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Water Shortage Analysis based on Reservoir Surfaces with varying Population and Rainfall for 2011-20 at Egra in Purba Medinipur

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Abstract: Egra is one of the blocks of Purba Medinipur in West Bengal. The northing and easting of Egra are 21.9°N and 87.53°E respectively. The total number of reservoirs is a hundred (100) as of the year 2020. Reservoir water is utilized for irrigation and industrial purpose.

According to Census report 2011, it has been observed that the total population in Egra was 345,926 and the growth of population in Egra is 2.25% p.a. In Egra the population density is more than that of West Bengal. This is enhanced many more times in the last decade i.e from 2011 to 2020.

In 2011 the total perimeter of the reservoir was 18630.00m with an area of 145513.00 m^2. But in 2020 total perimeter of reservoirs was 13752.40 m with an area of 115255.40 m^2. So the water content has been reduced in reservoirs of Egra location in Purba Medinipur.

Now increases in population, irrigation and industrialization have been taken place in the Egra manifold. So the withdrawing of water from the reservoirs of Egra has been taken place in indiscriminate ways. But the filling up of water of the reservoirs is very low as the amount of precipitation in the entire Purba Medinipur is quite less. From the Indian meteorological department, it has been found that in maximum years from 1991 to 2020 in Purba Medinipur annual rainfall was around1600 mm. So abstraction is more than the recharge of reservoirs.

It's an alarming situation for Egra. If such an indiscriminate usage of water from reservoir for increasing irrigation and industrialization has been taken place then reservoirs will become dry. If irrigation and industrialization are taking place by the withdrawal of groundwater then the ground water table will be diminished. So if groundwater harvesting is adapted to store water in the reservoir to supply water required for irrigation and industrialization then it may be benefitted.

Keywords: Reservoir, perimeter, area, irrigation, industrialization, population

I. INTRODUCTION

Egra is one of the districts of Purba Medinipur. It has two blocks. Northing and Easting of Egra are 21.9°N and 87.53°E respectively.

The study area is shown in Fig 1. Water is used for all the purposes of life. River and canal water is the main source of water in a state like West Bengal.

Surface water after treatment is distributed in all the sectors like household, irrigation, industry, etc. As surface water is intermingled with seawater from the Bay of Bengal, therefore river water like the Haldi River, Rupnarayan River, Rasulpur River in Purba Medinipur has become saline.

For that reason, the upliftment of groundwater became much more. Since the annual rainfall of West Bengal is moderate so the abstraction of groundwater is more than its recharge. As the groundwater level is declining so reservoir water is much more used for irrigation and industrial purpose. In Purba Medinipur there is a total of 100 reservoirs and ponds of varying capacity is found in Egra in the year 2020.

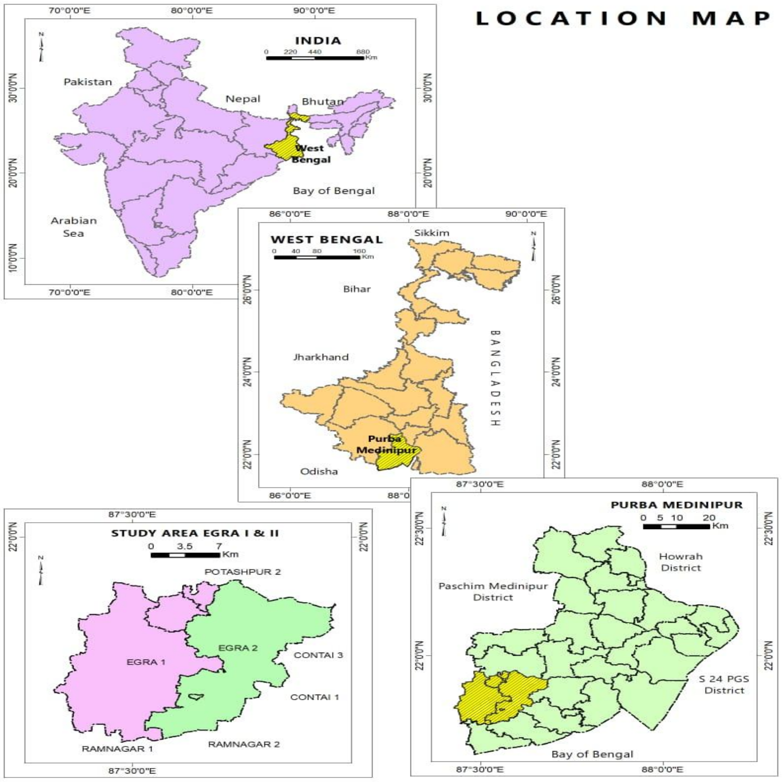

Fig1 Study Area

Mac Donagh *et al* (7) detected a variety of water storage in the Neotropical Region, Argentina since 1990. The colonization started in southern lakes, and during the last ten years of the research, the din flagellate arrived and flourished in subtropical reservoirs. In this context, the colonization of C. hirundinella and there population development has been analyzed from its first record in the Río Tercero Reservoir (February 1999 to February 2001).

Wisser *et al* (15) showed a global estimate of reducing water storage capacity in large reservoirs might affect the normal behavioral pattern of human life. They have also predicted that sea-level rise might change the sign of relatively freshwater reservoir, surface water and aquifers.

Dawoodet *et al* (3) established that evaporation reduction was the suppression of evaporation by adjusting the rate at which water vapor escaped from water surfaces. The need for water-saving was a huge concern in areas of low rainfall and low runoff. Water reduction by evaporation from reservoirs could be decreased for the greatest purpose of limited inflow. Using polyethylene with changing densities (800, 875 and 900 kg/m^3) as floating cover to the water-filled up cylindrical garner with 8 cm diameter leading diminished evaporation rate. A suitable trash density of 800 kg/m3 gave diminishing evaporation rate of about 57% from the calculated theoretical results which were a good result.

Liu *et al* (4) stated that water application and use became a more necessary determinant of environmental equality and human development according to the objective of the UN. Water scarcity was one of the major challenges which had an overarching application for other world crisis especially poverty, hunger, ecosystem crisis, climate change, decreasing world peace and security. Their research activities could be grouped as desalination plants; water retention (like rainwater reservoirs and reuse); wastewater reuse; dams and reservoirs.

El-Shazli *et al* (5) have used to identify the changes in the storage capacity of the Aswan High Dam Reservoir (AHDR) in the past five decades through a digital elevation model (DEM), and satellite images, In their study they indicated that the total storage capacity of the AHDR calculated by the DEM has reduced by 12%. This diminishing value mainly occurred in the live and the dead storage capacities. The properties of the reservoir have changed in the southern part of China and at the entry point of the lacustrine part. A gradual change of the entrance to the riverine part was seen. The surface area of the AHDR was reduced at low water levels because of sedimentation. The average reduction of the surface area between water levels of 140 and 168 m which was about 15%, and was equivalent to almost 10 km^3.

Mao *et al* (8) had shown that water quantity in reservoirs established from 1997to2014 significantly changed the measured evapotranspiration patterns over China.
Ye *et al* (9) analyzed of water level fluctuation of lakes and reservoirs in Xinjiang, China by adopting ICES at laser altimetry data from 2003 to 2009.
Eshani *et al* (1) showed an increase in surface temperature and change in precipitation patterns along with the intensity of floods are the cause of the spreading of melting ice in the world. It is changed related to global climate change. Climate change was expected to put an effect on the water supply-demand balance in NUS (Northeast United States) and the challenge, therefore, lied on water management strategies. It enhanced the eccentricity of water resources strategies towards floods and droughts. The trade-offs between reservoir outflow to maintain flood control, drought control, per capita demand, and energy evolution should be checked. The only affected resource became the water resource. Then the most populated areas of the Northeast United States should meet up per capita water demand.
Maity *et al.* (17) showed that the surface water was insufficient in Purba Medinipur, West Bengal. So the application of groundwater extraction is becoming more and more due to enhanced population, industrialization, and urbanization. Due to the over-utilization of groundwater, seawater intrusion was happening in that district. To support this various field studies related to subsoil characteristics, groundwater quality parameter assessment had been carried out. Piezometric surface of underground water at various seasons had been also developed. It had also been estimated the safe extraction of water from vertical and qanat well in that locations. It had also been concluded from the journal that vertical riser coupled with quanta well were suitable for that district.
Ramsundram *et al* (6) did the modeling of the hydrological cycle to simulate the water resource. It had been well researched for over a decade. They had done researches in the arid region of Tamilnadu; in their research paper, they found out the inflow database of Stanely reservoir, Tamilnadu. A modeling framework had been established that predicted the reservoir inflow taking the future climatic scenarios.
Maity *et al* (18) observed that due to excessive over extraction of groundwater; seawater intrusion was conducted in Purba Medinipur, India. On the experimental studies, they found high values of groundwater quality parameters at various locations of the district. They also suggested remedial measures to control the hazardous effect of seawater intrusion.
Maity *et al* (16) showed that since seawater intrusion has been taken place in the Purba Medinipur, due to which groundwater was taking the shape of a cone of depression. They suggested some remedial measures in controlling the seawater intrusion.
He *et al* (2) showed that reservoir optimal operation is important to coordinate with various profit-making goals so they were a typical multiobjective optimization problem. With the advancement of multiobjective evolutionary algorithms (MOEAs) in the past history, so that of researchers had focused on MOEAs. The appropriate discrete step of the state variable is a key presets to balance the superiority and computational efficacy of non-dominated solutions with the application of MODP and MODP-BRL.
Fang *et al* (13) have assessed the water storage in China's Lakes and reservoirs over the last three decades. They have calculated the volume of water available in their study area and also showed the various uses of that amount of water. They had also assessed the different quantities of water utilized by different units in their study area.
Chakraborty *et al* (19) developed a numerical model based on which future prediction of groundwater table of Purba Medinipur was made. It was shown that that the groundwater leveling was declining every year at a huge rate. The data had been validated too. On that discussion, it could be assumed that saline water intrusion had been occurred in that district.
Chakraborty *et al* (10,11) showed that due to the huge amount of withdrawal of groundwater from Contai, Purba Medinipur the water quality parameters in groundwater have increased to a large extent over the years.
Chakraborty and Das (12) have examined the conditions of reservoirs in Contai, Purba Medinipur with respect to time and increasing population.
Cai et al (14) have developed a numerical model to determine the capacity of reservoirs at Yangtze River locality.

II. METHODOLOGY

In this paper, Egra in Purba Medinipur is selected as a study area. The main objective of this paper is to find out reservoirs' total area and total perimeter over the last decade i.e. from the year 2011- 2020. The entire operation is done by the Google Earth Pro tool. First, in Google Earth Pro tool Egra, West Bengal has been typed to identify the location. When it is shown in the satellite imagery map then it is enlarged to the desired amount. On the map hundred (100) natural reservoirs of irregular shape and in close vicinity of vegetation are seen. Clicking on the time slider it is shown the current date. After backward dragging of the years, it has been obtained that throughout the last decade 100 numbers of reservoirs existed. A place mark is added to all the reservoirs to obtain the northing and easting of the reservoirs. Polygon is added constructed around all the reservoirs individually very carefully without leaving a single portion. After completion of polygon making and selecting the units of perimeter and area as metre and square metre in measurement section, the desired perimeter and area of reservoirs at any instant of time are obtained. This process is repeated every year from 2011-2020 for all the reservoirs to obtain the total area and perimeter of reservoirs over the decade in Egra, Purba Medinipur.

III. RESULTS AND DISCUSSION

The details of reservoirs in Egra are tabulated below. Total 100 reservoirs in Egra are having a perimeter and the area is shown graphically as follows. This water is utilized for irrigation and industrial purpose. From the district handbook, population of Egra was found 206,216 in 1971; 217,070 in 1981; 241,185 in 1991; 301,485 in 2001; and 345,926 in 2011. The average percentage increase in population in Egra is calculated ~2.25% per annum which is enormous. Withdrawal of water has been increased many more times in 2020 Egra manifold is increased in population and irrigation and industrialization. So the water withdrawal of from the 100 existing reservoirs of Egra has been taken place. But the filling of reservoirs is very less since the amount of rainfall in the entire Purba Medinipur is quite less. From the Indian meteorological department, it is found that in most of the years the annual precipitation was around 1600 mm. So abstraction is more than the recharge of reservoirs. It’s an important situation for Egra. The details of the locations of reservoirs are tabulated in Table 1.

Table 1 Location of 100 reservoirs in Egra, Purba Medinipur

Reservoir No.	Latitude	Longitude
1	$21^0$53’57.50” N	$87^0$32’12.34” E
2	$21^0$54’2.51” N	$87^0$32’17.19” E
3	$21^0$54’1.46” N	$87^0$32’20.88” E
4	$21^0$53’59.82” N	$87^0$32’21.61” E
5	$21^0$54’6.34” N	$87^0$32’18.01” E
6	$21^0$54’6.18” N	$87^0$32’13.65” E
7	$21^0$54’9.63” N	$87^0$32’13.81” E
8	$21^0$54’5.53” N	$87^0$32’23.45” E
9	$21^0$54’11.97” N	$87^0$32’29.93” E
10	$21^0$54’14.94” N	$87^0$32’32.69” E
11	$21^0$54’14.02” N	$87^0$32’35.72” E
12	$21^0$54’12.70” N	$87^0$32’39.32” E
13	$21^0$54’9.25” N	$87^0$32’28.33” E
14	$21^0$54’9.01” N	$87^0$32’33.57” E
15	$21^0$54’9.18” N	$87^0$32’32.37” E
16	$21^0$54’3.34” N	$87^0$32’39.73” E
17	$21^0$54’4.01” N	$87^0$32’33.78” E
18	$21^0$54’6.26” N	$87^0$32’36.76” E
19	$21^0$53’49.94” N	$87^0$32’39.92” E
20	$21^0$53’49.08” N	$87^0$32’25.86” E
21	$21^0$53’48.84” N	$87^0$32’32.50” E
22	$21^0$53’56.91” N	$87^0$32’27.69” E
23	$21^0$53’14.94” N	$87^0$32’32.93” E
24	$21^0$53’56.16” N	$87^0$32’23.47” E
25	$21^0$53’56.55” N	$87^0$32’25.85” E
26	$21^0$53’58.18” N	$87^0$32’26.04” E
27	$21^0$53’59.09” N	$87^0$32’27.46” E
28	$21^0$53’50.68” N	$87^0$32’25.09” E
29	$21^0$53’50.68” N	$87^0$32’20.96” E
30	$21^0$53’49.18” N	$87^0$32’25.62” E
31	$21^0$53’48.62” N	$87^0$32’14.55” E

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32	21^{0}53'46.37" N	87^{0}32'15.58" E
33	21^{0}53'37.15" N	87^{0}32'26.65" E
34	21^{0}53'34.68" N	87^{0}32'25.92" E
35	21^{0}53'35'.80" N	87^{0}32'25.74" E
36	21^{0}53'31.83" N	87^{0}32'25.67" E
37	21^{0}53'30.27" N	87^{0}32'26.72" E
38	21^{0}53'26.20" N	87^{0}32'26.61" E
39	21^{0}53'27.80" N	87^{0}32'28.04" E
40	21^{0}53'28.44" N	87^{0}32'25.63" E
41	21^{0}53'28.10" N	87^{0}32'29.52" E
42	21^{0}53'25.78" N	87^{0}32'30.89" E
43	21^{0}53'17.25" N	87^{0}32'17.81" E
44	21^{0}53'13.07" N	87^{0}32'19.51" E
45	21^{0}53'12.43" N	87^{0}32'21.72" E
46	21^{0}53'10.56" N	87^{0}32'25.82" E
47	21^{0}53'4.22" N	87^{0}32'11.37" E
48	21^{0}53'8.13" N	87^{0}32'58.43" E
49	21^{0}53'4.37" N	87^{0}32'1.18" E
50	21^{0}53'2.82" N	87^{0}32'1.04" E
51	21^{0}53'5.25" N	87^{0}32'59.81" E
52	21^{0}53'5.27" N	87^{0}32'56.79" E
53	21^{0}53'6.09" N	87^{0}32'4.76" E
54	21^{0}53'6.83" N	87^{0}32'6.07" E
55	21^{0}53'8.15" N	87^{0}32'1.51" E
56	21^{0}53'7.04" N	87^{0}32'1.73" E
57	21^{0}53'10.98" N	87^{0}32'58.81" E
58	21^{0}53'9.20" N	87^{0}32'0.78" E
59	21^{0}53'8.15" N	87^{0}32'58.30" E
60	21^{0}53'8.92" N	87^{0}32'56.26" E
61	21^{0}53'7.14" N	87^{0}32'55.82" E
62	21^{0}53'10.51" N	87^{0}32'53.26" E
63	21^{0}53'11.04" N	87^{0}32'54.34" E
64	21^{0}53'14.53" N	87^{0}32'53.69" E
65	21^{0}53'22.31" N	87^{0}32'9.66" E
66	21^{0}53'21.73" N	87^{0}32'13.17" E
67	21^{0}53'18.81" N	87^{0}32'9.11" E
68	21^{0}53'19.18" N	87^{0}32'8.17" E
69	21^{0}53'16.75" N	87^{0}32'6.53" E
70	21^{0}53'17.91" N	87^{0}32'11.83" E
71	21^{0}53'14.99" N	87^{0}32'12.39" E
72	21^{0}53'13.20" N	87^{0}32'11.58" E
73	21^{0}53'12.82" N	87^{0}32'13.96" E
74	21^{0}54'21.25" N	87^{0}32'13.97" E
75	21^{0}54'13.89" N	87^{0}31'58.10" E
76	21^{0}54'15.37" N	87^{0}31'54.79" E
77	21^{0}54'9.70" N	87^{0}32'0.89" E
78	21^{0}54'10.60" N	87^{0}32'5.46" E
79	21^{0}54'6.00" N	87^{0}32'54.12" E

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80	21^{0}54’1.85” N	87^{0}31’50.36” E
81	21^{0}53’59.89” N	87^{0}32’51.35” E
82	21^{0}54’13.43” N	87^{0}32’52.50” E
83	21^{0}54’20.02” N	87^{0}31’58.69” E
84	21^{0}54’20.94” N	87^{0}32’5.04” E
85	21^{0}53’17.25” N	87^{0}32’17.81” E
86	21^{0}53’57.26” N	87^{0}31’57.67” E
87	21^{0}53’48.49” N	87^{0}31’59.05” E
88	21^{0}53’53.18” N	87^{0}31’4.24” E
89	21^{0}53’46.39” N	87^{0}32’6.57” E
90	21^{0}53’39.85” N	87^{0}32’6.13” E
91	21^{0}54’31.42” N	87^{0}31’55.58” E
92	21^{0}54’22.64” N	87^{0}32’41.41” E
93	21^{0}54’34.48” N	87^{0}32’22.88” E
94	21^{0}54’48.54” N	87^{0}32’16.22” E
95	21^{0}53’53.44” N	87^{0}32’39.88” E
96	21^{0}53’25.95” N	87^{0}32’6.58” E
97	21^{0}53’25.95” N	87^{0}32’5.37” E
98	21^{0}53’29.69” N	87^{0}32’12.97” E
99	21^{0}53’54.59” N	87^{0}32’14.24” E
100	21^{0}53’53.62” N	87^{0}31’57.61” E

The total perimeter and area of reservoirs have been evaluated by the Google Earth Pro tool from 2011 to 2020. The values of total perimeter and area are tabulated below in Table 2.

Table 2 Total perimeter and area of reservoirs from 2011 to 2020 at Egra, Purba Medinipur

Year	2011	2012	2013	2014	2015
Total perimeter(m)	18630.00	18225	17818	17229	16746
Total area(m^2)	145513	144843	144325	144030.00	143721

Year	2016	2017	2018	2019	2020
Total perimeter(m)	16406	16167.00	15909	15447	13752
Total area(m^2)	142393	141019	137386	131389	115255

From the district handbook, population of Egra was found 206,216 in 1971; 217,070 in 1981; 241,185 in 1991; 301,485 in 2001; and 345,926 in 2011. The average percentage increase in population in Egra is calculated ~2.25% per annum which is enormous. By extrapolation population of Egra from the year 2012 to 2020 are found out and tabulated below in Table 3.

Table-3 Projected population at Egra, Purba Medinipur from 2011 to 2020

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Population	345,926	353,709	361,668	369,806	378127	386,635	395335	404231	413327	422627

A graphical comparative analysis between the population of Egra, Purba Medinipur and the total perimeter and area of reservoirs between 2011-2020 is shown in Fig 2.

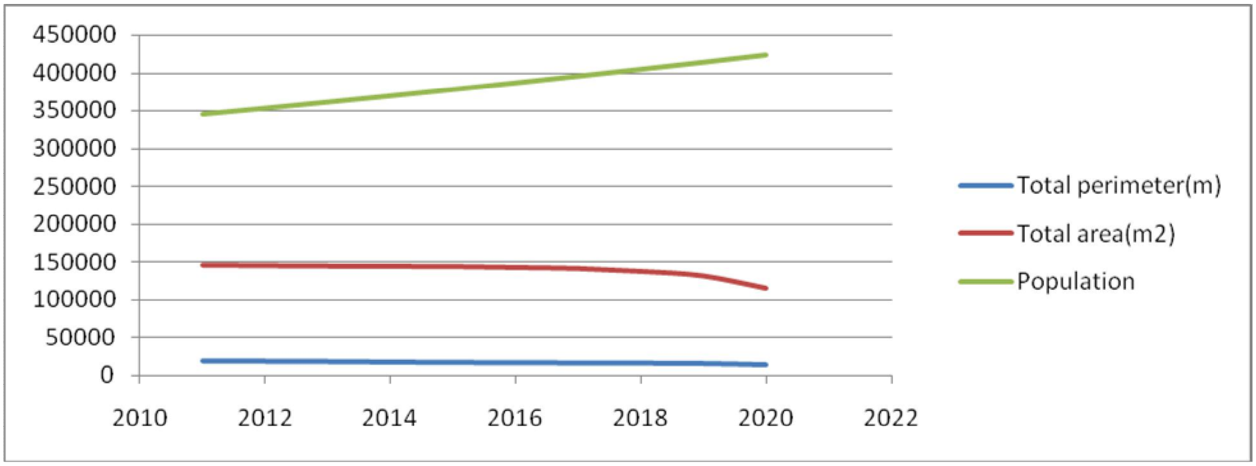

Fig 2 Comparative analysis between the population of Egra, Purba Medinipur and total perimeter and area of reservoirs between 2011-2020

From Fig 2 it has been observed that with the increase of population graphically in Egra, Purba Medinipur the area and perimeter of reservoirs decreased over the decade.

It is obtained that the correlation coefficient between the decadal population of Egra and the total perimeter and area of reservoirs are -0.97 and -0.81 respectively. So it can be inferred from the analysis that with the increase of population the perimeter and area of reservoirs were affected greatly.

The yearly annual rainfall of Purba Medinipur is nearly 1600 mm. The yearly variation of rainfall is not much. So no relationship between reservoir perimeter and area with rainfall can be established. So it can be concluded that population is the major factor in the determination of reservoir perimeter and area compared to annual rainfall.

IV. REMEDIAL MEASURE

Water protection is too important for irrigation and industrial purpose. To protect it for human awareness is very much needed. For getting water for irrigation and industry people are taking surface water as an alternative. But surface water like the Haldi River is highly saline and cannot be used for humans. It becomes very much important to limit the withdrawal of water from the reservoir by the government.

V. CONCLUSION

From the above analysis it has been seen that Egra, a district of Purba Medinipur, India is a small district. But in the year 2011it was observed that there was a huge population. This huge population density which is higher than that of West Bengal has been increased in a decade. These reservoirs became empty due to some constructional activity. It has also been observed that the perimeter and area of reservoirs in the year 2011 were higher than that of in the year 2020. This reservoir storage is usually used for growing irrigation and industrial activity. For that reason, people of Egra are inclined to use groundwater. Due to indiscriminate use of groundwater level declines. According to Gyben Herzberg's principle if the groundwater level declines then seawater into the mainland which creates more compound problems increases in water resource management strategy. It creates an alarming situation in Egra district. Some treatment can be given to lithology character and surface water and Bay of Bengal so that there will be no hindrance in obtaining reservoir water for irrigation and industrial purpose. Some laws by the Government must be enforced activity to reservoirs so that water extraction of from the reservoir can be limited.

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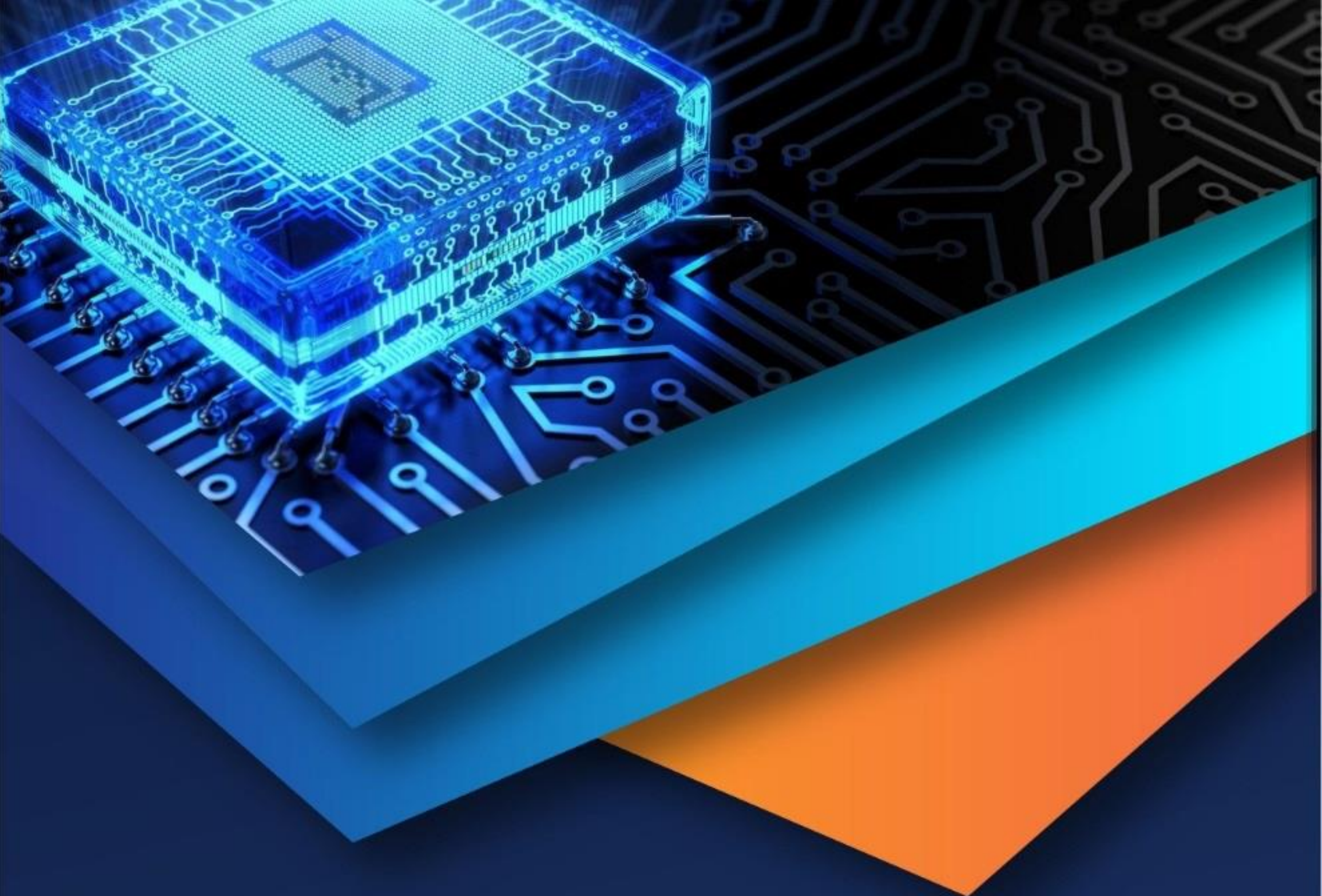

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