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Use of HEC-HMS Software for Quantitative Assessment of Water of Dumboor Reservoir, Tripura, India

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Abstract: ***The river Gumti, one of the largest rivers of Tripura, is flowing west ward and finally falls into the river Meghna, Bangladesh. The river Gumti is formed by the confluence of two rivulets, named Raima and Sharma, the former originating in the Longtarai Range and the later in the Atharomura Range. From its confluence point the combined flow of the two rivulets is known as the Gumti which flows southward. Before a dam was constructed across the Gumti river, the river used to spill over a series of rapids which are locally known as Dumboor falls. Due to the construction of this dam for hydropower plant a large reservoir is created , known as Dumboor reservoir. In this paper a quantitative assessment of water of Dumboor reservoir has been done for possible use of drinking and Irrigation etc. The hydrologic simulation model has been used using HEC-HMS software for estimating the quantity of water. From the observation of model discharge of the reservoir water, in various seasons during the period 2004-2013, this has been found that minimum discharge is 20.48 m^3/s during pre monsoon and maximum discharge is 101.73 m^3 /s during monsoon.***

Keywords: HEC-HMS, Dumboor reservoir, simulation model

I. INTRODUCTION

Tripura is the second smallest state of North-East India and is located from 22^0 51'N to 24^0 32' N latitude and $90^0$09'E to 92^0 20'E longitude. In this state there are five major parallel hill ranges (Jampui, Sakhantang, Langtarai, Atharamura and Baramura-Deotamura) covering with greenery forest of varying density and ten major rivers (Langai, Juri, Deo, Manu, Dhalai, Khowai, Haora, Gumti, Muhuri and Fenny) maintaining the key role of water circulation within the state. Out of several water bodies of this state, Dumboor is the largest water body having lake area 41 sqkm and is located at 120 km away from state capital Agartala. There are 48 islands in the midst of the reservoir. There is a hydel power project near this reservoir where the River Gumti originates .This area is popularly known as Tirthamukh, which is famous for big fair held every year on Paus Sankranti.

Different types of migratory birds have enhanced the extra ordinary natural beauties of the surrounding hills of the lake area. It has been observed that there remains water crisis in the Dumboor reservoir throughout the year except for the monsoon period. It was identified that due to rising of bed level of the water, that gets filled in the reservoir spills out in huge amount especially during monsoon season. This water crisis issue effects not only the production of electricity but also the local habitat near the plant. It is also affecting other irrigation projects, treatment plant near the locality and fish production in the reservoir. Hydrological models are very helpful for planning the use of water resources in a sustainable way without disturbing the regional ecosystems and livelihoods [1].The HEC-HMS developed by Hydrologic Engineering Centre (HEC) of US Army Corps of Engineers, is well-known hydrologic model [2] and can be used to estimate water quantity in Dumboor reservoir in different season as well as of water discharge.

II. MATERIALS AND METHODS

A. Study Area

Dumboor reservoir is a charming water body situated in South Tripura at latitude of $23^0$25′45″ and longitude of $91^0$49′20″. The storage capacity of the Dumboor Reservoir is 23,570 Hectare meter. Dead Storage at river level is 2590 Hectare meter and live storage is maintained at 20.980 Hectare meter. The submerged area at F.R.L of 92.05 m and M.W.L of 95.25m was found to be respectively 46.34 and 74.86 Sq.Km. The reservoir is enrich of natural and cultured fishes. In one of the island "Narkel Kunja" has been developed.Actual basin area of this reservoir has been shown in fig 1.

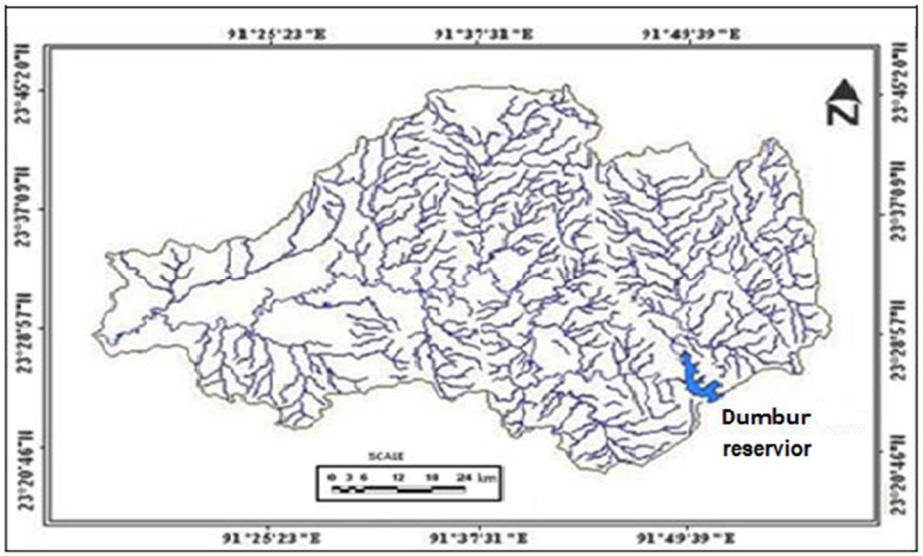

Fig 1: Dumboor basin area

B. Hydrology

The reservoir has a catchment area 576sq.Km. From the record of last ten years (2004-2013) annually it receives 1.99 meters of rainfall at an average whereas peak rainfall remains at around 2.97 meters (2007) and a minimum rainfall was observed in 2008 which amounted to 1.35 meters of rainfall within that year. In the last ten years average peak rainfall in month varied from 358 to 403 mm where by the month of June was found to have the highest rainfall. The minimum and maximum rainfall remains at an average within 2.103 m^3/sec to 91.77m^3/sec respectively. The annual Evaporation loss was found to be 0.86metres. The river at the dam site has a catchment area of 547 km^2. Turbidity of water is very high due to soil erosion on account of denudation of forests in catchment area by shifting cultivators (*jhoom*).

C. Sampling Details and Instrumentation

A field survey was conducted twice in a month during the year 2013-2014 to collect the flow value of Gumti reservoir through an instrument- River Surveyor. The resolution of River-surveyor measurement is .01m^3/s. Data are stored in memory cells of the device which are then transferred to database of computer and after then these have been analysed by using HEC-HMS (Hydrologic Engineering Centre - Hydrologic Modelling System) software [3].

III. QUANTITATIVE ASSESSMENT OF DUMBOOR RESERVOIR

A. Delineation of Reservoir Watershed

The watershed of Dumboor reservoir have been delineated with the help of Google Earth which is actually a virtual globe map and geographical information program that was originally called by Earth Viewer 3D. Fig 2 is representing the delineation of this reservoir watershed.

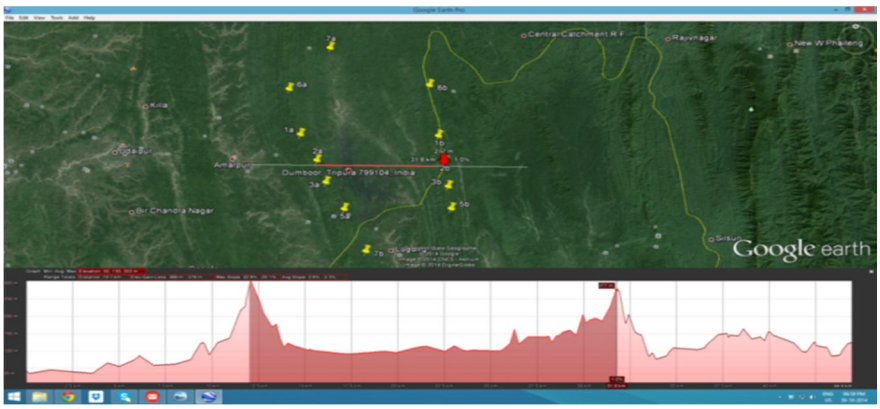

Fig 2: Delineation of Dumboor reservoir Watershed

B. Image Processing

With the help of Image-J software, Catchment area of Dumboor reservoir is shown in figure 3 and it is estimated as 574 Km^2. From the percent area of specific land use pervious and impervious area are separated as per figure 4, fig 5 and fig 6.

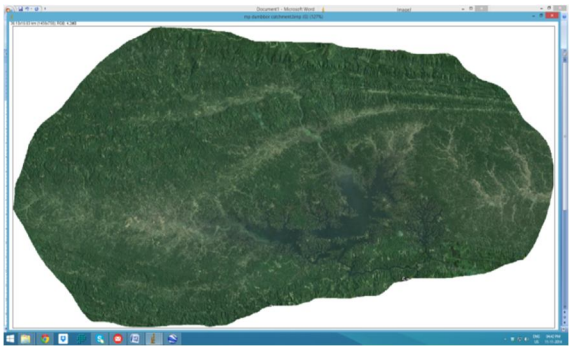

Fig 3: Dumboor Catchment area

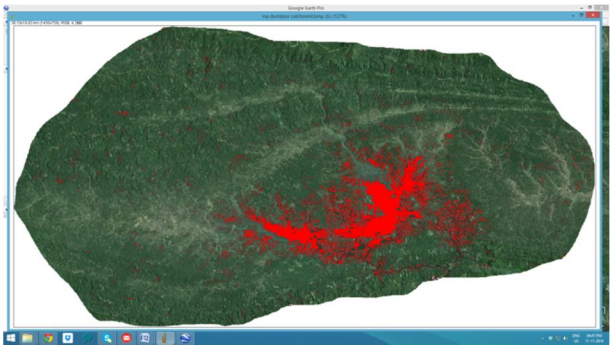

Fig 4: Water Body area in Dumboor catchment

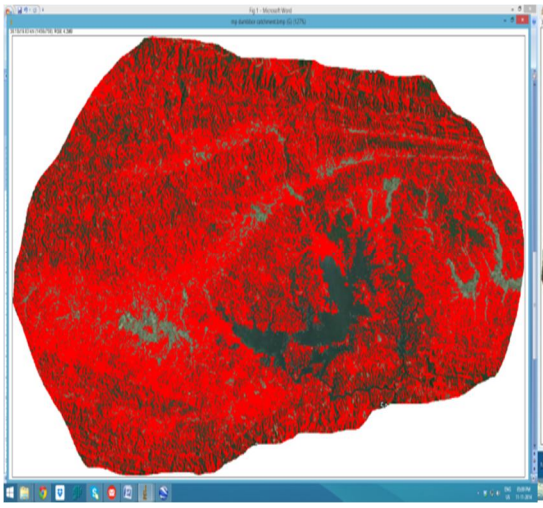

Fig 5: Forest area in Dumboor catchment

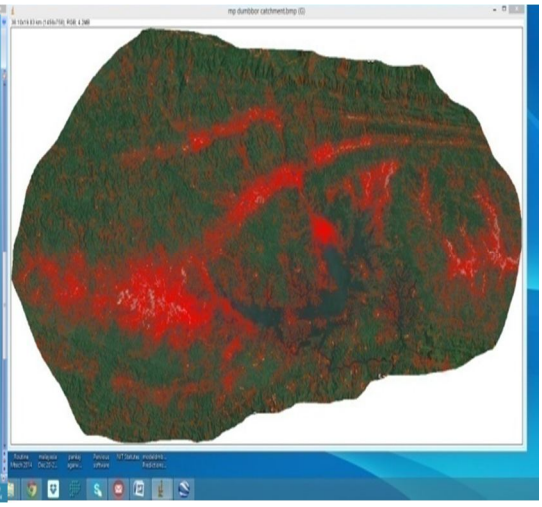

Fig 6: Impervious area of Dumboor Catchment

Table 1 Land use classification after image processing

Name of Catchment	Settlement/impervious in %	Forest in %	Agricultural land in %	Water body in %
Dumboor	18.36	68.40	7.38	5.86

The percent wise land use classification for Catchment area is showing in the table 8.4. The watershed area is mostly covered with four types of land use viz. settlement, forest, agricultural land and water body. It is showing that study area averagely has 18.36% impervious area and 81.64 % pervious area. The percentage of pervious area is around 4.45 times more than the impervious area.

C. Water Budget Estimation

For water quantity assessment for Dumboor reservoir, water flow is an important issue. But in Dumboor reservoir, no earlier daily stream flow data is available .So rainfall and temperature for a period of 10 years (Jan 2004 to Dec 2013) were collected from Meteorological department.

Using these Evapotranspiration has been calculated by Thornthwaite Formula [4] with the help of mean monthly temperature by adjusting day-lengths. In fact the derived Evapotranspiration is helpful for finding the runoff using the HEC-HMS model (Technical Reference Manual 2004 and user's 2000).

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IV. RESULT AND DISCUSSION

Using the hydrological model, flow of the reservoir during the year 2004-2008 and 2009-2013 has been found out. Model output (stimulated flow) during these two time scale is shown in figure 7 & figure 8 respectively. Season wise model flow for a period of 10 years (Jan 2004 to Dec 2013) has been displayed in table 2.

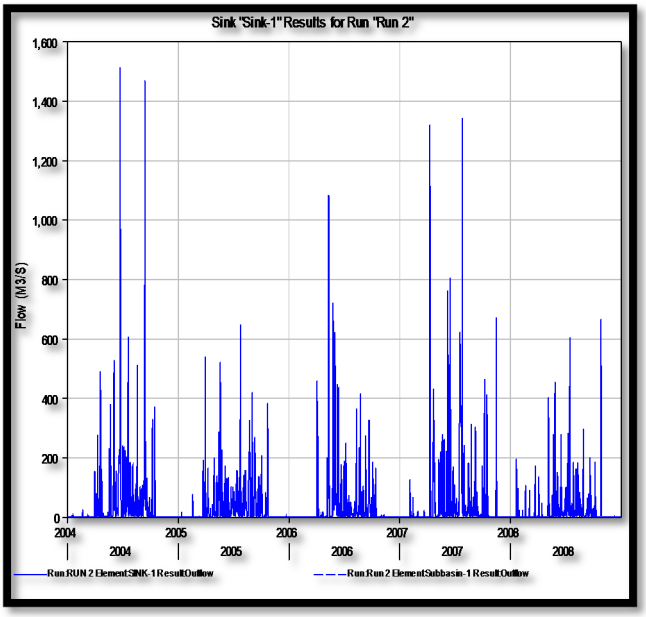

Fig 7: Modeled flow Hydrograph for Dumboor reservoir from 2004-2008

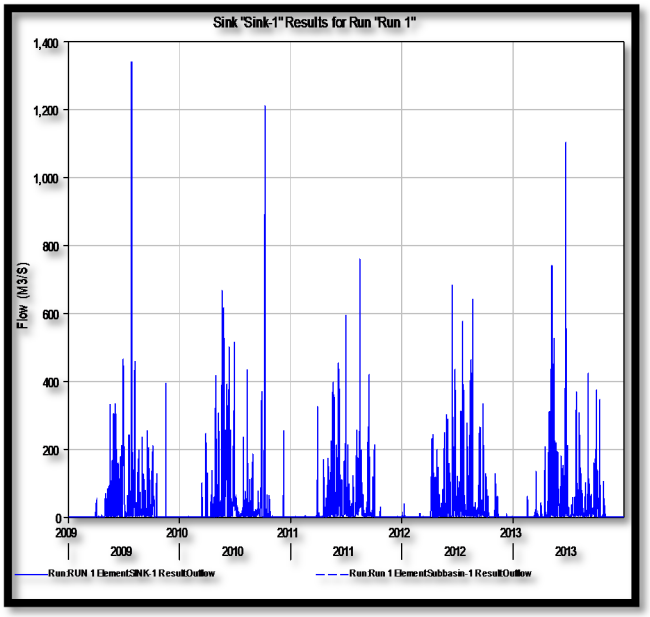

Fig 8: Modeled flow Hydrograph for Dumboor reservoir from 2009-2013

Table 2: Season wise model flow (m^3/S) in Dumboor reservoir

year / Season	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Pre monsoon	33.86	47.8	50.09	57.72	24.19	20.48	52.95	35.02	32	63.01
monsoon	101.73	57.43	63.53	101.31	44.78	78.60	51.94	61.58	73.94	53.83
Post monsoon	7.64	9.29	5.89	18.25	12.43	9.53	16.78	3.71	6.89	9.52

V. COMPARISON OF MODEL VALUE AND FIELD OBSERVED VALUE THROUGH RIVER SURVEYOR

For validation of the model, comparison of model value and field observed value is required. For field observed value, River Surveyor instrument has been utilized. Instant discharge is also measured at Dumboor reservoir by the instrument River Surveyor. Leading edge technologies such as Bluetooth, spread spectrum radio, mobile phones, and RTK (Real-Time Kinematic) GPS are all incorporated to elevate performance and expand utility. A field survey was conducted twice in a month during the year 2013-2014 to collect the flow value of Dumboor reservoir. A summary of the field observed values and model values along with the deviations have been presented in the table 3.

Table 3: Calculation of percentage deviation from the observed and model flow values

Date	Model Flow(m^3/s)	Observed Value (River Surveyor)	% of Deviation	Date	Model Flow (m^3/s)	Observed Value (River Surveyor)	% of Deviation
08-01-13	1	1.02	1.960784	13-01-14	1	1.01	0.990099
22-01-13	1	1.03	2.912621	27-01-14	1	1.02	1.960784
12-02-13	1	1.05	4.761905	10-02-14	1	1.75	42.85714
26-02-13	1	1.01	0.990099	24-02-14	1	1.27	21.25984
11-03-13	2.7	2.96	8.783784	14-03-14	19.4	15.34	-26.4668
25-03-13	1	1.05	4.761905	22-03-14	7.7	8.1	4.938272
08-04-13	18.3	16.1	-13.6646	17-04-14	19.7	18.4	-7.06522
22-04-13	85.6	81.81	-4.63269	27-04-14	67	93.1	28.03437
13-05-13	17.2	15.56	-10.5398	12-05-14	8.5	7.2	-18.0556
28-05-13	128.27	120.82	-6.1662	25-05-14	102.1	125.8	18.83943
08-06-13	80.8	74.73	-8.12257	06-06-14	54.1	79.23	31.71778
23-06-13	320.7	303.95	-5.51077	22-06-14	280.1	325.4	13.92133
08-07-13	101.4	111.55	9.099059	16-07-14	49.5	71.36	30.63341
24-07-13	353.3	360.83	2.086855	26-07-14	269.4	296.7	9.201213
09-08-13	124.1	102.56	-21.0023	11-08-14	152.5	191.66	20.43202
30-08-13	84.1	75.02	-12.1034	27-08-14	82.8	115.06	28.03755
09-09-13	112.1	89.67	-25.0139	08-09-14	123.5	124.59	0.87487
26-09-13	160.8	184.79	12.9823	24-09-14	145.1	134.56	-7.83294
14-10-13	4.1	4.89	16.15542	16-10-14	2.1	2.54	17.32283
28-10-13	0.7	0.71	1.408451	27-10-14	7.8	5.51	-41.5608
15-11-13	2.3	2.28	-0.87719	10-11-14	0.8	0.81	1.234568
25-11-13	0.8	0.81	1.234568	24-11-14	0.8	0.76	-5.26316
09-12-13	0.8	0.69	-15.942	08-12-14	0.8	0.77	-3.8961
23-12-13	0.8	0.79	-1.26582	22-12-14	0.8	0.81	1.234568
Mean Absolute Percentage Deviation(MAPD)							2.200956

It may be observed from table 8.6 that there were not many variations between the observed flow and model flow. The Mean Absolute Percentage Deviation (MAPD) of the value is 2.2009% which is found to be satisfactory. With a view to visually observe the difference between the observed and model flow, a plot is drawn with observed flow as abscissa and model flow as ordinate. The plot is shown in figure 8.19. If there is no variation between observed values and model values then they must lie on same straight line of the plot. However in the plot certain records show variations between observed and predicted values. Survey in different location of reservoir revealed the phenomenon of huge siltation which causes rise in bed level of reservoir .During monsoon water is spilled due to overflow and the people near the reservoir are also affected for occurrence of frequent flood. This is due to the huge soil erosion in the area nearby

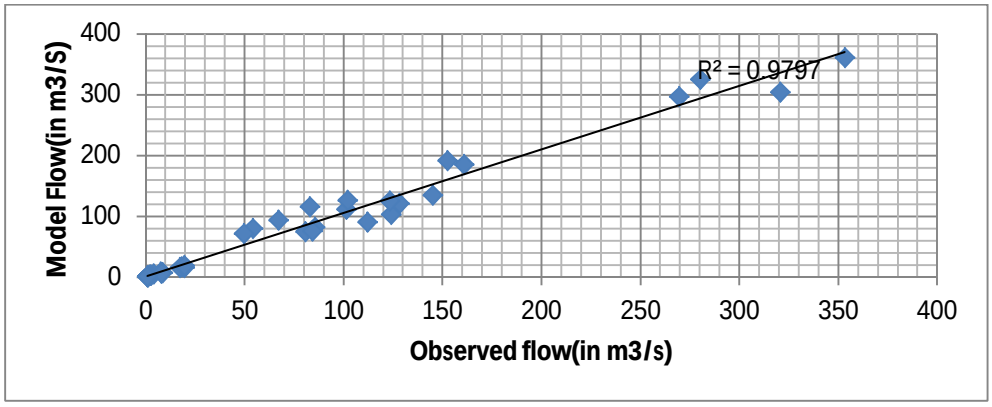

Figure 9: Plot between model flow and observed flow

the reservoir. This has been observed that tribal people of that area cut big trees for cultivating zoom in the slope of hilly terrain near the reservoir which causes huge soil erosion causing siltation.

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VI. CONCLUSION

From the study of model discharge of the reservoir water in various seasons viz. Pre Monsoon, Monsoon and Post monsoon during the period 2004-2013, it has been found that minimum discharge is 20.48 m^3/ s
during pre monsoon and maximum discharge is 101.73 m^3 /s during monsoon period. Moreover from the knowledge of actual number of households of dumboor reservoir area amount of water that can be circulated per person per day in different period may also be estimated from available water. Using the available water a treatment plant may be constructed for fulfilling the need of the people of Dumboor reservoir area.

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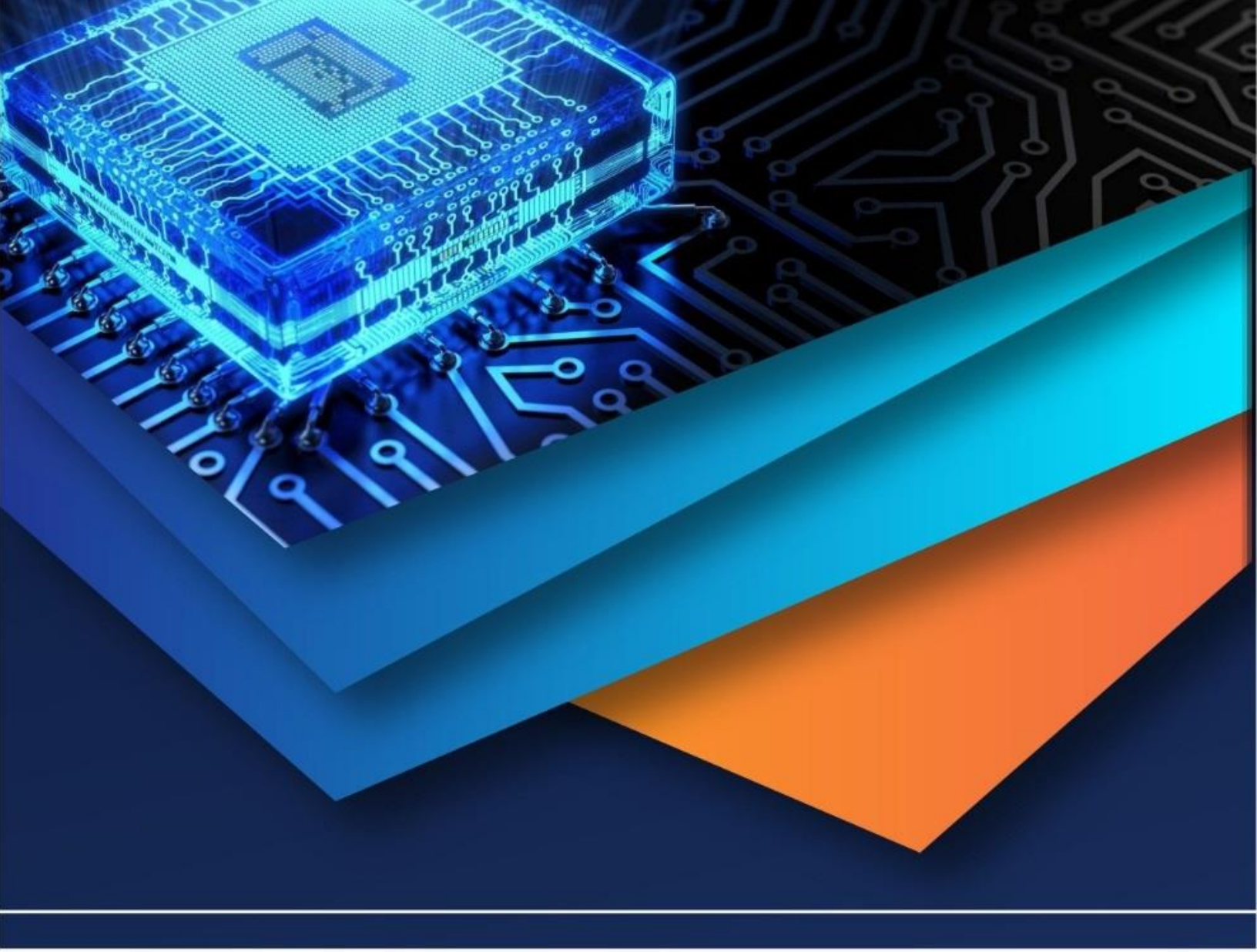

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