen that the students exhibited a relative high level of environmental attitude with the male having a score of 748.5 as against their female counterparts scoring 746.5 while for that of schools, private school students had a more positive environmental attitude with an average score of 745.5 as against students from government schools that scored an average of 730.9.

3.2.1 Significant difference of the students' responses

This session shows the significant difference of the students' responses on environmental attitude based on their gender and as well as their schools and it is shown in table 7 below.

Table 7 Significant difference of student's response on environmental attitude in respect to gender and to schools

	Source of Variation	SS	Df	MS	F	P-value	F crit
Gender Environmental Attitude							
	Between Groups	44.24	1.00	44.24	0.00	**0.95**	4.11
	Within Groups	398028.84	36.00	11056.36			
	Total	398073.08	37.00				
School Environmental Attitude							
	Between Groups	2019.18	1.00	2019.18	0.15	**0.70**	4.11
	Within Groups	472119.68	36.00	13114.44			
	Total	474138.87	37.00				

As seen on table 7 above, there was no significant difference found on students' response on Environmental Attitude responses when compared to gender and schools because the P-values for both were all above 0.05.

3.3 Environmental Knowledge

A total of 18 questions was asked in order to assess the level of knowledge of the students who participated in the study about the environment and their response to those question is shown in table 8 below.

Table 8 Distribution according to student's environmental knowledge

	Questions (*perfect answer*)	**Frequency**	**%**
1	Environmental issues are a danger and threat to whom? (*For all living things in the world)*	313	73.8
2	Which of the following must be disposed of into the trash? (*leftovers*)	282	66.6
3	Which of the following are from vertebrates? (*frog*)	324	76.4
4	Which is not necessary for growth of plants? (*starch*)	356	84
5	Which of the following examples show environmental problems which threaten the future of our world? (*Global warming and Acid rain*)	287	67.7
6	Which of the following air pollution is not caused by people? (*Volcanic eruption*)	290	68.4
7	Which of the following is not a natural disaster? (*Tankers and traffic accidents*)	319	75.2
8	Which of the following is not as a result of climate change, considering that all plant species in the world disappears? (*The amount of oxygen in the atmosphere increases*)	191	45
9	Which of the following event is useful for the environment? (*Rather than using a car, walk short distances)*	332	78.3

10	Indiscriminate disposal of domestic waste outside leads to? (*Contaminated air, water, and soil*)	343	80.9
11	Which of the following is a living entity? (*plants*)	334	78.8
12	What would be the result of environmental pollution? *(Clean air is reduced)*	351	82.8
13	Which of the following will occur due to an increase in the proportion of poisonous gas in the air? (*The world's climate will change and global warming will happen)*	359	84.7
14	Which of the following will occur due to uncontrolled hunting? (*Many animal generations would become extinct*)	280	65.1
15	Which of the following is a protected plant? (*Orchid*)	155	36
16	Which one of the following is the reason for the cities and industrial enterprises being built on the fertile land? (*We get more products*)	325	76.7
17	Which of the following is the camel habitat? (*desert*)	321	75.7
18	Which of the following is not a factor which destroyed the vegetation? *(Watering trees)*	295	69.6
	Average total respondents who answered correctly		**71.42**

After analyzing the data from their responses, results from average total respondents who answered correctly was 71.42%, and this showed a high level of environmental knowledge among the students.

3.4 Correlation Between Environmental Knowledge and Environmental Attitudes

In order to determine if whether there wass a correlation between environmental knowledge and environmental attitude level, we used the Pearson correlation coefficient and on comparing the individual responses scores on environmental knowledge with environmental attitude, the result displayed a strong positive correlation value of r=0.807 shown in table 9 below between the two variables, which means the higher the environmental knowledge, the positive their attitude towards issues of the environment and vice versa.

Table 9 Correlation between responses of students on environmental knowledge and environmental attitudes

	Variable	1	2
1.	Environmental Attitude	-	
2.	Environmental Knowledge	**0.807**	-

4. Discussions and Conclusion

Pro-environmental behavior, environmental attitude and environmental knowledge level of secondary school students in Abuja, Nigeria was assessed, discussions and conclusion were made in the session based on the findings of this study.

On comparing result findings with that of Haron *et al.* 2015; Ibrahim and Babayemi (2010), it is found out that there were some similarities with their findings, where environmental knowledge correlated positively with pro-environmental behavior.

This study also supports the findings from previous research made on pro-environmental behavior by Desrochers, *et al.,* (2019) where it was stated that females were more environmentally friendly than the male, this may be due to females having these traits of kindness, honesty, full of emotions and compassions more that the male, these makes them more conscious of the environment and more likely to participate in environmental sustaining behaviors than their male counterparts.

When results for pro-environmental behavioral responses from the students were compared according to the objectives of the study, it was observed that the general student's pro-environmental behavioral level was on the average, but the female students exhibited more pro-environmental behaviors more than the male students.

Meanwhile, when it is compared pro-environmental according to schools, it was observed that the students from private owned schools exhibited more environmentally friendly behaviors. The reason for this could be because in Nigeria, private schools provide better learning environment for the students with options of self-development and extra-curricular activities.

Students' environmental knowledge were high but has a room for improvement because the more the knowledge, the beneficial it is for our environments. On comparing environmental knowledge response with environmental attitudes, it was observed that the environmental knowledge response correlated with their attitude, this shows that environmental knowledge is indeed a factor that determines environmental attitude.

4.1 Recommendations

The following recommendations were made after findings and conclusions were made in regards to the deficiency found in the students' responses.

In order to promote an environmentally friendly nature among the students in Abuja, we suggested that government should invest in impacting environmental knowledge through awareness programs because the better the knowledge level, the better their attitude which helps the students to make rightful decision in the future.

Government should mandate all National TV, News Papers and Magazines to always advertise environmental related issue on their platforms because what is seen sinks better in our subconscious mind than what is heard.

Since students spend more time nowadays with their phones, information regarding the environment should be pass through social media, as this tool can help educate more students on environmental related issues.

Competitions should be set between schools in Abuja, both private and government owned regarding environmental related issues, this would help create more environmental awareness among the students.

Stakeholders should organize rallies on environmental related issues from time to time in Abuja, as this would help increase environmental consciousness among the students.

And also, environmental awareness program should always be organized in school right from the kindergarten stages, so they grow to understand what to do and what not to do concerning the environment.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

Abuja-Citiserve (2004). Estimates of Waste Generation Volumes and Income Potential in Abuja. Population Abuja (English Edition), 805:1-29.

Adedeji Daramola & Eziyi O. Ibem (2019). Urban environmental problems in Nigeria: implications for sustainable development

Adeyemi O. B., (2011). Waste Management in Contemporary Nigeria: The Abuja Example

Akinyele.I.O et al (1994) 'Poverty reduction and urban violence: the case for street food vendors in Nigeria', in Albert.O.I et al (Eds.)(1994) urban management and urban violence in africa. Ibadan: ifra vol 2.

Babayemi, J. O., & Dauda, K. T. (2009). Evaluation of solid waste generation, categories and disposal options in developing countries: A case study of Nigeria.Journal of Applied Sciences and Environmental Management, 13(3), 83–88. ISSN: 1119–8362. Retrieved fromhttp://www.ajol.info/Index.php/jasem/article/viewFile/55370/43836

Babayemi, J. O., Ogundiran M. B., and Osibanjo O., (2016). Overview of Environmental Hazards and Effects of Health Effects of Pollution in Developing Countries: a Case study of Nigeria.

Bearer C. F., (1995). Environmental Health Hazards: How Children Are Different from Adults.

Decamps H. (2000). Demanding more of Landscape Research (and researches) Landscape and Urban Planning. Environmental Pollution 47 105-109.

Desrochers J. E., Albert G., Milfont T., Kelly B., and Arnocky S. (2019). Why do Women care more about the environment than Men?

Dźwigoł H. (2018). Scientific Research Methodology in Management Sciences

Ibrahim F., M. and Babayemi F., O. (2010). Knowledge & Attitude of a Group of Nigerian Undergraduates Towards Environmentalism

Imam, A., Mohammed, B., Wilson, D.C, Cheeseman, C.R., (2008). Solid waste management in Abuja, Nigeria, Waste Management, Volume 28, Issue 2.

Navarro f., & Vincenzo T. (2019). Waste management in developing countries: A review of global issues.

Nnaji C.C. (2015). "Status of municipal solid waste generation and disposal in Nigeria", Management of Environmental Quality: An International Journal, Vol. 26 Issue 1 pp. 53 – 71.

NPC. (2012). National Population Commission Nigeria. Retrieved from www.population.gov.ng. Accessed 16th April 2012.

Obiadi, Bons N., & Onochie, A. O. (2018). Abuja, Nigeria Urban Actors, Master Plan, Development Laws and their Roles in the Design and Shaping of Abuja Federal Territory and their Urban Environments

The Nigerian National Bureau of Statistics (2019). Report on poverty and inequality.

United Nations Organization (1996). International Year for the Eradication of Poverty.

DISASTER SCIENCE AND ENGINEERING

2022, Volume 8, Number: 1
Page: 11- 18
Received: 18 January 2022
Accepted: 13 April 2022

Investigation of Maximum Power for Tracking Photovoltaic System

Fotovoltaik Sistem Takibi İçin Maksimum Gücün İncelenmesi

McDominic Chimaobi Eze[1], Lida Ebrahimi Vafaei[2]

[1]*McDominic Chimaobi Eze; Near East University;mcdominic.eze@gmail.com; 0000-0003-0688-5551;+905551475123*
[2]*Near East University; lida.ebrahimivafaei@neu.edu.tr; 0000-0004-0681-5552*

Abstract

Due to the daily increase in energy demand and the sequential lack of nonrenewable sources of energy, the whole world is looking forward to finding new substitutes. The PV systems are one of the best alternatives for supplying power to individuals and utility. In our project, for better performance and for collecting more solar radiations, we installed a PV – orientation system resulting in higher efficiency with lower losses in the PV system. This can be achieved by supplying the solar panels with sensor and motor that guarantee facing the sun during day hours. Then we will hold a comparison between the power achievements in case PV solar panels are fixed and the PV –oriented adjustable type. We will also include a general study On the design and structure of assisted equipment's that are used are used in sensing and measuring as pyrometer we also developed a MATLAB program that controls the PV panels orientation in order to collect maximum solar radiation by tracking the sun path. The results show that the PSO-based MPPT controller is simple, quick, and effective, and that it locates the maximum PowerPoint faster. Because the MPPTs shown are 93-98 percent efficient, they can produce a power boost of up to 10% to 43%.

özel

Due to the daily increase in energy demand and the sequential lack of nonrenewable sources of energy, the whole world is looking forward to finding new substitutes. The PV systems are one of the best alternatives for supplying power to individuals and utility. In our project, for better performance and for collecting more solar radiations, we installed a PV – orientation system resulting in higher efficiency with lower losses in the PV system. This can be achieved by supplying the solar panels with sensor and motor that guarantee facing the sun during day hours. Then we will hold a comparison between the power achievements in case PV solar panels are fixed and the PV –oriented adjustable type. We will also include a general study On the design and structure of assisted equipment's that are used are used in sensing and measuring as pyrometer we also developed a MATLAB program that controls the PV panels orientation in order to collect maximum solar radiation by tracking the sun path. The results show that the PSO-based MPPT controller is simple, quick, and effective, and that it locates the maximum PowerPoint faster. Because the MPPTs shown are 93-98 percent efficient, they can produce a power boost of up to 10% to 43%.

Keywords: DC/AC Power Conversion, Inverters, Photovoltaic system.

Keyword: DC/AC Güç Dönüşümü, İnvertörler, Fotovoltaik sistem.

1. Introduction

a) Brief history of PV system

Among the recent decades the whole world is looking forward to finding and developing efficient substitutes to the conventional nonrenewable sources of energy as coal, natural gas and petroleum. [1] One of the most important issues that is subjected to continuous developments and updates and grapping enormous concern and attention is the

Corresponding author: mcdominic.eze@gmail.com

photovoltaic system. The global installed capacity of solar power is more than (100GW) and that makes it the biggest renewable source of energy just after Hydro and wind power [2].

For exploitation of spaces and areas, installation of PV cells may be floor fastened integrated with farming and grazing or roof or wall fixed of a building.[3] The working value of PV is nearly negligible as there is not any gasoline used and maintenance value is low as there aren't any transferring parts a few of the gadget and sun panels life time > 30 years and inverter could also be changed simplest two times.[4] The set up cost is still relatively top however because of executive policies and recent traits there's vital price aid happens about (5-7 %) in line with year. And is also connected to the software grid depending at the software and economics that fluctuate from position to position and from one nation to every other. Connecting the PV gadget to application is most often most popular because of ease of installation where there is no wish to hooked up battery gadget as a should plus being extra economic because it reduces price of invoice by promoting further electrical energy to the electrical corporate[5].Recent tendencies and researches are in steady progress the place PV packages are not restricted to supplying energy to small constructions and appliances best however they integrated huge scale of applications as mega power stations, spacecraft, telecommunication, waft voltaic, transportation, hybrid techniques and lights roads techniques. The best possible efficient sun mobile was produced on April 2011 with (η=43.five%) using multi-junction concentrator while the absolute best potency without concentrator was produced on 2009 reached (35.eight%) using triple junction era. we will be able to see the percentage of production of Photovoltaic modules among the global.

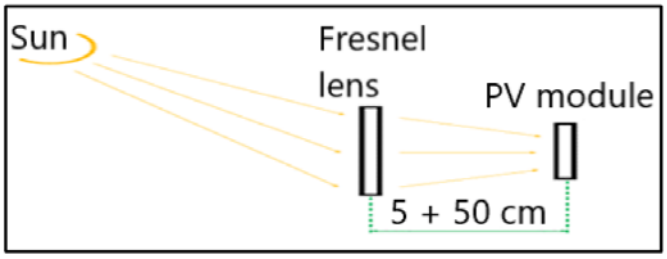


Fig. 1 Photovoltaic Cell configurations.

2. Materials and Method

2.1 Basic Components of PV system

- **PV modules/arrays:** single solar cells connected in combination to shape a module and then modules attached in combination to form a PV array.
- **Solar tracker:** for more efficient machine, solar trackers purpose to receive extra gentle on the surface through adjusting the panels to face solar rays in a perpendicular angle.
- **DC-DC converter integrated with MPPT controller:** as a way to generate a managed duty cycle to succeed in most energy tracking
- **Inverter:** Responsible for converting the produced DC current from the PV into AC so it that may be attached successfully to the application grid.
- **Rechargeable Battery:** Rarely used because of prime price but at the moment they are more and more used these batteries for power storing so as to be used at night time or feed the grid in case of additional top call for
- **Utility Meter:** measure the amount of energy intake and even the ability fed into the grid.
- **Monitoring:** for monitoring the performance of the PV device.

Tracking sun panels have the best potency of the 3 types as the panels are designed to track the solar trail in all places for day time. By the use of single axis tracker, the panels can observe the solar from east to west. [6] While the usage of double or 2 axis trackers, the sun panels can monitor the sun from east to west plus an additional axis for seasonal adjustments for the declination of the solar. [7]. although the tracking solar panels document the absolute best efficiency, the fee will have to be regarded and calculated. The tracking solar panels can give a mean increase in energy output from 20 to 30 % however this extra value can also be paid by buying 25 % extra panels of less expensive type that produce this difference in power build up[8,9]. Moreover, evaluating the mechanical disasters due to technical or environmental results, it is most popular to install adjustable mounting form of solar pane. The voltage drop across the wires will have to be additionally calculated and to be minimized as May just as conceivable whereas voltage drop decreases, energy losses decrease as well. It is recommended that the voltage drop alongside the wires don’t exceed 4

%. Generally for a house installed PV gadget, copper conductors are recommended and preferred over aluminum conductors.

- Modules and array configuration
- Specifications of the inverter
- Presence of junction box or not
- Coldest and hottest temperature
- Number and specifications of overcurrent devices
- Type of conductors used in wiring
- Distance will be extended/ traveled by wires

Conductor and wire types

- USE-2 and PV wires are preferred for outdoor wet conditions as they can resist ultraviolet12 rays and moisture
- THHN wires are preferred for indoor and dry locations
- USE and UF are preferable for underground and moisture applications
- THW,TW and THWN are used in conduits and are preferable for outdoor wet applications

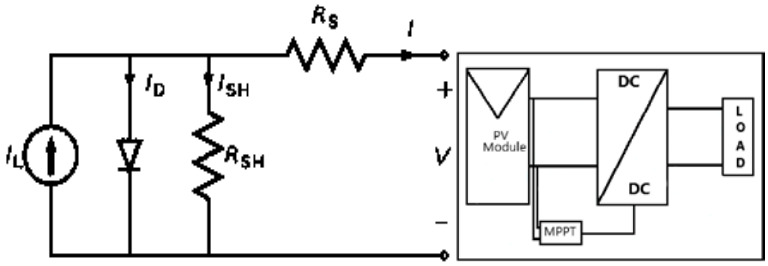


Fig. 2: Equivalent Circuit and Photovoltaic system

Current produced by solar cell

$$I = I_L - I_D - ISH \quad (1)$$

Voltage across element governed by the current through the elements

$$V_j = V + IR_s \quad (2)$$

Shockley diode equation, current directed through the diode

$$I_D = I_0\{\exp[\frac{qV}{nkT^j}] 1\} \quad (3)$$

Maximum power point tracking

$$\frac{dI}{dV} = -\frac{I}{V} \quad (4)$$

3. Tables and Figures

The maximum power efficiency is attainable if a scaling factor is used to compensate for a change in weather conditions and a periodical sweep operation during partial shading conditions. In the PSO technique, the system efficiency is higher due to the high convergence accuracy between the particle positions and zero steady-state oscillations under the PSC

3.1 Monitoring and Performance Analysis

The FDR comprises essentially of three sections: the disappointment identification framework, the disappointment profiling strategy and the impression technique. On the off chance that the observed vitality yield is fundamentally lower than the reenacted vitality yield, a disappointment is distinguished [10]. The FDR assesses the example of the vitality misfortune by making a profile of the real disappointment and contrasting it and predefined profiles of a few much of the time happening disappointments. Contingent upon the connection between the genuine disappointment profile and the predefined profiles, the FDR surveys the probability of various disappointments. The impression strategy serves for investigation of examples in reliance of three unique areas: standardized observed force, time (hour of the day), and sun rise.

PV with tracking System and without tracking System difference

Some major difference between a fixed and a tracking solar panel is the amount of electricity they produce. Solar panels generate electricity based on the amount of sunlight that strikes them. The output will be greatest if the rays are perpendicular. If you install a solar panel without a tracking system, it will not track. Only 4–5 hours a day will a significant amount of energy be generated. Let's say you have a fixed panel that can output 250 watts. In a day, 250 watts multiplied by 5 hours multiplied by 0.77 equals 962.5 watts. If you place the same panel on a solar monitoring system, it can generate energy for up to 8 hours every day. Because it follows the sun throughout the day. In a day, energy created =250wx8hx0.77 = 1540wh

There is a discrepancy of 575 watts. There is an almost 45% increase in energy production.

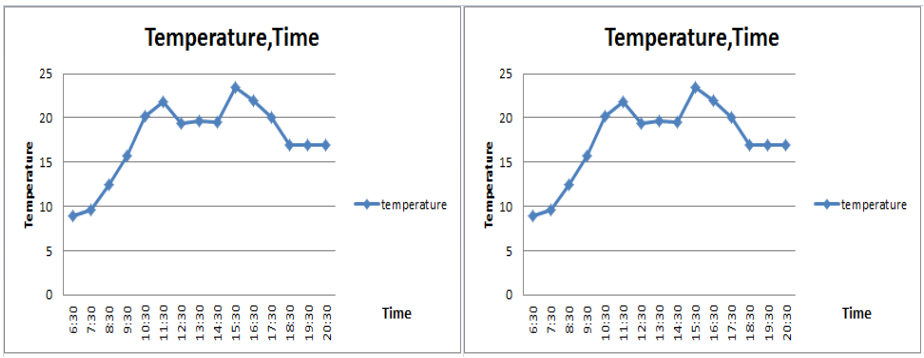
3.2 Experimental Results and Analysis

We did an experiment using pyranometer at NEU solar laboratory for couple days and we measured temperature for each hour then we choose temperature value from 6.30 until 20.30 every day and took the average for modeling and analysis as shown in the figures below: Value of air temperature at NEU University in solar laboratory indicated in the graph. Using a specific panel with panel specification with a grid tie of 60 cells, the 60 with a 20V norminal panel. With a traditional charge controller to charge a battery bank of 24V. MPPT power stations may modify the output voltages, allowing them to be employed in a battery system. For more information on the benefits of an MPPT charge controller over a PWM charge controller.

Performance at 800 W/m^2, NOCT, AM 1.5

- Nominal – 20V
- Number of cells – 60
- Open Circuit Voltage (Voc) – 38 V
- Max Power Volts (Vmp) – 28.7 V
- Short Circuit Current (Isc) – 7.96 A
- Maximum Power Point Current – 7.43 A
- Maximum Output Power – 210 W

(a) (b)



(c)

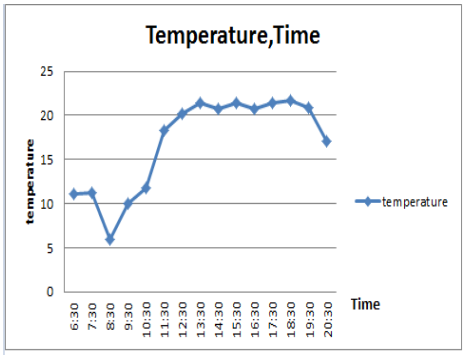


Fig. 3: Temperature variation graph for the Value of air temperature at NEU in solar laboratory (a), (b) and (c)

Radiation in Cyprus from meteorological office. Daily Radiation – Clearness Index average solar radiation in Cyprus throughout the year (kWh per square meter per day).

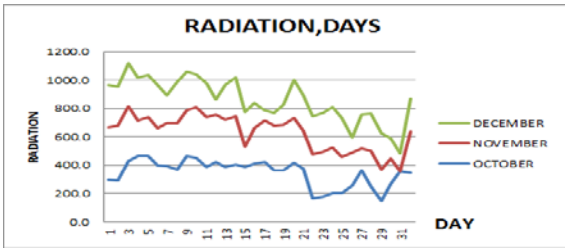


Figure 4: The radiations in Cyprus (meteorological office).

The Maximum output seems to be the photovoltaic vout high point, which is positioned at the "knee" of the curves in the graph above. The maximum wattage is achieved when the volts and amps are combined (Volts x Amps = Watts).

This is the point where the MPPT electronics tries to keep the volts and amps to maximize the power output when using a Maximum Power Point Tracking MPPT) charge controller or inverter. The Pmax is the wattage that a solar panel is listed as, where Pmax = Vmpp x Impp.

3.2 Experimental values in Cyprus without orientation with inclusive the Solar tracking and PV panels efficiency.

A mobile PV panel driven by a solar tracker is kept under the best possible insolation for all positions of the Sun, as the light falls close to the geometric normal incidence angle. Automatic solar tracking systems (using light intensity sensing) may boost consistently the conversion efficiency of a PV panel, thus in this way deriving more energy from the sun. figure (4) for an experimental average of several days. We put the panel facing the sun oriented toward south direction and slope angle of 32°, then we measured both of current and voltage by using voltmeter for each hour, starting at 6 o'clock morning until sunset at 5 o'clock and also calculate power for each hour the values obtained was represented in the graphs. Figure 5 (a) and (b) respectively.

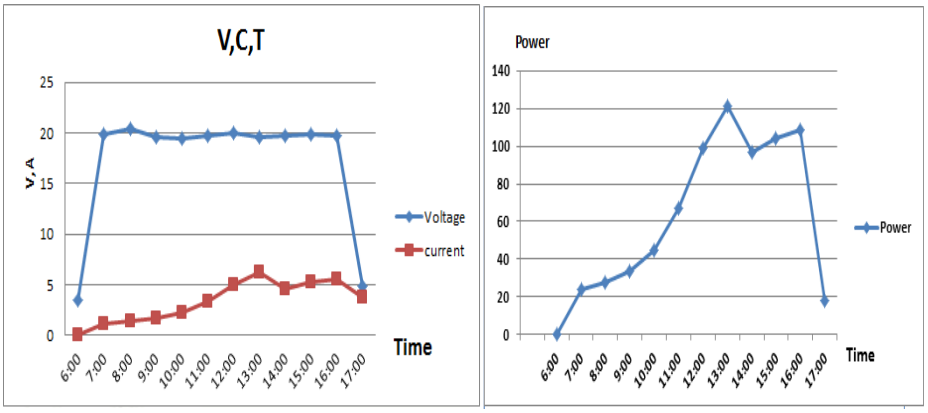


Fig. 5: Experimental values in Cyprus (voltage, current) and Experimental values in Cyprus (power). (a) & (b).

The PV Panel's P-V and I-V characteristics are shown in Figure 5. The approach was able to successfully track a peak power of 210 W, with Vmpp and Impp of 28.7 V and 7.96 A, respectively.

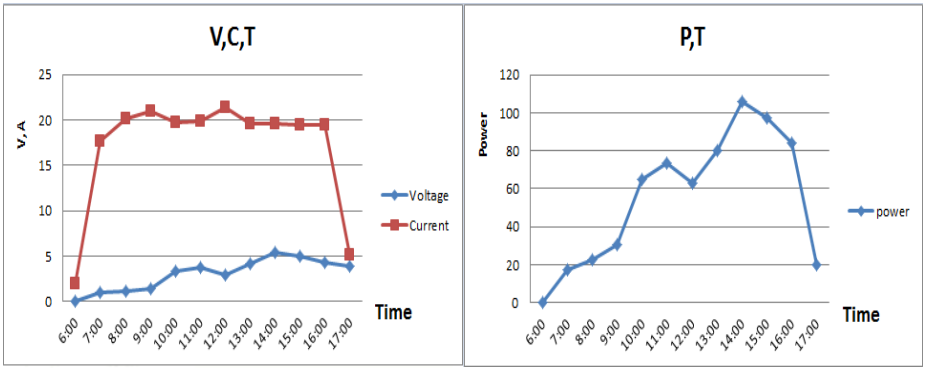


Fig. 6: Experimental values in Cyprus (voltage, current) and Experimental values in Cyprus (power). (a) & (b).

Figure 6 depicts the obtained Power Vs Iteration curve. The peak power of 210.1 W is achieved using the P&O method at this iteration, and the curve of Power Vs Iteration is obtained using the P&O method. At this iteration, the convergence is achieved, yielding a peak power of 210.4 W.

We put the panel facing the sun oriented toward south direction and slope angle of 32°, then we measured both of current and voltage by using voltmeter for each hour, starting at 6 o'clock morning until sunset at 5 o'clock and also calculate power for each hour the values obtained was represented in the graphs. Figure 6 (a) and (b) respectively. The results demonstrate result simulates the PSO-based MPPT controller is simple, rapid, and effective, and that it finds the maximum PowerPoint more quickly. The MPPTs presented are 93-98 percent efficiency and therefore can produce a power boost of up to 10% to 43%.

3.3 Implementation of MATLAB program

By adding an IC-ship, connected to the sensor that senses the maximum radiation from the sun, the motor can be rotated accordingly to achieve maximum power[11]. Though by giving the values of the geographical latitude of the exact place, the time and the date as input values to the MATLAB program as the figure 7(a) and (b), we get the following:

- **The Input Description**:

1. UTC (Coordinated Universal Time)
2. Lat (Site Latitude in degrees)
3. Lon (Site Longitude in degrees)
4. Altitude of the site above sea level (km).

- **the output will be** :

1. (Azimuth location of the sun in degrees)
2. (Elevation location of the sun in degrees)

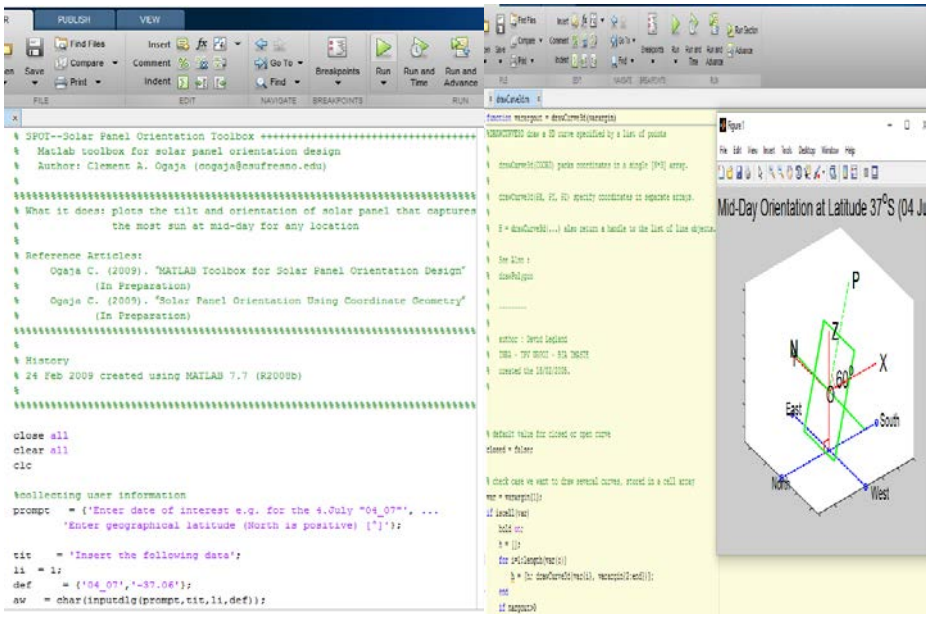


Fig. 7: Implementation of MATLAB program (a) and (b)

Based on the design configuration presented in the previous section, we executed a completely operational small scale experimental model of a single-axis solar Tracking system. With this model we were able to evaluate the specific control Components using the Techno soft Easy Motion Studio platform[12]. Starting from this Small scale equipment, we can go forward and implement the proposed technology within larger power PV systems.

4. Conclusion

The study encompasses a functional block diagram as well as detailed MPPT methods using P&O, PSO, and GA methodologies. MATLAB. was used to successfully model a solar cell. P&O, PSO, and GA techniques are used to track the greatest power point. Simulations are used to evaluate the performance of the suggested MPPT methods under various irradiation and temperature conditions. The outcomes are contrasted and analyzed. It very important to control the instabilities of the voltage to avoid transmission losses in other to avoid voltage collapse, the paper proposes a basic strategy that requires just estimations of improve conductance. The proposed MPPT calculation progressed conductance. In any case, by utilizing this MPPT technique now we have expanded productiveness through 42.5%.This technique figures the most excessive power and controls legitimately the extricated energy from the PV. The proposed technique gives various preferences which can be applicable following scalability, response is prime and neatly keep watch over for the separated force [13, 14]. According to the simulation results, a PSO-based MPPT controller is

simple, fast, efficient, and has a faster convergence rate. The MPPTs that have been discussed are approximately 92-97 percent efficient. In the winter, a power gain of 20 to 43 percent can be reached, while in the summer, a gain of 10 to 20 percent can be accomplished. Thinking about the selection within the lots, the consonant segments of PV present are expanded, which makes the operating level move away from the MPP. In this way, any other legal responsibility cycle should be chosen to maintain the following exactness, the effectiveness of a PV framework may also be stepped forward with a precise following job and fast union toward GMPP for each local weather condition. We can see the significance of this work in ceconomic-scale benefit with generation of more power amid peak demand hours.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

This research is supported by Near East University (Grant no. 0405273) and i will like ot also acknowledge for her support and patient.

References

Ateş, Greentech Media, Solar Junction CPV Efficiency Records http://landartgenerator.org/blagi/archives/127/trackback, 15 April 2011

Records Sharp Develops Solar Cell with World's Highest Conversion Efficiency of 35.8%, http://www.greentechmedia.com/articles/read/solar-junction-setting-new-cpvefficiency, 22 October 2009

Paula Mints Navigant Consulting and Paula Mints, http://phys.org/news/2009-10-sharp-solar-cell-world-highest.html Graph: PSE AG 2015", 2014.

EPIA-European Photovoltaic Industry Association-. "Global Market Outlook for Photovoltaics", 12 June 2014.

Neil Cullen, Jim Thornycroft, Alan Collinson, "Risk analysis of islanding of photovoltaic power systems", 2002

Henry Snaith, "Efficient Hybrid Solar Cells Based on Meso-Superstructured Organometal Halide Perovskites". Science338 (6107): 643–647. doi:10.1126/science.1228604.PMID 23042296, 2012.

R. Williams, "Becquerel Photovoltaic Effect in Binary Compounds". *The Journal of Chemical Physics*, 1960.

http://www.pveducation.org/pvcdrom/properties-of-sunlight/elevation-angle.

Landau, C., "Optimum Tilt of Solar Panels, MACS Lab Incorporated, Grass Valley, CA", July 18, 2012.

Fritts CE. "On a New Form of Selenium Photocell". *American J. of Science* ;26: Pp-465, 1833

D. M. Chapin, C. S. Fuller, and G. L. Pearson. "A New Silicon p-n Junction Photocell for Converting Solar Radiation into Electrical Power". *Journal of Applied Physics* 25 (5): Pp. 676–677, May 1954.

Hydro One, "Technical Interconnection Requirements for Distributed Generation", 2010.

T. Noguchi, S. Togashi, and R. Nakamoto, "Short current pulse-based Maximum-Power Point Tracking Method for Multiple Photovoltaicand-Converter Module-System", IEEE Trans on Ind. Elec., Vol. 49, 2002.

E. Solodovnik, S. Liu and R. Dougal, "Power Controller Design for Maximum Power Tracking in Solar Installations", IEEE Transactions on Power Electronics, Vol. 19, No. 5, pp.1295-1304. 2004.

DISASTER SCIENCE AND ENGINEERING

2022, Volume 8, Number: 1
Page: 19 - 25
Received: 18 January2022
Accepted: 17 June 2022

Power System Reliability Assessment Considering Impacts of Climate Change

Mohammadreza Gholami [1], Dr.Parvaneh Esmaili [2]

[1]*Near East University, Electrical Engineering Department, Lefkosa, North Cyprus m.r.gholamy@gmail.com*

[2]*Near East University, Electrical Engineering Department, Lefkosa, North Cyprus, parvaneh.esmaili@neu.edu.tr*

Abstract

Power system reliability, as one of the most significant issues in power system studies, is affected remarkably by load demand changes. On other hand, climate changes and global warming lead to increasing the electricity demand of a power system. In this paper, the impacts of global change on generation power system reliability indices have been investigated. Loss of Load Probability and Expected Energy Not Supply are considered as power system reliability indices. In addition, a Particle Swarm Optimization method is used to assess these reliability indices. IEEE_79 Reliability test system is selected as a standard test system. The results show that reliability indices are affected noticeably by temperature rising and climate change.

Keywords: Climate Change, Power System Reliability Indices, Loss of Load Probability, Expected Energy Not Supplied, Load demand, Particle Swarm Optimization

1. Introduction

Power system reliability indices are used as the most important constraints by power system planners. As it is shown in figure 1, the assessment of system reliability is applied to three main hierarchical levels, termed HLI, HLII, and, HLIII. At the first level, generation system reliability, the total system generation is investigated to determine its ability to meet the total system demand requirements. At the generation system level, the transmission lines are ignored and considered as completely reliable elements with no failure rate. At the second level, composite power system or bulk system, both generation units and transmission lines are evaluated and the transmission system elements are considered completely reliable. All three parts and elements of a power system (generation units, transmission lines, and transmission system elements) are considered in HLIII studies. The three hierarchical levels are shown in Figure1. In this paper, generation system reliability (HLI) is assessed. The reliability of a system is evaluated using the proper indices. In this paper, LOLE (Loss of Load Probability) and EENS (Expected Energy not Supplied), as the two common reliability indices, are chosen and calculated. Obviously, reliability indices are affected significantly by changes in load demand and the LDC (Load Duration Curve) pattern of a network. Power system reliability can be improved by enhancing the performance and efficiency of generation, transmission, and distribution elements, applying demand-side management methods, and improving load demand patterns. In another word, reducing power consumption leads to a more reliable system without making changes in a power system.

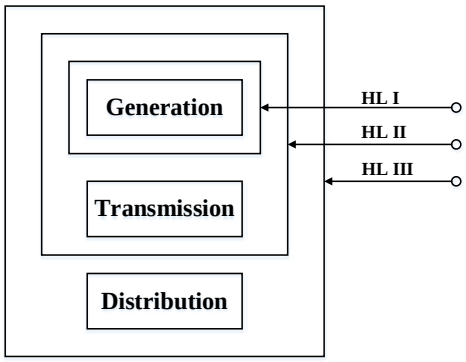


Figure 1. Power System Hierarchical Levels (HL)

On the other hand, climate changes noticeably affect the load demand of a power system [1-4]. However, the impacts of climate change are not limited to rising ambient temperature and can lead to changes in many parameters such as wind speed, humidity, and many other factors. Although all these parameters are important in power system studies, previous studies have shown that temperature has more effects on load demand compared to other variables. In many researchers, the effect of rising temperatures on load demand is investigated using different methods. To determine the relationship between temperature rising and load demand, neural networks have been used widely. Neural networks are powerful techniques and are able to solve complex relations. However, they require a huge amount of information for training and most authors prefer to use simpler methods. For this, a simpler regression approach was proposed by Linder. His method uses regression models to connect demand and temperature based on daily and monthly periods. In this paper, the impact of global warming and increasing the temperature on generation power system reliability indices due to changes in load demand is investigated using the regression method.

The probabilistic adequacy reliability assessment methods can be categorized as analytical and simulation-based methods (Monte Carlo Techniques). Due to their shortcomings, many researchers have used hybrid and meta-heuristic algorithms to calculate the power system reliability indices. In [5-11] generation and composite power system, reliability indices are assessed using the Genetic Algorithm (GA) as a search tool to sample the system states. Also, [12-18] uses other optimization methods to reduce the amount of sampled system states, computational time and achieve better coverage. By using meta-heuristic methods, not only most probable failure states and contribution of each state and system elements at a given load can easily be achieved, but also, computation time is decreased and parallel computation can be done. In this paper, a particle swarm optimization algorithm is used to calculate the generation reliability indices. The algorithm is tested on the standard reliability test system RTS-79 consists of 32 generating units.

The effects and impact of climate change on electricity demand have been analyzed in many papers. The researchers have investigated these impacts on both short-term and long-term periods. Also, the investigations show that temperature has the most effective factor among other parameters such as wind speed and humidity. Authors in [27] have used the neural network as the main method to relate the temperature and load demand. Also, in [28-29], and [2] the regression models are used instead of neural networks. In this paper, we have used the result of the reference [2] regarding the effect of rising 1 centigrade degree on peak and mean load demand on different seasons. The changes in peak load demand due to 1 centigrade degree are shown in Table I, which is applied to the load demand amount of this paper's case study (IEEE-RTS_79 Reliability test system).

Table 1. Changes in peak demand due to 1 degree of temperature rise.

Demand	Winter	Summer	Monsoon
Changes on Peak Demand %	4.2	4.6	2.8

The previous papers have proposed algorithms for assessment of reliability of power system and investigated the changes in load demand due to climate change separately. In this paper, the impact of global warming on generation reliability indices is analyzed.

The rest of the paper is classified as follow: First, the power system reliability assessment methods are described in section II. In section III, the algorithm approach is presented in which the reliability indices are calculated by the PSO (Particle Swarm Optimization) as a commonly used and powerful meta-heuristic optimization algorithm. Also, algorithm approach is presented and is described in this section. Finally, case study and the results and impacts of climate change on reliability indices are shown in section IV.

2. Power System Reliability Adequacy Assessment Methods

Generally analytical (including both discrete and continuous methods) and simulation-based (Monte Carlo Techniques) are the main two basic methods of system adequacy assessment. The main differences between these methods are related to the process of selecting system states and calculating reliability indices.

In analytical techniques, the system is represented using mathematical models and the reliability indices are calculated by solving the equations. The state space, contingency enumeration, and minimal cut set are the most commonly used analytical methods.

Simulation-based techniques, generally termed Monte Carlo Simulation (MCS) methods, solve the problems using random variables. These methods are widely used by researchers for the evaluation of power system reliability. MSC techniques are iteration based and results of all iterations are converted to a distribution function. Then the reliability indices are calculated by the achieved functions.

MCS methods are able to collect information about the both mean value and probability distribution of the reliability indices. In these methods, contingencies with higher probability are more likely to select and maybe simulated several times. Monte Carlo Simulation methods are divided into two main categories: Non-Sequential and Sequential Techniques [19-26].

In analytical methods, the system states are selected in terms of different contingency levels. This selecting process ends while a specific stop criterion is reached. The stop criteria can be a particular element outage numbers or when the probability of a selected state is less than a threshold value. Finally, indices are calculated using mathematical formulation according to the evaluation result of the selected states. Simulation-based techniques select the system states based on the random failure behavior of system elements and the states with a higher probability of occurrence are more likely to select. The stop criterion in these methods can be a specific number of simulations or other stopping rules. Finally, the reliability indices are calculated by averaging the indices obtained from each simulated state.

Both methods have their own advantageous and disadvantageous. The computational time of reliability evaluating is much less independent from the reliability level of the system. One important thing worthwhile to be considered is that in simulation-based methods, the number of selected states increases remarkably by increasing the system reliability level. Also, the outage of a component in a power system may be affected by the outage of other components and simulation methods cannot handle this in simulation process of simulation based methods. Another advantage of analytical methods is that selected states are independent of the system load curve while in simulation methods, the process should be done separately for each selected state.

On other hand, analytical methods have some shortcomings. Many simplifying assumptions are needed in using these methods while the effect of these approximations is not clearly known. Furthermore, they are proper for reliability assessment of small systems, and simulation methods have been proposed to be used in large and complex systems considering the behavior of their random components.

Because of all disadvantages mentioned above, meta-heuristic algorithms have been widely used to assess and calculate the reliability indices. They are able to calculate the reliability indices using evaluating fewer states of the system with acceptable accuracy. Also, more information of the system such as the most failure state and the most probable failure state can be determined easily using these methods. In this paper, a Particle Swarm Optimization algorithm is used to calculate the reliability indices of the test system.

3. Algorithm Approach

In this chapter, the reliability definitions and formulas are given first. Then it is described how to calculate the generation reliability indices by PSO in detail.

3.1 Reliability Definitions

Every generation unit is considered as an element and has its own Failure (μ) and Repair (λ) rate. The Force Outage Rate (FOR) parameter is determined for each generation unit based on equation 1:

$$\mathrm{FOR}_i = \frac{\lambda_i}{\lambda_i + \mu_i} \qquad (1)$$

This parameter is used to calculate the availability of a generation unit (equation 2). Also, each generation unit is considered to have two statuses: (1=on and 0=off). Then a probability value (PS) is calculated for each state of the system depending on the unit's FOR and status (equation 3).

$$\text{Availibility of unit i} = \begin{cases} \text{FOR i} & \text{if related binary is 0} \\ 1 - \text{FORi} & \text{if related binary number is 1} \end{cases} \quad (2)$$

$$\text{PS}_\text{j} = \prod_{\text{i}=1}^{\text{ng}} \text{Availibility j} \quad (3)$$

Where:

Ng= number of generation units

As mentioned above, a system state is shown by generation unit's status. The state of the system in which all units are in upstate is shown in Fig 2.

Figure 2. The sample status of the system

Capacity MW	**115**				**76**				**197**			**100**			**12**					**400**		**50**						**20**			
STATUS	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

The total generated power of a system state is calculated by equation 4. The total generated power is compared to hourly load amount. If the generated amount bigger, it is considered a successful state. Otherwise, it is considered a failure state and will be used to calculate reliability indices.

$$\text{G}_\text{i} = \sum_{\text{j}=1}^{\text{ng}} \text{g}_\text{j} * \text{b}_\text{j} \quad (4)$$

Where:

G i is the generated power of state i.
ng is the number of generation units.
g j is the capacity of unit j.
b j is a binary number equals to 1 if the unit is on and equals to 0 if the unit is off.

There are 2ng possible states for a system that are evaluated in analytical methods. The most two commonly used indices are Loss of Load Probability (LOLE) and Energy Expected Not Supplied (EENS). These indices are calculated by equations 5 -8 for the system:

$$\text{LOLE}_{\text{system}} = \sum_{\text{i}=1}^{8760} \text{LOLE}_{\text{Loadi}} \quad (5)$$

$$\text{LOLE}_{\text{Load i}} = \sum_{\text{i}=1}^{\text{k}} \text{PS}_\text{i} \quad (6)$$

$$\text{EENS}_{\text{system}} = \sum_{\text{i}=1}^{8760} \text{EENS}_{\text{Loadi}} \quad (7)$$

$$\text{EENS}_{\text{Load i}} = \sum_{\text{i}=1}^{\text{k}} \text{PS}_\text{i} * (\text{Load}_\text{i} - \text{PG}_\text{i}) \quad (8)$$

Where:

8760 is number of hours in a year (for RTS_79, 8736 hours is given in a year).
k is number of failure state at load i.
PSi= probability of sampled failure state i.
Loadi= amount of load at hour i
PGi= power generated at failure state i.

3.2 Reliability Indices Calculation Using PSO

PSO, used frequently by researchers to solve complicated problems, is used to lower the computation burden of the system reliability calculation by searching in the power system possible states and choosing the most probable one. The number of possible states of a system with n generation units is 2n, while PSO is able to search and find the most probable ones, save them and calculate the reliability indices by saved sampled states. In the PSO algorithm, the swarms are updated based on equations 9 and 10:

$$v_i(t) = v_i(t-1) + \rho_1(x_{boss} - x_{i(t)}) \quad (9)$$

$$x_i(t) = x_i(t-1) + v_i(t) \quad (10)$$

Where, xi (t) presents ith swarm, and xboss is the position of the best swarm.

So, the fitness function of the algorithm is defined as PS (probability of a system state). The first collections of states are generated randomly, but the others are selected intelligently according to the PSO operations. Each system state is shown by a swarm in PSO algorithm. The algorithm ends when it reaches the stop criteria which can be a specific number of iterations. The number of proper iterations can be determined based on the size of the problem or the number of the generation units. Finally, reliability indices can be calculated based on the information of saved states' information and the LCD (Load duration Curve). The algorithm steps are given below:

1- Save the power system reliability information (the information includes the number of generation units, each unit power output in MW, and failure and repair rate of each generation unit).
2- Select PSO parameters (including population size, Iterations, C1 and C2 parameters).
3- Save Load Duration Curve information (hourly load demand for a period of one year).
4- Randomly generate the first population consisting of swarms (each swarm represents a system state).
   - While current iteration<maximum iteration do:
5- Calculations of fitness function for each swarm
6- Swarms moving toward their best historical information and the best swarm of the current generation.
7- Evaluating the states (to evaluate states as a failure a success compared to maximum load amount).
8- Saved failure states in an array.
9- Back to item 5.
10- Calculate the LOLE and EENS as generation reliability indices.

4. Case Study and Results

In this paper, The RTS-79 is chosen as a standard reliability test system. The test system includes 32 generation units. The capacities of units are from 12 to 400 MW as smallest and largest respectively. The sum of generated capacities is 3405 MW, while the maximum load is considered 2850MW. Other necessary information such as unit sizes, number of units, forced outage rates, and hourly load demand is given. In the first step, the reliability indices of the system, based on the original load demand information and without considering the temperature rising, are calculated by both an analytical method (unit addition algorithm) and PSO as a meta-heuristic algorithm. The results are given at Table 2.

Table 2. Reliability indices of the test system without considering the temperature rising.

Reliability Index	Unit addition algorithm	PSO algorithm
LOLE	9.355	9.343
EENS	1168	1164.5

In the next step, the increases in load hourly demands are considered based on the 1-degree temperature rise in different seasons. Then the reliability indices are calculated using the PSO algorithm and compared to the original values calculated by the same algorithm. The results are shown in Table 3. Finally, the reliability indices, both LOLE and EENS, are calculated again considering 2 degrees of temperature rise. The results are given in Table 4.

Table 3. Reliability indices of the test system with considering the 1 degree temperature rising.

Reliability Index	Original Value	Considering 1 degree temperature rising
LOLE	9.343	19.9441
EENS	1164.5	2679.3

Table 4. Reliability indices of the test system with considering the 2 degree temperature rising.

Reliability Index	Original Value	Considering 2 degree temperature rising
LOLE	9.343	39.3824
EENS	1164.5	5744.8

The results show that global warming and the temperature rising have remarkably decreased the reliability of the power system. In other words, global warming causes more blackouts and energy loss in a power system. The LOLE index

(showing the number of blackout hours in a year), is increased by 10.6 and 30.03 hours in a year by increasing the 1 and 2 degrees of temperature respectively. In addition, the amount of not supplied energy has been increased 1514.8 and 4580.3 MWh in a year due to increasing the 1 and 2 degrees of temperature.

5. Conclusion and Suggested Work

In this paper, the impacts of global warming and temperature rise as one of the most important effects of climate change are investigated on the reliability of a power system. Two LOLE and EENS indices have been chosen to represent the reliability of a system. Also, and Particle Swarm Optimization was used to calculate the power system reliability indices. The standard RBTS-79 reliability test system was considered as the case study. The increase in hourly load demand was considered as the impact of global warming. The reliability indices were calculated considering the 1 and 2 degrees of temperature rise. The results show that global warming has a noticeable negative effect on system reliability by increasing the power blackout hours and not supplying energy amounts. Furthermore, an investigation of the effects of global warming on other power system factors is suggested by the authors. The effect of temperature rise on the failure rate of power system elements such as generation units and transmission lines will be considered in future works.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

1. N. X. Tung, N. Q. Dat, T. N. Thang, V. K. Solanki and N. T. N. Anh, "Analysis of temperature-sensitive on short-term electricity load forecasting," 2020 IEEE-HYDCON, 2020, pp. 1-7, doi: 10.1109/HYDCON48903.2020.9242910.
2. Parkpoom, Suchao & Harrison, Gareth. (2008). Analyzing the Impact of Climate Change on Future Electricity Demand in Thailand. Power Systems, IEEE Transactions on. 23. 1441 - 1448. 10.1109/TPWRS.2008.922254.
3. Pandey, G.P.; Shrestha, A.; Mali, B.; Singh, A.; Jha, A.K. Performance enhancement of radial distribution system via network reconfiguration: A case study of urban city in nepal. J. Renew. Energy Electr. Comput. Eng. 2021, 1, 1–11.
4. M. Victoria Gasca, M. Bueno-López, F. Ibáñez and D. Pozo, "Ambient Temperature Impact on the Aggregated Demand Response Flexibility in Microgrids," 2021 IEEE Madrid PowerTech, 2021, pp. 1-6, doi: 10.1109/PowerTech46648.2021.9494915.
5. N. Samaan and C. Singh, .Using of genetic algorithms to evaluate frequency and duration indices for generation system reliability. Presented at the Proc. 11th Intell. Syst. Appl. to Power Syst. Conf. (ISAP 2001), Budapest, Hungry, pp. 251-256, June 2001.
6. N. Samaan and C. Singh, .An improved genetic algorithm based method for reliability assessment of generation system, Presented at the Proc. 8th Int.Middle-East Power Syst. Conf. (MEPCON 2001), Cairo, Egypt, pp. 235-242, Dec. 2001
7. N. Samaan and C. Singh, .Adequacy assessment of power system generation using a modified simple genetic algorithm, IEEE Trans. Power Syst., vol. 17, pp. 974-981, Nov. 2002.
8. N. Samaan and C. Singh, .New method for composite system annualized reliability indices based on genetic algorithms, Presented at the Proc. IEEE PES Summer Meeting, Chicago,pp. 850-855, July 2002.
9. N. Samaan and C. Singh, .Using genetic algorithms for composite system reliability indices considering chronological load curves, Presented at the Proc. 12th Intell. Syst. Appl. to Power Syst. Conf. (ISAP 2003), Lemnos, Greece, Aug.2003.
10. N. Samaan and C. Singh, .Genetic algorithms approach for the evaluation of composite generation-transmission systems reliability worth, Presented at the Proc. of IEEE PES Transm. And Dist. Conference, Dallas, Sep. 2003.
11. A N. Samaan and C. Singh, .Genetic algorithms approach for the assessment of composite power system reliability considering multi-state components, presented at the Proc. of Int. Conf. on Probability Methods Applied to Power Systems (PMAPS 2004), Ames, Iowa, Sept. 2004.
12. Ii RCG, Member S, Wang L, Alam M. Intelligent State Space Pruning Using Multi- Objective PSO for Reliability Analysis of Composite Power Systems: Observations, Analyses, and Impacts, in IEEE Conference, pp. 1–8; 2011.
13. Benidris M, Elsaiah S, Mitra J. Power system reliability evaluation using a state space classification technique and particle swarm optimisation search method. IET Gener Transm Distrib 2015;9(14):1865–73.
14. Ii RCG, Member S, Wang L, Alam M. State Space Pruning for Reliability Evaluation Using Binary Particle Swarm Optimization, in IEEE PES power System Conference and Exposition, pp. 1–7; 2011.
15. Benidris M, Member S, Mitra J, Member S. Composite Power System Reliability Assessment Using Maximum Capacity Flow and Directed Binary Particle Swarm Optimization, in North American Power Symposium, pp. 1–6; 2013.
16. Mohamadreza Gholami, Reza Sharifi, Hamid Radmanesh, “Development of Composite Power System Effective Load Duration Curves by Using a New Optimization Method for Assessment Composite Generation and Transmission

Reliability", International Journal of Power and Energy Research, Vol. 1, No. 1, April 2017 https://dx.doi.org/10.22606/ijper.2017.11004

17. Gholami, Mohammadreza, HOSEINI, SEIED HADI, MOHAMAD TAHERI, MEISAM, "Assessment of Power Composite System Annualized Reliability Indices Based on Improved Particle Swarm Optimization and Comparative Study between the Behaviour of GA and PSO", 2nd IEEE International Conference on Power and Energy (PECon 08), December 1-3, 2008, Johor Baharu, Malaysia
18. R Billinton and A. Sankarakrishnan, .A comparison of Monte Carlo simulation techniques for composite power system reliability assessment, Presented at the Proc. IEEE Comm., Power and Comp. Conf. (WESCANEX 95), Winnipeg, Canada, vol. 1, pp. 145-150, May 1995.
19. L.W.R. Billinton, Reliability Assessment of Electric power systems using Monte Carlo Methods.pdf., 1994.
20. Melo ACG, Silva AML. "A conditional probabiuty approach to the calculation of frequency and duration indices in composite reuabilily evaluation", IEEE Trans Power Syst 1993;8(3):1118–25.
21. Pereira MVF, Balu NJ, Objectives A, System P. Composite Generation /Transmission Reliability Evaluation. Proc IEEE 1992;80(4):470–91.
22. Bhuiyan RNAMR, "Modelling multistate problems in sequential simulation of power system reliability studies". IEEE Proceed Gener Transm Distrib 1995;142(4):343–9.
23. Billinton R, Sankarakrishnan A. Effective techniques for reliability Worth assessment in composite power system networks using Monte Carlo simulation. IEEE Trans Power Syst 1996;11(3):1255–61.
24. Billinton RGR, Chen H, "A Sequential Simulation Technique for Adequacy Evaluation of Generating Systems Including Wind Energy". IEEE Trans Energy Convers 1996;11(4):728–34.
25. Jayatheertha HJ, "Evaluation of composite electric system performance indices using sequential Monte Carlo simulation". Int J Adv Eng Res Stud 2012;vol. EISSN2249: 4–7.
26. Mello JCO, da Silva AML, Pereira MVF. Efficient loss-of-load cost evaluation by combined pseudo-sequential and state transition simulation [in]. IEEE Proc Gener, Transm Distrib 1997;144(2):147–54.
27. X. Li and D.J. Sailor, "Electricity use sensitivity to climate and climate change", Energy Planning and Policy, vol. 7, no. 3, pp. 334-346, 1995.
28. K. P. Linder, "National impacts of climate change on electric utilities", in: The Potential Effects of Global Warming on the United States, J. B. Smith and D. A. Tirpak, Eds., Washington, D.C.: Environmental Protection Agency, 1990.
29. C.-L. Hor, S. J. Watson and S. Majithia, "Analyzing the impact of weather variables on monthly electricity demand", IEEE Trans. Power Syst., vol. 20, no. 4, 2078 – 2085, Nov. 2005.

DISASTER SCIENCE AND ENGINEERING

2022, Volume 8, Number: 1
Page: 26 - 35
Received: 19 January 2022
Accepted: 07 Aprile 2022

Numerical simulation of Earthen Dams failure due to Overtopping (Case study: SILVEH Earthen Dam)

Yaghma Shahanaghi[1*], Zinet Selmin Burak[2]

[1]Institute of Marine Sciences and Management, Istanbul University, Vefa, Fatih, Istanbul, Turkey; Y.shahanagi@gmail.com; https://orcid.org/0000-0002-4922-1643; +905550839380 .
[2]Institute of Marine Sciences and Management, Istanbul University, Vefa, Fatih, Istanbul, Turkey; sburak@istanbul.edu.tr; https://orcid.org/0000-0003-0780-0687.

Abstract

Dams break due to an earthquake, bombing, piping, overtopping, or some lack in design and construction process is unavoidable, which could lead to loss of life and property downstream of the dam. This study aims to understand of SILVEH dam break, under the scenario that considers the dam failure, due to overtopping and to prepare a hydrograph and flood zone downstream due to the failure of the SILVEH dam. In this research, obtaining and recognizing high-risk areas downstream of SILVEH Dam, due to dam break is another important goal. NAYS 2D FLOOD software has been used to simulate the failure of the SILVEH dam. SILVEH dam is an earthen dam, located in PIRANSHAHR city, in the West Azerbaijan Province. In the northern part of the study, immediately after the broken axis, the main flood flow dam in the valley is not very deep in the LAVIN River and due to the relatively steep slope, the water depth is not high and rarely rises from the river valley, but in the southern parts and reaching smoother areas are increases in the depth of flow. The maximum flood velocity is estimated at 20 meters per second and the lowest flood flow velocity is estimated at 2 meters per second. MAHABAD-PIRANSHAHR road and power transmission lines and bridges in the mentioned road will suffer the most damage from water floods due to the possibility of breaking the SILVEH dam.

Keywords: Dam failure, Flood mapping, Overtopping, Earthen dam, NAYS 2D FLOOD**.**

1. Introduction

A dam is a structure that is built to create a reservoir to store excess water in wet seasons, control devastating floods, supply drinking water and water needed for agriculture, electricity generation, and other things and has many benefits for human society. But the failure of the dam leads to the release of a large volume of water, which causes huge flood waves downstream of the dam and can cause a lot of human and financial losses (Hassanzadeh *et al.,* 2015). Risk and estimation of damages due to the possible failure of dams have long been considered and studied by researchers (Mohammadnejad *et al.,* 2014). Dam failure due to overtopping is one of the most common failure modes. Thirty percent of dam failures in the United States over the past 75 years have been caused by overtopping. Dam failure analysis is often performed with the two main objectives of determining the output hydrograph of the reservoir and the flow rate of this hydrograph along the downstream route (Wahl, 1998). developed an implicit one-dimensional model to solve the problem of dam failure in dry and wet beds and showed that the results of the numerical model are in good agreement with the available laboratory data (Zhang *et al.*, 1992). Roshandel et al (2010), using the limited volume method simulated the failure of a dam on a dry and wet bed by solving shallow water equations and used a natural solvent to solve the Riemann problem (Roshandel *et al.,* 2016). Jia et al (2010), simulated a massive 2008

[*] Corresponding author: Y.shahanagi@gmail.com

Mississippi River flood using a limited German-based numerical model. Gradual failure of submerged areas was considered in this model and the simulation results were validated using satellite images (Jia *et al.*, 2016). A two-dimensional model based on the solution of shallow-up equations to simulate the currents caused by dam failure was presented and the numerical results with the results of the experimental model were validated (Singh *et al.*, 2011). The failure of the Aparan Dam located in Armenia with a failure time of 10 hours and a gap width of 5 and 50 meters according to the characteristics of the river and the dam body, in HEC-RAS software was simulated (Ludvig, 2011). The simulation results showed that the maximum output flow will be 625 and 4350 meters per second, respectively. The maximum Q is reduced to 614 and 4280 meters per second 28 km downstream of the dam. The water velocity for Scenario 2 was approximately 10 m/s and 10 km with a moderate slope and 16 to 18 m/s at 10 to 20 km downstream with a steep slope. After the necessary hydraulic calculations, they also presented flood zonation maps at the bottom of the dam (Bjerke, 2011). The Muyu reservoir iodine failure in China in two basic steps was studied. In the first step, the main reasons for the destruction of the dam were investigated. In the second step, the numerical analysis of the dam failure is investigated and the effect of parameters such as water level behind the dam, inlet flow to the reservoir, and the presence or absence of embankment downstream on the dam failure and flood zoning is evaluated (Changzhi *et al.*, 2014). An approach based on a combination of hydraulic modeling and GIS to assess the risks of possible failure of the Zardras concrete dam in northeastern Algeria was employed. To extract geometric information, they used GeoRAS-HEC in a GIS environment. Flow simulation of dam failure was performed using HEC-RAS and then the results were zoned using GIS software. Finally, a flood risk map was created based on the water depth and flow velocity map in the GIS environment. According to this plan, a large number of people will be affected by the failure of the Zardzas dam. This study also showed that the use of GIS techniques in combination with hydraulic modeling can play a significant role in improving flood management (Derdous *et al.*, 2015). Flood zoning due to the failure of India's Nirasagar Dam using ArcGIS software was utilized. To do this, they created the river features and other geometric characteristics of the reservoir and basin in HEC-GeoRAS software and then transferred them to HEC-RAS software for hydraulic modeling. Finally, the results were displayed in Google Earth to identify the flood zone (Hajeri *et al.*, 2016). Considering the importance of the dam failure phenomenon and choosing the appropriate method for its analysis, as well as preparing an emergency action plan to evacuate the affected people downstream and minimize potential losses, review, and compare studies have been paid in this regard (Kumar *et al.*, 2017).

2. Materials and Methods

2.1 Location and general objectives of SILVEH Dam

The project area is located in northwestern Iran, in the province of West Azerbaijan, and the city of PIRANSHAHR. SILVEH Reservoir Dam to supply safe drinking water to PIRANSHAHR city with an annual amount of 18 million cubic meters, agricultural water supply to 5700 hectares of lands downstream of the dam (PIRANSHAHR plain), agricultural water supply to 3950 hectares of JALDIAN plain lands (through tunnel and transmission canal JALDIAN water located inside the reservoir), electricity supply of the region at the rate of 18 GWh per year, as well as fish farming, tourist attractions, tourism, control and regulation of flood flows will be constructed. This dam is located on LAVIN Chay River from the tributaries of Zab river in the north of Kelas catchment and in the south of West Azerbaijan province, about 12 km northwest of PIRANSHAHR city and 150 km southwest of Urmia city in a range of longitude+45 to 110 0 45 east and latitude 510 0 36 to 6 656 36 North (see Fig. 1)

Figure 1. Overview of Silveh Dam.

2.2 General specifications of the design

Dam location	12 km from PIRANSHAHR - 2.5 km from SILVEH village
The name of the river	LAVIN (the main source of the Class River)
The average annual yield of the river	220.7 mcm
Reservoir volume at the normal level	84 mcm
Reservoir level at the normal level	655.8 ha
Adjustable water volume	203.5 mcm/year
Water required by the environment	23.8 mcm
Type of dam	Soil with clay core

2.3 Software Presentation

Nays 2D Flood is a flood flow analysis solver that relies on unsteady 2-dimensional plane flow simulation using boundary-fitted coordinates[1] as the general curvilinear coordinates. This solver adopts the 2-dimensional plane flow simulation of the Nays2D Solver developed by Professor Yasuyuki Shimizu of Hokkaido University for flood flow analysis. The data needed for an overflow calculation by Nays 2D Flood are topographic data and data of inflow discharge and roughness of each river or each inflow point.

2.4 Numerical simulation

The first step in analyzing the failure of SILVEH Dam is to investigate how to create and expand the gap in the dam body and, consequently, to determine the hydrograph of the output of the dam site at the time of dam failure. In fact, this hydrograph is the output of the gap created in the body of the dam, which needs to be routed downstream of the dam to analyze the threat of downstream areas. Among the main causes of cracks and fractures in earthen dams, overflow from the dam (Overtopping) is of great importance. The flow overflow scenario is called the Stormy day scenario. In the present scenario, it is assumed that the water level in the first is at the maximum value and the Q flow to the reservoir of the PMF dam. In this research, NAYS 2D FLOOD software has been used to simulate the failure of the SILVEH dam.

[1] Boundary-fitted coordinates are set along the boundaries because a rectangular Cartesian coordinate system has difficulty reproducing complicated, winding boundaries. The governing equations in the rectangular Cartesian coordinate system are mapped to the general curvilinear coordinate system and are calculated. Because of its features, the system is also called a boundary-fitted coordinate system.

2.5 Flood zoning due to failure of SILVEH dam

Due to the type of flood hydrograph - due to the sudden change in flow rate and depth during floods due to the failure of the dam, flow analysis is only possible with dynamic analysis of non-continuous flow. In this research, a 2D non-continuous flow model is used for modeling. Arc GIS software has been used to zone the flood downstream of the dam fracture section. This software is one of the most widely used software in the GIS environment, which can be used to connect descriptive information with spatial information (Hassanzadeh *et al.*, 2015). Figure (2) shows the digital model of the study area. The following coefficient is of great importance as a parameter of current resistance. The main channel is considered in the numerical model with an average roughness coefficient of 0.035. The flood plain is also modeled with the following coefficient of about 0.05. It should be noted that residential areas are also modeled with a high sub-coefficient.

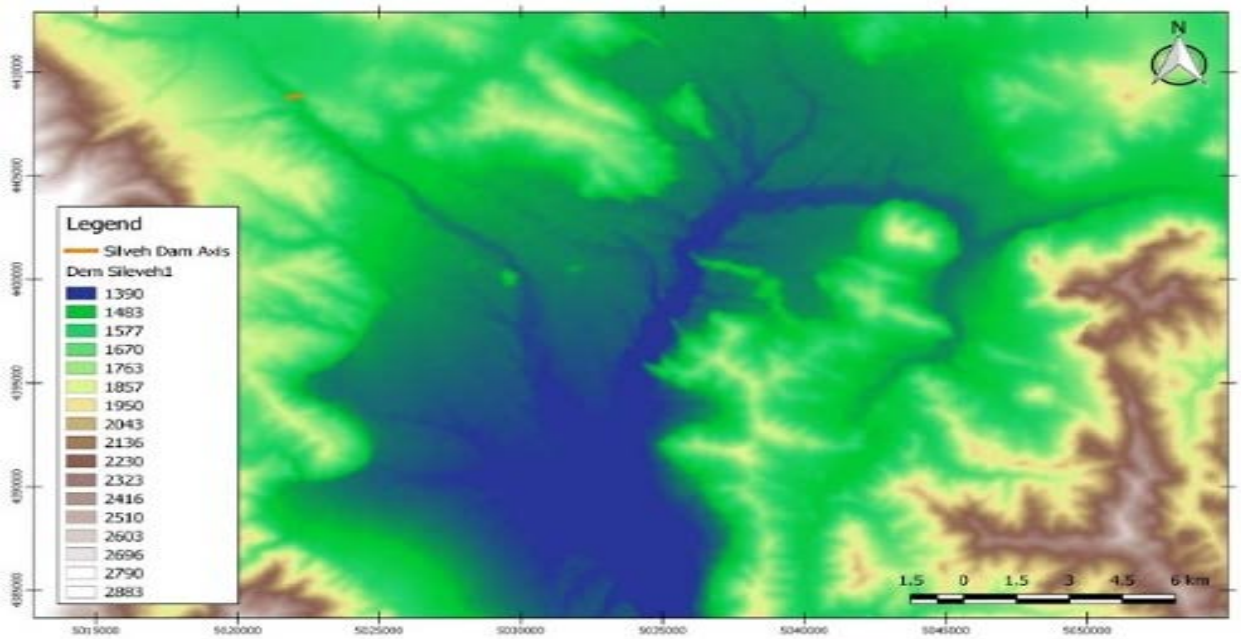


Figure 2. Digital model of the study area.

To solve the equations governing the solution field, the study area is broken into smaller networks and the equations are solved in these elements. Due to the features of the Nays Flood numerical model, regular rectangular grids have been used. This type of meshing causes a rapid solution of the flow field and achieves good results. The elements used in this study had a length and width of approximately 15 meters, which is suitable for solving the field due to the very wide area of the study area. The following figure shows the network range and boundaries of the numerical model. The flood entrance border is located on the axis of the SILVEH dam. This boundary is used as the inlet boundary and failure hydrographs are defined to this boundary. Side borders are considered wall borders. These boundaries are determined by the initial and outline simulations, and it is ensured that in the original flood simulations these boundaries will not be reached. The output boundary is also considered the Output boundary and the current will flow out of this boundary (see Fig. 3).

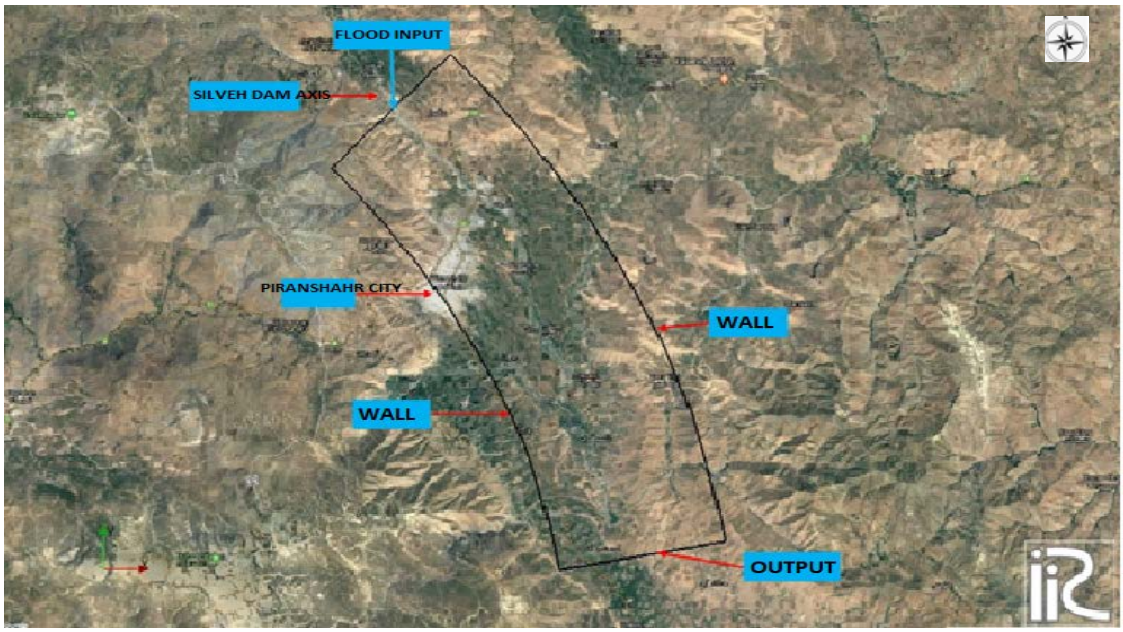


Figure 3. Boundary condition and simulation range.

3. Results

Assessing the risk of failure of SILVEH dam on downstream areas due to flood failure due to high velocity in both longitudinal and wide directions reduces the time and thus increases financial and human losses compared to natural floods. Research shows that the rate of casualties in the area after the dam failure if there are 90 minutes of flood warning time is about 20%, while with the reduction of warning time to 15 minutes, the rate of casualties to 50% increase. According to different scenarios of dam failure, danger zones are classified according to the time between the moment of dam failure and the arrival of the resulting wave (in other words, the scheduled time). Table 1 presents three different risk areas.

Table 1 Danger zones according to escape time

Area	**Description**	**Escape time, t (minute)**
1	Very high risk	t <30 -
2	ordinary	30<t<120 -
3	low risk	t>120

Flow velocity plays a major role in flood damage. However, so far, no precise relationships have been found to predict the effect of flow velocity on flood damage and risk. To deal with this problem, risk mapping has been used in various ways, usually using the risk matrix. These include Two Policies (2000), Adrianz (2001), Ross (2003), Faturley et al. (2003), Verotenolder et al. (2003), and Huang et al. (2004) (Huang, 2005).

A factor called the damage parameter was obtained (Harrison, 1864), which is defined as VD in terms of m^2/s, by examining the flood resulting from the failure of the Dal Dike Dam; In this parameter, V is the velocity in m/s and D is the depth in (m) (Roos, 2003).

In the Queensland Reconstruct on Authority project, the following table was prepared by examining at least 5 different sources to present the flood risk classification, and based on this table, 2 were drawn.

Table 2 Flood Risk Rating (Queensland Flood Assist, 2011)

	Low	**Significant**	**Much**	**More than**
Depth (D)	<0.5	<2	<2	>2
Velocity (V)	<1.5	<2	<2	>2
D × V	<0.6	0.8 to 0.6	1.2 to 0.8	>1.2

3.1 Overtopping scenario

In the overtopping scenario, due to the washing of the surface of the earth dam body and the continued passage of water over the body, it destroys the shell and finally the failure of the dam. Due to the maximum depth of flood zoning, in the northern part of the study area and immediately after the broken axis of the main dam, the flood flow in the valley is not very deep in the LAVIN river and due to the relatively high slope, the water depth is not high and rarely rises from the river valley, but in the southern parts and reaching smoother areas, the depth increases and the maximum depth is near the village. Soghanlu is seen. In this region, the velocity parameter has the highest limit due to the high initial velocity of the flow resulting from the failure of the dam and the relatively high slope of the path and the straight path of the flow velocity in this part bypassing the northern region and reducing the flow energy. Also, the flow velocity is minimized by crossing various obstacles and reaching lower areas. The important villages and areas at risk of flooding are as follows.

Table 3 Coordinates of the studied villages

Row	**Village name**	**y**	**x**	**Row**	**Village name**	**y**	**x**
1	ROZGARI	514256	4066093	3	Gelepsin	517023	4061811
2	DRABKE	515651	4065335	4	LAVIN and ZIDAN	517867	4058185

The time of flood reaching ROZGARI village and DRABKE village in the overtopping scenario is about 22 minutes and 28 minutes, respectively. In this regard, the area of these villages is in a very high-risk area due to the time of escape and the villagers do not have much chance to escape to safe areas. The flood flow caused by breaking the dam in ROZGARI village, the valley part of the village is exposed to flood waves with a height of more than 12 meters and a velocity of more than 20 meters per second. It seems that all the structures in this part, as well as the road bridge PIRANSHAHR to MAHABAD, should be destroyed and in the higher part of the stream and the velocity of the flood resulting from breaking the dam in the village of ROZGARI, the depth of the flood will reach 2 meters and the velocity of the flood will reach 2 meters per second, which seems to be damaging. This is especially true in the financial sector, while in the village of DRABKE, the valley part of the village is exposed to flood waves of more than 14 meters high and velocity more than 15 meters per second. All structures in this area should be completely destroyed. Velocity and depth contours in Zargari village as well as flood zoning can be seen for example below (see Fig. 4).

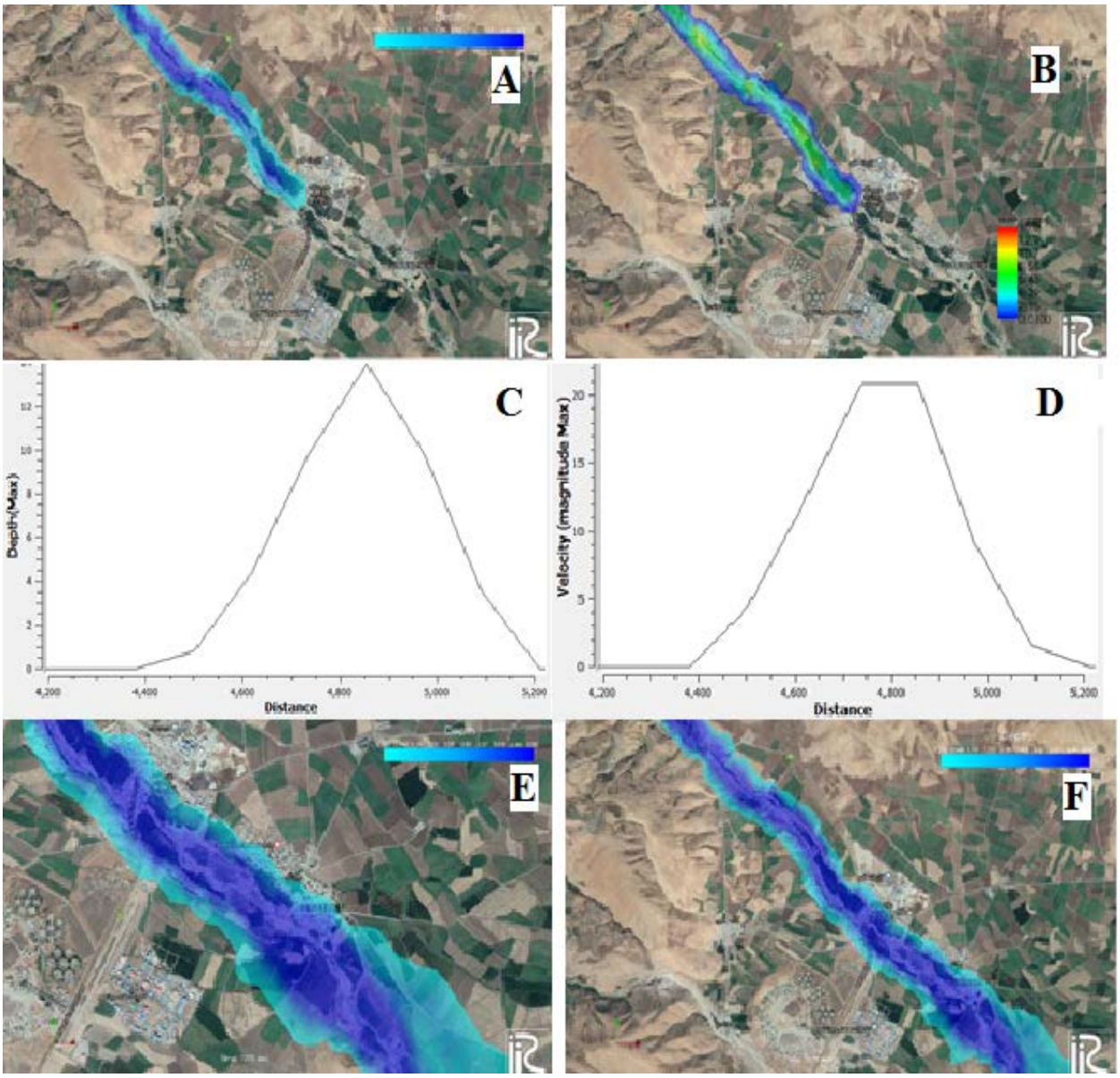


Figure 4. The depth and velocity counters and output graphs of the software. Contour depth flow when reaching the ROZGARI village (A). Flow rate contour when reaching the velocity of ROZGARI village (B). Graph of maximum depth occurred in the section of Rozgari village (C). Graph of the maximum velocity occurred at the intersection of ROZGARI village (D). The contour of the maximum flood zone in the area of DRABKE village (E). The contour of the maximum flood zone in the area of ROZGARI village (F).

In the passing scenario, the time for the flood to reach GALAPSIN village is about 37 minutes. In this respect, the village is within normal limits due to the time and the villagers have a moderate chance to escape to safe areas. In GALAPSIN village, the water level at the time of reaching the village is about 13 meters and the flow velocity currently is 11 meters per second. According to Table 2, GALAPSIN village risk criteria for flood risk is excessive. In Figure 5, flood zoning can be seen in GALAPSIN village.

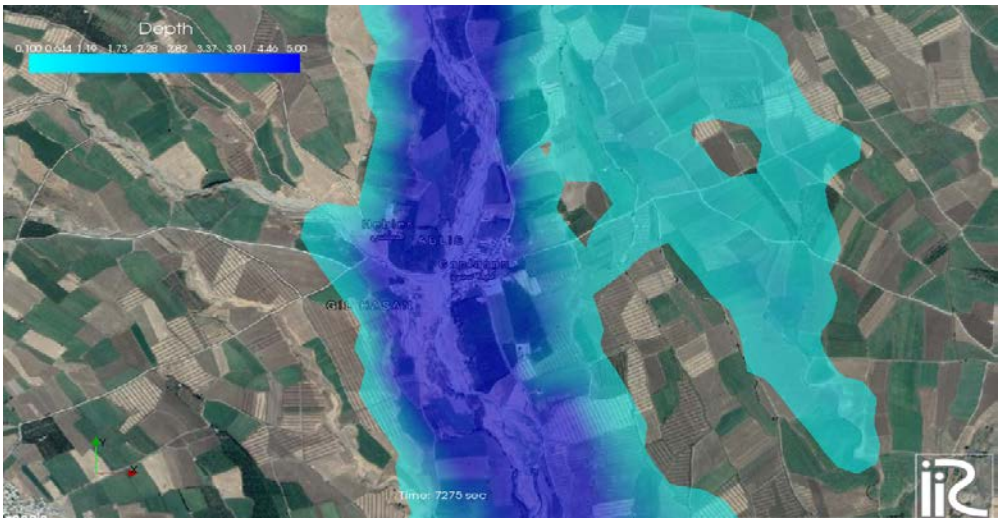


Figure 5. The contour of the maximum flood zone in GALAPSIN village

The flooding time to LAVIN and ZIDAN villages is about 48 minutes. In this regard, the village is within normal limits according to the time and the villagers have a chance to be in safe areas. In LAVIN and ZIDAN villages, the water level is about 5 meters when it reaches the village, and the flow velocity currently is 8 meters per second. According to Table 2, the paternal risk criteria of LAVIN and ZIDAN villages are too high. Figure 6 shows the depth and velocity counters and output graphs of the software.

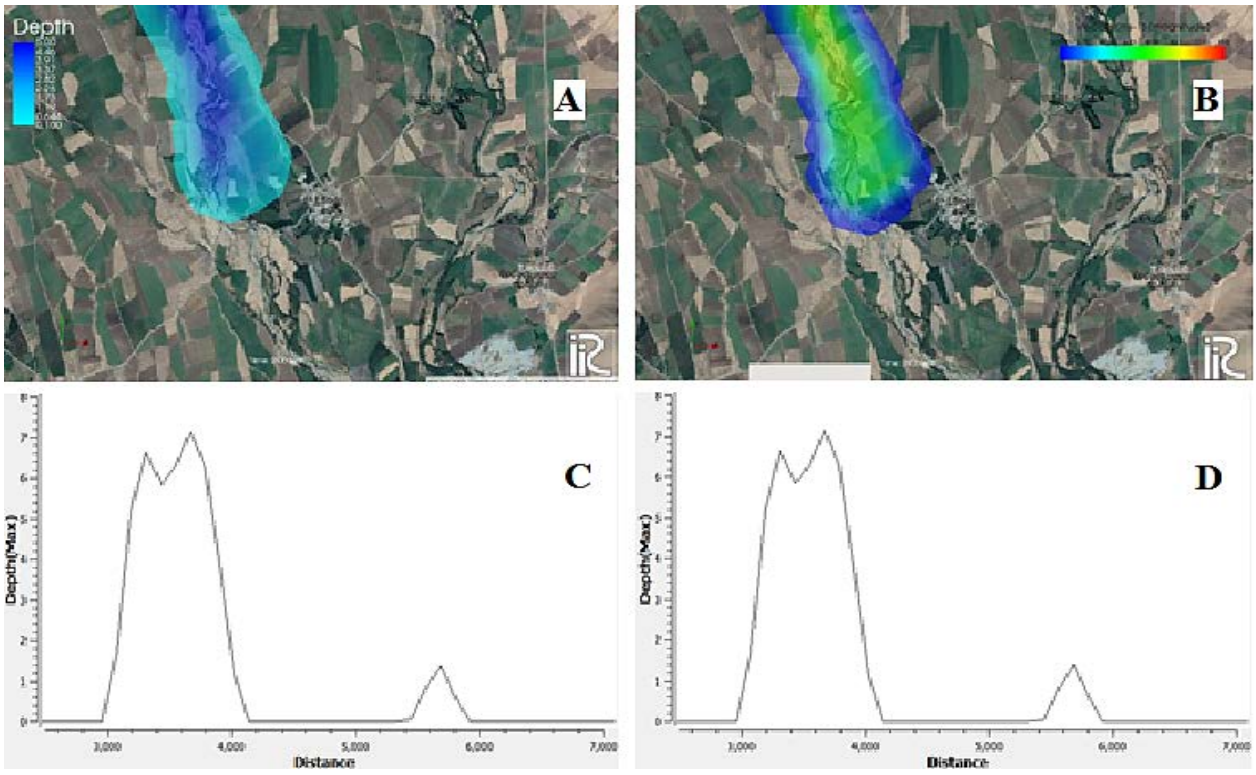


Figure 6. The depth and velocity counters and output graphs of the software. Contour depth flow when reaching the LAVIN and ZIDAN villages (A). Flow rate contour when reaching the velocity of LAVIN and ZIDAN villages (B). Graph of maximum depth occurred in the section of LAVIN and ZIDAN villages (C). Graph of the maximum velocity occurred at the intersection of LAVIN and ZIDAN village (D).

Conclusion

In the northern part of the study area and immediately after the axis is broken. In the southern parts and reaching smoother areas, the depth of flow increases.

The villages of ROZGARI and DRABKE are in a very high-risk area with less than 30 minutes in terms of time, and the rest of the studied villages are in the normal range in terms of escape time or escape time between 30 to 120 minutes.

The maximum depth of flood is estimated at 14 meters and the minimum depth at 1 meter. The maximum flood velocity is estimated at 20 meters per second and the minimum flood velocity is estimated at 3 meters per second.

In terms of flood risk criteria, most of the surveyed areas and villages are in very high-risk areas.

MAHABAD PIRANSHAHR road and power transmission lines and bridges in the said road will suffer the most damage from water floods due to the possibility of breaking the SILVEH dam.

References

Bjerke, Ludvig P. *Dam Break Analysis for Aparan Reservoir, Armenia.* Norwegian Water Resources and Energy Directorate. (2011) Oslo, Norway.

Changzhi, Li, Wang Hong, Chi Zhixue, Yang Yongfeng, Rao Zhengfu, and Cope Mike. "Dam break flood risk assessment for Laiyang City." *Journal of Geological Resource and Engineering* 4 (2014): 189-199. DOI:10.17265/2328-2193/2014.04.001

Derdous, Oussama, Lakhdar Djemili, H. Bouchened, and Salah Eddine Tachi. "A GIS based approach for the prediction of the dam break flood hazard–A case study of Zardezas reservoir “Skikda, Algeria”." *Journal of Water and Land Development* 27 (2015): 15-20. DOI: 10.1515/jwld-2015-0020

Hajeri, Sujaykumar S., A. V. Shivapur, and B. Venkatesh. "FLood plain mapping and dam break analysis for Neerasagar reservoir." *International Research Journal of Engineering and Technology* 3, no. 6 (2016): 1279-1285. e-ISSN: 2395-0056

Hassanzadeh, Nourani, Sepehri, Dalafroozeh, Hassanzadeh M and Almaspour. "Wave analysis due to dam failure and flood plain zoning using a mathematical model (Case study: Venyar Dam) " *Journal of Water and Soil* 25, no 1 (2015):1-1.

Huang, Yan. *Appropriate modeling for integrated flood risk assessment*. The Netherlands: University of Twente, 2005. ISBN 90-365-2251-X

Jia, Yafei, Azad Hossain, and Xiaobo Chao. "Computational Modeling of Midwest Flood 2008: Levee Breaching and Flood Propagation." In *World Environmental and Water Resources Congress 2010: Challenges of Change*, pp. 1298-1303. 2010.

Kumar, Sunil, Anil Jaswal, Ashish Pandey, and Nayan Sharma. "Literature review of dam break studies and inundation mapping using hydraulic models and GIS." *International Research Journal of Engineering and Technology* 4, no. 5 (2017): 55-61. e-ISSN: 2395 -0056

Mohammadnejad, B.a.d.a, Ma Fatemi Kia, J, Behmanesh, M. Montaseri. "Numerical Simulation of Wave Emission Due to Dam Failure in Two-Dimensional Vertical." *Journal of Civil and Environmental Engineering* 3, no. 24 (2014): 59-47.

Queensland Flood Assist, Planning for stronger more resilient floodplains, Part 2: Measures to support floodplain management in future planning schemes.ISBN: 978-0-9873118-4-9, (2011).

Roos, I.W. "Damage to buildings. Intermediary report." Delf cluster publication, 2003.

Roshandel, A., and N. Hedayat. "Simulation of dam break using finite volume method." *International Journal of Structural and Construction Engineering* 4, no. 11 (2010): 1406-1409. DOI: 10.5281/zenodo.1330701

Singh, Jaswant, Mustafa S. Altinakar, and Yan Ding. "Two-dimensional numerical modeling of dam-break flows over natural terrain using a central explicit scheme." *Advances in Water Resources* 34, no. 10 (2011): 1366-1375. DOI: 10.1016/j.advwatres.2011.07.007

U.S. Department of the Interior Bureau of Reclamation, Flood overtopping failure of dams, managing water in the west, (2017).

Wahl, Tony L. "Prediction of embankment dam breach parameters." *US Department of the Interior Bureau of Reclamation Dam Safety Office* (1998).

Zhang, Hou, Hassanzadeh Youssef, Nguyen Duc Long, and René Kahawita. "A 1-D numerical model applied to dam-break flows on dry beds." *Journal of Hydraulic research* 30, no. 2 (1992): 211-224. DOI: 10.1080/00221689209498935