

# Analysis of Government Healthcare Infrastructure for the District of West Bengal: A Case of Purulia and Bankura

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**Abstract:** *The healthcare infrastructure facilities' location selection is an important decision for any health oriented developmental approach. This paper is a brief oriental discussion about the location of district hospitals and their decision - making in terms of connectivity and the feasibility of healthcare infrastructure in spatial as well as population aspects. This paper talks about the various issues related to the location of healthcare facilities in terms of district hospitals in geographical locations by thematic GIS mapping and analysis techniques using Analytical Hierarchy Process (AHP) to determine the best possible location for future perspective. Comparing various healthcare locations of different districts of West Bengal and inferring the locational pattern of the infrastructures. This paper elaborates on the discussion of district hospitals and their placement around the districts of West Bengal. Bankura and Purulia districts of West Bengal are taken as a case study to understand the disparity in the health status of the people using the AHP method of calculation to understand the priority factor for the location of healthcare infrastructure. GIS mapping and buffer analysis have been used in the area to identify the lacking of healthcare infrastructure by proper data on population distribution and the number of healthcare institutions. This paper will review the techniques to understand the gap between whether this method is valid for government establishments and compare it with the spatial arrangement of health infrastructure.*

**Keywords:** Analytical Hierarchy Process, Decision Making, GIS mapping, Healthcare Infrastructure, Location Selection, West Bengal.

## 1. Healthcare Infrastructure

Healthcare infrastructure is a part of our social infrastructure which is the most important aspect of happiness as well as holistic and sustainable development of any society. As per our IPHS and URDPFI guidelines, our healthcare facilities are well defined in how many to be set up by the governmental organisations as per populations and spatial dimensions.

Better health is a must milestone to be achieved by any area to have developmental growth in every aspect of living such as in terms of good health as well as in good economic development as a good health population will produce good economic development. (Facilities et al., 2021)

Healthcare infrastructure is an overall framework which consists of three tires of mechanisms in India for Urban as well as for Rural India. The structure of Indian health infrastructure states that there should be a Sub Centre for 5, 000 population in both urban and rural and 1 Sub Centre for every 3, 000 population in difficult/tribal and hilly areas. Similarly a Primary Health Centre for every 30, 000 population in general areas and 1 per 20, 000 population in difficult/tribal and hilly areas and a Community Health Centre per 1, 20, 000 population in general areas and 1 per 80, 000 population in difficult/tribal and hilly areas as per National Health Mission. (Infrastructure :: National Health Mission, no date)

As we already know that India's Public Health System has been developed over the years as a 3 - tier system, namely primary, secondary and tertiary levels of health care. District Health System is the fundamental basis for implementing various health policies, delivery of healthcare and management of health services for the defined geographic area. Each district must have a district hospital which can accommodate from 75 – 500 beds at a time for various populations as per the spatial context. And this standard has been in process for years as per norms of Indian Public Health Standards. The district hospitals are further classified from Grade 1 to Grade 5 as per population from Grade 1 with 500 beds and Grade 5 with 100 beds. There are all standers to cater for the various population range of different districts. As per the report of Indian Public Health Standards 2012 district hospitals can only serve only 85 % of the desired population with a bed occupancy rate of 80%. (DGAFMS, 2004)

But as we all know India is a developing country and has a lot of hurdles to overcome in general terms of reaching out the hospitals from far distances. As all the desired population of any district doesn't always settle in the same place. The primary health care and sub - centres also cater for the rural and sub - urban population but the fact remains the same whether the desired population for the district need to travel the distance and sometimes the population of adjacent districts of other states approaches district hospital

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to get the facilities. We have always noticed that the district's hospitals are always located in the centre of business districts where the mass population is located which is always not the perfect decision to set up a district - level healthcare infrastructure. The district hospital promises to function as a parent or head institution to govern and help the other secondary and primary level health care facilities for smooth functioning and monitoring but that doesn't always mean that it can cater to the population that desires the district level hospital at rural health care centres.

The major gap is the disparity in the spatial and population - wise cement of the location of healthcare facilities. As IPHS has mentioned made norms that are purely based on their top - down approach or system of infrastructure that a single institution of a pre - defined number of beds to cater for a population that can vary from 35, 000 to 30, 00, 000 as per census 2001 and as per census 2011 the population of districts of India varies from 7948 to 1, 10, 00, 000 in various districts where the norms of IPHS fails and the population needed to cater doesn't always get the opportunity to reach the hospitals as per 2016 report of Basics Road Statistics of India there is still 31% of unsurfaced and only 60% of the total population of India feels they have the last mile connectivity.

So, according to the spatial dimension of a region of any district where the population is exposed in terms of connectivity between the place of stay and the district hospital. This paper will briefly discuss the spatial location of any district hospital of any two or three districts and help in finding the served and un - served areas in terms of population and spatial dimensions.

**Present Scenario of Healthcare Infrastructure of West Bengal**

With a population of 9, 12, 76, 115 as per the census 2011 comprising 23 districts but in 2021 election commission conducted a vote based on 20 districts and the population projected is 10, 21, 90, 000. As per the 2011 census, there were 3349 - grampanchayats and 121 municipal corporations which have also been updated by 2021. So in terms of healthcare facilities, there are 2579 Hospitals including NGO/Private, Local Bodies, Govt. Undertaking and Rural hospitals also there are 988 Health Centres and 10357 Sub Centres overall as of 31st December 2014. And the report also states that there is a total of 109566 beds available in 13924 health institutions which includes rural and urban areas. (Implementation, no date) Our main focus of this paper is to study only the district - level healthcare infrastructure of West Bengal which are government establishments of the district hospitals and their location in spatial dimension and the area they served under norms and reality.

As per the data of state bureau of health intelligence directorate of health service 2018 states that the total number of Districts Hospital in West Bengal are 18 in count with an average of 305 beds in every hospital and the population of each district as per 2011 is compared in the below table to understand the carrying capacity of the districts hospitals and how the other sub centres and rural hospitals are overburdened with the patients as the rate of performing index as per 2016 and 2017 of bed occupancy rate in percentage shows the growth in number of patients in 2 recurring years. (Desai, 2013)

In the later part of 2019 when the Covid outbreak and the catastrophic disaster made a huge impact on the healthcare infrastructure and then the location of the hospital was an important factor that can help millions of lives. Not only Covid but in various natural disasters as well and communication disruption healthcare locations play an important role.

**Table 1: Health Care Infrastructure of West Bengal District**

District/ Health District	District Hospital		Sub Centre	IPHS Guideline for Sub Centre as per population	Urban Health Centre	IPHS Guideline for Urban Health Centre as per population	PHC's	IPHS Guideline for PHC as per population	BPHC's	IPHS Guideline for BPHC as per population	Sub Divisional Hospitals	IPHS Guideline for Sub Divisional Hospital as per population	Rural Hospitals	Medical Colleges	Urban Population 2011 census	Population 2011 census
	No.	Total no. of Beds														
Alipurduar	1	370	245	298	2	3	13	50	7	12	2	3	0	0	126891	14,91,250
Bankura	1	300	564	719	4	6	59	120	22	30	1	7	5	1	300679	35,96,674
Purba Bardhaman	0			1544		62				64	1	15		1		
Paschim Bardhaman	1	450	900		19		124	257	257		1		6	0	3079584	77,17,563
Birbhum	1	542	484	700	5	9	58	117	19	29	1	7	4	1	448368	35,02,404
Koch Bihar	1	400	406	564	2	6	29	94	12	23	1	6	1	1	289300	28,19,086
Darjiling	2	865	230	369	10	14	22	62	12	15	1	4	3	1	718175	18,46,823
Dakshin Dinajpur	1	432	247	335	0	5	18	56	8	14	1	3	0	0	236075	16,76,276
Hugli	1	650	660	1104	19	43	59	184	18	46	1	11	8	2	2131994	55,19,145
Haora	1	642	448	970	27	61	41	162	15	40	1	10	11	2	3064668	48,50,029
Jalpaiguri	1	700	537	775	2	21	28	129	14	32	1	8	4	1	1044674	38,72,846
Jhargam	1	300	204	227	1	1	23	38	8	9	1	2	0	1	61712	11,36,548
Kolkata	0	0	0	899	144	90	0	150	0	37	6	9	0	6	4486679	44,96,694
Kalimpong	1	370	49	50	0	1	6	8	4	2	1	1	0	0	49403	2,51,642
Malda	1	300	511	798	4	11	35	133	15	33	1	8	6	2	551914	39,88,845
Paschim Medinipur	0	0	78	1183	2	14	30	197	5	49	1	12	4	2	714992	59,13,457
Purba Medinipur	1	500	706	1019	0	12	53	170	25	42	1	10	3	0	593468	50,95,875
Nadia	1	700	469	1034	8	29	47	172	17	43	1	10	7	2	1437591	51,67,600
North 24-Parganas	2	600	742	2002	38	116	52	334	22	83	1	20	6	1	5807128	1,00,09,781
South 24-Paiganas	1	625	1068	1632	3	42	61	272	30	68	1	16	9	1	2087997	81,61,961
Puruliya	1	506	485	586	0	7	52	96	20	24	1	6	5	1	373381	29,30,115
Uttar Dinajpur	1	400	344	601	4	7	18	100	8	25	1	6	1	1	362187	30,07,134
Murshidabad	1	300	5	1421	9	28	3	237	16	59	3	14	9	1	1405206	71,03,807
Total/Avg	22	9952	9382	18831	303	587	831	3139	554	785	31	188	92	28		941565565

Source: Author 2023, IPHS

As per above table we can have a clarification healthcare infrastructure of West Bengal district wise provided by government of West Bengal. So, the availability of health

care infrastructure in West Bengal in case of Rural and Urban sector consist of tree tier system, where there is a Sub Centre (SC) for every 3000 population with male and female

worker for Hill and Tribal and 5000 population for plain land, a Primary Health Care (PHC) centre for every 30000 population and Community Health centre for every 100000 population. And in urban area there is two tire system with Urban Health Centre (UHC) for every 100000 population followed by General Hospital that is Sub Divisional Hospital (SDH) or District Hospital (DH). (Hati and Majumder, 2013)

**Table 2: Health Infrastructure Score**

District	Combined Health Infrastructure Score					
	PHC Infrastructure		CHC Infrastructure		Composite Health Infrastructure	
	Score	Rank	Score	Rank	Score	Rank
Darjeeling	100.0	1	100.0	1	100.0	1
Jalpaiguri	65.1	7	61.3	10	61.9	8
Koch Bihar	64.2	9	65.2	6	64.4	7
Uttar Dinajpur	52.7	15	52.6	15	51.9	16
Dakshin Dinajpur	53.8	14	63.6	8	59.2	10
Maldah	52.6	16	56.5	12	54.3	13
Murshidabad	52.5	17	51.0	16	50.9	17
Birbhum	72.7	5	76.3	3	73.8	4
Bardhaman	62.3	10	62.2	9	60.9	9
Nadia	73.5	3	67.2	5	68.9	5
North 24 Parganas	64.8	8	46.8	18	53.0	15
Hugli	56.6	11	55.3	14	54.9	12
Bankura	73.4	4	76.2	4	74.7	3
Puruliya	82.0	2	79.3	2	79.9	2
Pachim Medinipur	71.3	6	64.1	7	66.2	6
Haora	54.1	12	55.6	13	53.2	14
South 24 Parganas	47.3	18	48.9	17	47.8	18
Purab Medinipur	54.1	13	58.8	11	56.4	11
<b>West Bengal</b>	<b>67.7</b>	<b>---</b>	<b>63.8</b>	<b>---</b>	<b>64.5</b>	<b>---</b>

Source: Author's calculation based on data from International Institute of Population Sciences and Dept. of Health and Family Welfare, Govt. of West Bengal

Source: Dept of Health and Family Welfare GO W. B

Form the above health infrastructure score of West Bengal District wise we can conclude that West Bengal does not stand well in the competitive factor in this infrastructure and so the health status of people gets affected. West Bengal with 1029 people per. sq km handle 2 to 3 times the pressure in health infrastructure. Major Drawback is in the spatial arrangement of health care infrastructure which can resolve the problem by proper analysis of location of health care infrastructure. From the above table 1 we can get inference about the lack of infrastructure as per IPHS guidelines in terms of population distribution and every district are lacking behind in catering the desire population.

**Spatial Analysis of the infrastructure**

There are 23 numbers of District level hospitals present till date in West Bengal and which continues to serve the people of each district apart from the people availing other hospitals of NGO or private organisations due to the lack in services or the distance in communication. Even we can observe that the districts of West Bengal sharing the boundaries of other regional states districts have an impact in the district hospital and 5% on an average of total bed occupancy of each districts is utilized by the nearby people of other states which in fact a social welfare in terms of reducing the regional disparity between states.

In GIS mapping techniques we can observe that the placement of districts hospitals and other healthcare infrastructure of each districts and the area of a defined population as per URDPFI norms of a district hospital can cater population and the radius of influence around each district hospital denotes the area that is most feasible to cater by the hospital and so the map analyses that the areas with a

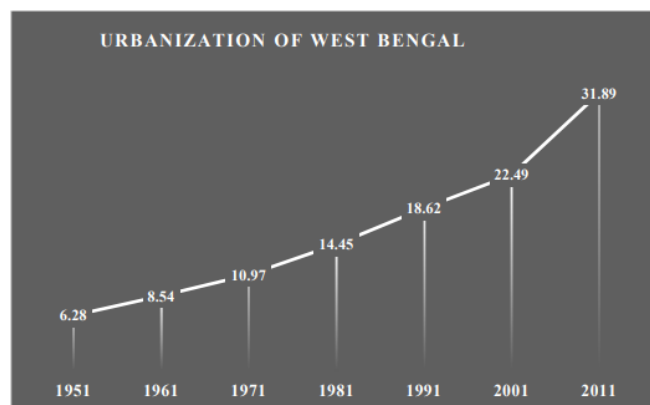
radius of 27 km having a population of 2 lakhs with feasible area.

Form this map we can observe a pattern that in North Bengal and South Bengal the Districts Hospitals are placed closer to each other which eventually forms a overlapping situation of over served areas.

Districts with larges spatial dimension the hospitals are located far apart which creates a space between two different districts of West Bengal and which evolved a space for privet and other NGO's to come up with their healthcare establishments.

We must not forget about other healthcare institution under government that are Rural Healthcare Centres, Sub Centres, Medical Colleges, and Primary Healthcare Centres which eventually tends to serve the gap areas in between districts but that main analysis of this paper is to understand the location of district hospitals.

From this thematic map we can observe a pattern that all the district hospitals are located at the city centres or central business districts of a city where the trends to serve the urban population more than that of a rural population. From the studies of urban health strategy (Government of West Bengal, 2008) have suggested that the health infrastructure is failing in West Bengal due to the urbanization growth trends and the over flooding of healthcare institution. As per report, 76% of health institutions are run by government in west Bengal where the main factor of failure in the infrastructure system due to urbanization and the location of these health institutions.



**Figure 1: Urbanization of West Bengal**

Source: Author 2023

One of the main reasons of over burdening is due to the location where people had to travel into city for their treatment and hence they trend to live nearby a healthcare institution. The paper suggested an objective about improving the health for all urban population with a special focus on poor and underserved and venerable which can only be solved by restructuring the framework of healthcare institutions.



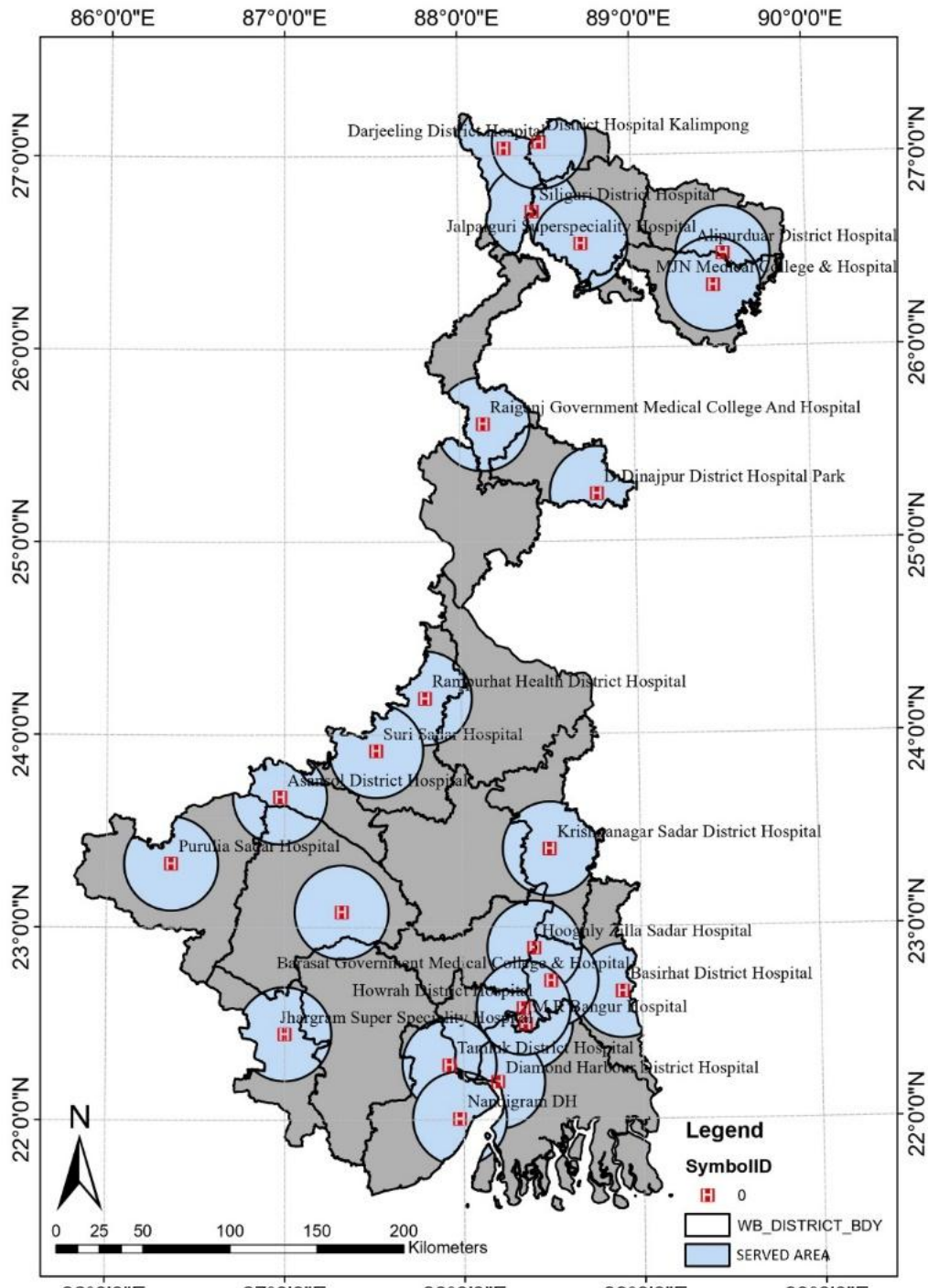


Figure 2: District Hospital Location of West Bengal

Source: Author 2023

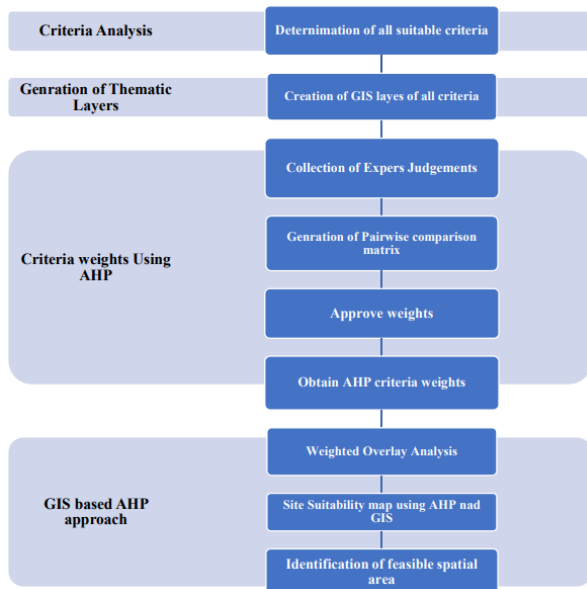
An initiative have been taken to spatial mapping by GIS of Health infrastructure in west Bengal by Kolkata metropolitan development (In, Population and Bengal, 2005) where they are mapping the health care institution of ULB wise data analysis. With this step ahead, a sense of location analysis should be important to understand the relationship by analysis the population with the urbanisation trend and help to decongest and reduce over burdening of urban population in health care infrastructure.

**AHP in Healthcare Infrastructure**

Analytical Hierarchy Process (AHP) consist of a proper methodology to study an area by criteria analysis which helps in the determination of all suitable criteria for the

location of hospitals and then with those criteria we need to generate the thematic lays of GIS layer maps. After collecting and organising the expert’s judgements in AHP data set of pairwise matrix comparison is assigned with weights and helps to obtain AHP criteria weights. So after the final outcome of weights of AHP criteria overlay analysis is to be performed to generate site suitability map using AHP and finally identification of best feasible land for hospital. (Tripathi, Agrawal and Gupta, 2022)

This can be explained using a methodology chart:



**Figure 3:** AHP Methodology

Source: Tripathi, Agrawal and Gupta, 2022

Criteria required for hierarchy analysis of hospital or healthcare infrastructural location area can be classified under 3 major level 1 criteria as Socio Economical, Geographical and Environmental.

### C1. Socio Economical Criteria

- 1) Population Density - The population density is an important factor determining the location as the hospital must serve or cater as much population it can to have an inequality structure.
- 2) Location of Slum - It's like a parasite to a city that is a part which we can't ignore and it starts to decay the whole city organisms and it requires a lot of health and sanitation attentions.
- 3) Proximity to Rural settlements - The rural settlement must also have an easy access to tertiary or secondary sector of health infrastructure with respect to the location.
- 4) Land Cost - land value can regulate the cost of providing a health institution.
- 5) Availability of governmental land - one of the main factors to judge the location based on availability of land under government infrastructure land use.

### C2. Geographical Criteria

- 1) Proximity to Road - Easy and effective access to road for the people of need can reduce almost 80% of the difficulties and barriers to access the hospital.
- 2) Distance from other healthcare institute - It's not very important but a distant must be kept in mind while location finding as there should be a radius to influence.
- 3) Proximity to Railway - Another important factor to consider the accessibility issue of the public.
- 4) Slope - To understand the gradient of the topography which can affect the location and can vary place to place. It's almost a location specific criterion.

### C3. Environmental Criteria

- 1) Air Pollution - Important factor to judge the climatic condition before assigning the location.

- 2) Green cover - Green cover area plays an important role in maintaining the micro climatic condition of that location and it can act upon the patient's physiologically.
- 3) Industrial area - Less industrial zones more suitable land it is for any kind of socio - economic development.
- 4) Water Bodies - Waters also plays an important role in marinating the micro and macro climatic condition.

This criterion is used to formulate the pair wise matrix comparison and then systematically generate thematic maps on this criterion by assigning weightage to the corresponding maps to formulate and compare them by overlaying the maps to generate the desire spatial areas where the feasibility of district hospitals should be established at that particular location.

### Delimiting the Region

Considering two adjacent districts of West Bengal where the rate of urbanisation is low as per 8.3% growth rate Purulia and Bankura (Rahaman and Das, 2018) as an analysis districts to apply the AHP & GIS techniques to determine the future district hospitals location to cater out the over burdening.

Purulia have a history from 5 century AD as Purulia was one of the 16 Mahajanapadas and was a part of the country known as Vajra Bhumi. (History | Purulia District, Government of West Bengal | India, no date) It has a population of 2930115 out of which only 12.74 % lives in urban and 87.26% in rural as per 2011 census. It also consists of 22667 villages and 25 census town and 3 statutory town and as per 2001 census the population was 2536516 which has a decadal growth of 13.43%.

Where Bankura history of is more of an ancient time line where the earliest sign of human habitation was found near Dihar about 1000BC chalcolithic people near the bank of Dwarakeswar river, it also has a history of Hindu raja of Bishnupur.

According to census 2011 the population of Bankura 3596292 and census 2001 3192695 with a population growth of 12.64%.

Both the state are sharing a common administrative boundary and having a spatial area of 6259sq. km and 6882 sq. km respectively. (District Profile | Purulia District, Government of West Bengal | India, no date)

### Socio Economical Factor of Bankura and Purulia

As per census 2001 and 2011 we can clearly have an idea of the socio economical factor of Purulia which is mostly dependent on primary sector for their livelihood and the district fall under the category of backward class. Maximum part of the district has an agro based infrastructure and which are remotely poor and lack of technological infrastructure. And by the decadal change we can also observe the change in occupation from agriculture to other secondary or tertiary sectoral shift in occupation. (Roy and Jana, 2015)

**Table 3:** Decadal Change of occupation of Purulia

Years	Cultivators	Agricultural Labourers	Household Industrial Workers	Other Workers
2001	22.43	11.2	4.68	17.57
2011	13.92	10.73	3.68	19.21

Source: Calculated from District Census Handbook of Purulia, 2001 & 2011

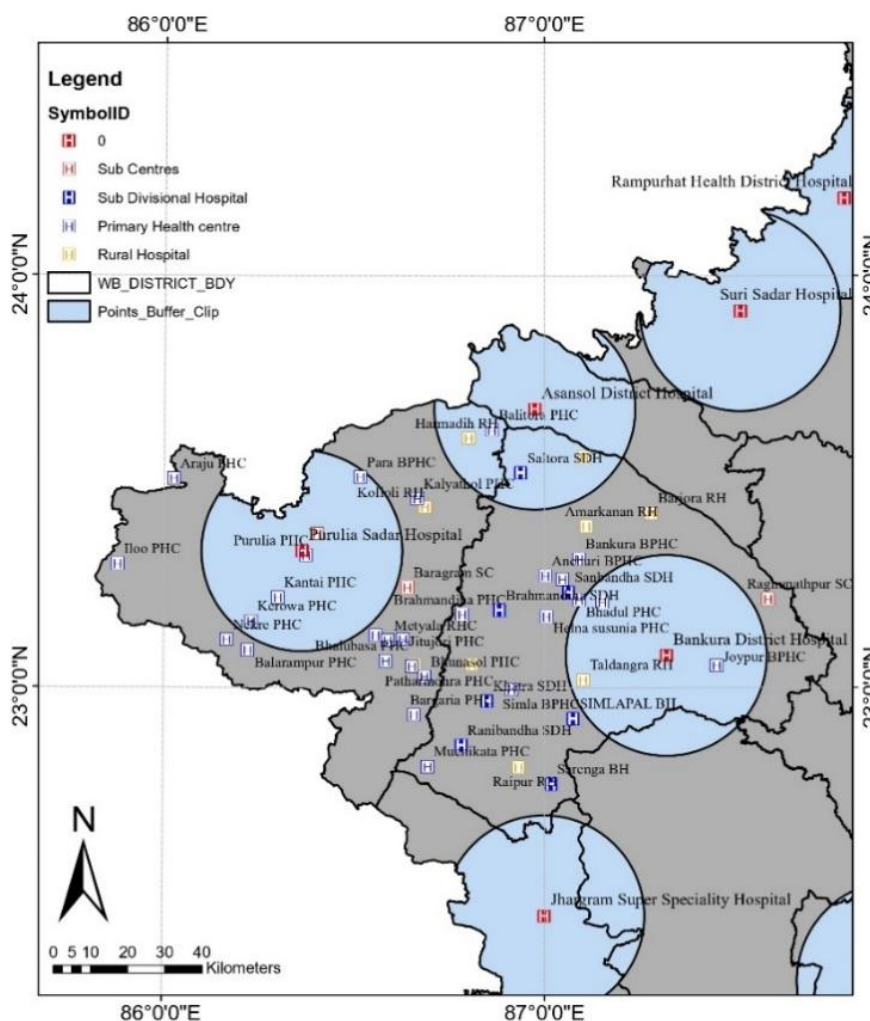
Source: Census 2001, 2011

According to West Bengal human development report 2004 income index of Bankura was 0.26 and by census 2011 we can have a clear view of occupational status of Bankura where the maximum is indulged in primary sector of economic work, where maximum is involved in agricultural labourers and only 7.4% of workers are in the urban area. With a high population growth and low socio economical factor according to Simpson index of occupation made the area poorer socio economic condition. (Chel, no date)

**Table 4:** Workforce Participation of Bankura

Bankura	Total Worker	Cultivators	Agricultural Labourers	Household Industrial Workers	Other	Simpson Index
Rural	1356914	22..69	47.37	4.00	25.94	0.6552
Urban	109396	1.69	4.16	6.49	8766	0.2253

Source: Census 2011



**Figure 4:** Healthcare infrastructure location of Bankura and Puruli

Source: Author 2023

Both Purulia and Bankura has a health care infrastructure consisting primary healthcare institution and tertiary health institution without the secondary sub divisional or district level hospital. A report by IPHS suggest that eventually the district hospitals must ready to transform into super speciality hospital (DGAFMS, 2004) but the report doesn't even talk about the location so the pre-existing location at the city centre remains constant and more and more attraction of people into the city will eventually make it a clumsy environment of over burdening and its all-round the same issue we discussed earlier in the literature studies.

So, the spatial location of health care infrastructure of these two districts and the area served as per the infrastructural capacity also with the unserved or over-served areas. This clarifies the pre-assumed issues of location in every secondary and tertiary health infrastructure. As we all know the primary and rural hospitals are needed to be located at the village centre which deals with the rural population of location specific.

After visualization of healthcare infrastructure of two adjacent districts of West Bengal we can understand and



have a sense of interlinkage between health institutions and their connectivity. Almost every spatial area are being covered by their radius of influence and very less number of tertiary health infrastructure are there where as we can observe the number of primary sector. As per the research of (Dey and Chattopadhyay, 2018) had classified the gap findings of healthcare infrastructure of West Bengal under 5 criteria from which they ranked up the districts into 4 division from very less deprived to highly deprived physical infrastructure where Purulia, Murshidabad, Maldha, Uttar dinajpur and Dakshin Dinajpur are highly deprived in physical infrastructure. We can observe the district with

huge spatial area tends to have less infrastructure due to its socio economic and cultural aspects and also due to connectivity. (Dey and Chattopadhyay, 2018)

**AHP utilization method:**

Pair wise matrix under these criteria are evaluated based on understanding and judgement knowledge to assign the scale of importance so the matrix could be produced on determining the importance level of each sub criteria to one another.

**Table 5:** District Hospital location analysis of Bankura and Purulia using AHP

District Hospital Location for Bankura and Purulia Districts														
Level 1 Criteria	Level 1 Criteria	Socio Economic Criteria					Geographical Criteria				Environmental Criteria			
	Level 2 Sub Criteria	Population Density	Location of Slum	Proximity to Rural settlements	Land Cost	Availability of governmental land	Proximity to Road	Distance from other healthcare institute	Proximity to Railway	Slope	Air Pollution	Green cover	Industrial area	Water Bodies
Socio Economic Criteria	Population Density	1.0000	0.5000	2.0000	5.0000	5.0000	6.0000	4.0000	6.0000	0.5000	0.3333	4.0000	3.0000	4.0000
	Location of Slum	2.0000	1.0000	3.0000	5.0000	7.0000	7.0000	5.0000	6.0000	0.2000	0.3333	4.0000	4.0000	5.0000
	Proximity to Rural settlements	0.5000	0.3333	1.0000	4.0000	4.0000	4.0000	0.2000	4.0000	2.0000	0.5000	4.0000	4.0000	4.0000
	Land Cost	0.2000	0.2000	0.2500	1.0000	7.0000	7.0000	0.2000	0.2500	0.5000	0.2000	0.2500	0.2500	0.2500
	Availability of governmental land	0.2000	0.1429	0.2500	0.1429	1.0000	2.0000	0.2500	4.0000	0.3333	0.2500	0.3333	0.2000	0.2000
Geographical Criteria	Proximity to Road	0.1667	0.1429	0.2500	0.1429	0.5000	1.0000	0.2000	0.5000	0.5000	0.3333	0.3333	0.2500	0.2500
	Distance from other healthcare institute	0.2500	0.2000	5.0000	5.0000	4.0000	5.0000	1.0000	4.0000	0.3333	2.0000	3.0000	3.0000	3.0000
	Proximity to Railway	0.1667	0.1667	0.2500	4.0000	0.2500	2.0000	0.2500	1.0000	0.2500	0.5000	0.3333	0.5000	0.3333
	Slope	2.0000	5.0000	0.5000	2.0000	3.0000	2.0000	3.0000	4.0000	1.0000	0.3333	2.0000	2.0000	0.3333
Environmental Criteria	Air Pollution	3.0000	3.0000	2.0000	5.0000	4.0000	3.0000	0.5000	2.0000	3.0000	1.0000	2.0000	2.0000	2.0000
	Green cover	0.3333	0.2500	0.2500	4.0000	3.0000	3.0000	0.3333	3.0000	0.5000	0.5000	1.0000	0.3333	0.3333
	Industrial area	0.3333	0.2500	0.2500	4.0000	5.0000	4.0000	0.3333	2.0000	0.5000	0.5000	3.0000	1.0000	3.0000
	Water Bodies	0.2500	0.2000	0.2500	4.0000	5.0000	4.0000	0.3333	3.0000	3.0000	0.5000	3.0000	0.3333	1.0000
Total		10.4000	11.3857	15.2500	43.2857	48.7500	50.0000	15.6000	39.7500	12.6167	7.2833	27.2500	20.8667	23.7000

Source: Author 2023

After assigning the scales of importance between the sub - criteria to total sum of each column with different criteria are added up to get a normalization weightage. Then all the total sum values of each columns are used to divide each values of the cell belongs to their column to obtain a new chart with normalised value.

**Table 6:** Normalization of District Hospital location analysis of Bankura and Purulia using AHP

NORMALIZATION District Hospital Location for Bankura and Purulia Districts																
Level 1 Criteria	Level 1 Criteria	Socio Economic Criteria					Geographical Criteria				Environmental Criteria				AVERAGE Wi	PERCENT AGE %
	Level 2 Sub Criteria	Population Density	Location of Slum	Proximity to Rural settlements	Land Cost	Availability of governmental land	Proximity to Road	Distance from other healthcare institute	Proximity to Railway	Slope	Air Pollution	Green cover	Industrial area	Water Bodies		
Socio Economic Criteria	Population Density	0.0962	0.0439	0.1311	0.1155	0.1026	0.1200	0.2564	0.1509	0.0396	0.0458	0.1468	0.1438	0.1688	0.1201	12.0106
	Location of Slum	0.1923	0.0878	0.1967	0.1155	0.1436	0.1400	0.3205	0.1509	0.0159	0.0458	0.1468	0.1917	0.2110	0.1507	15.0653
	Proximity to Rural settlements	0.0481	0.0293	0.0656	0.0924	0.0821	0.0800	0.0128	0.1006	0.1585	0.0686	0.1468	0.1917	0.1688	0.0958	9.5790
	Land Cost	0.0192	0.0176	0.0164	0.0231	0.1436	0.1400	0.0128	0.0063	0.0396	0.0275	0.0092	0.0120	0.0105	0.0368	3.6753
	Availability of governmental land	0.0192	0.0125	0.0164	0.0033	0.0205	0.0400	0.0160	0.1006	0.0264	0.0343	0.0122	0.0096	0.0084	0.0246	2.4588
Geographical Criteria	Proximity to Road	0.0160	0.0125	0.0164	0.0033	0.0103	0.0200	0.0128	0.0126	0.0396	0.0458	0.0122	0.0120	0.0105	0.0172	1.7237
	Distance from other healthcare institute	0.0240	0.0176	0.3279	0.1155	0.0821	0.1000	0.0641	0.1006	0.0264	0.2746	0.1101	0.1438	0.1266	0.1164	11.6402
	Proximity to Railway	0.0160	0.0146	0.0164	0.0924	0.0051	0.0400	0.0160	0.0252	0.0198	0.0686	0.0122	0.0240	0.0141	0.0280	2.8039
	Slope	0.1923	0.4391	0.0328	0.0462	0.0615	0.0400	0.1923	0.1006	0.0793	0.0458	0.0734	0.0958	0.0141	0.1087	10.8712
Environmental Criteria	Air Pollution	0.2885	0.2635	0.1311	0.1155	0.0821	0.0600	0.0321	0.0503	0.2378	0.1373	0.0734	0.0958	0.0844	0.1271	12.7057
	Green cover	0.0321	0.0220	0.0164	0.0924	0.0615	0.0600	0.0214	0.0755	0.0396	0.0686	0.0367	0.0160	0.0141	0.0428	4.2785
	Industrial area	0.0321	0.0220	0.0164	0.0924	0.1026	0.0800	0.0214	0.0503	0.0396	0.0686	0.1101	0.0479	0.1266	0.0623	6.2303
	Water Bodies	0.0240	0.0176	0.0164	0.0924	0.1026	0.0800	0.0214	0.0755	0.2378	0.0686	0.1101	0.0160	0.0422	0.0696	6.9577
CHECK TOTAL		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1	100

Source: Author 2023

After normalisation of each cell values then the average of all rows with each sub - criterion are calculated to find out the percentage of importance to be taken care of multiplication by 100 to obtain the percentage of weightage to be assigned to each criterion.

So, we observe that the height preferences to be taken care of the slum by 15% and then the population by 12% with the correspondence of air pollution of 12.7% so this value are used in the next step of application.

In the next step of application of this AHP values into GIS thematic map that were obtained based on criteria by implementing a weighted linear combination (WLC)

operation. (Tripathi, Agrawal and Gupta, 2022) In this process one or more criteria are taken into account and then each criteria is transformed into a GIS layer and manually decides the range values. The overall suitability map is obtain or generated by using the WLC equation which evaluates the suitability of land standardized score and normalized weight. (Tripathi, Agrawal and Gupta, 2022) Here  $A_j$  is the alternative score of  $j$ th value and  $X_i$  stand for standardize score of  $i$ th criteria and  $W_i$  represents the normalized weight of  $i$ th criteria.

$$A_j = \sum X_i * W_i, \text{ with } \sum W_i = 1$$

**Table 7:** Normalization factor calculation of district Hospital location analysis of Bankura and Purulia using AHP

NORMALIZATION District Hospital Location for Bankura and Purulia Districts																
Level 1 Criteria	Level 1 Criteria	Socio Economic Criteria					Geographical Criteria				Environmental Criteria				AVERAGE $W_i$	WLC
	Level 2 Sub Criteria	Population Density	Location of Slum	Proximity to Rural settlements	Land Cost	Availability of governmental land	Proximity to Road	Distance from other healthcare institute	Proximity to Railway	Slope	Air Pollution	Green cover	Industrial area	Water Bodies		
Socio Economic Criteria	Population Density	0.0962	0.0439	0.1311	0.1155	0.1026	0.1200	0.2564	0.1509	0.0396	0.0458	0.1468	0.1438	0.1688	0.1201	1.2491
	Location of Slum	0.1923	0.0878	0.1967	0.1155	0.1436	0.1400	0.3205	0.1509	0.0159	0.0458	0.1468	0.1917	0.2110	0.1507	1.7153
	Proximity to Rural settlements	0.0481	0.0293	0.0656	0.0924	0.0821	0.0800	0.0128	0.1006	0.1585	0.0686	0.1468	0.1917	0.1688	0.0958	1.4608
	Land Cost	0.0192	0.0176	0.0164	0.0231	0.1436	0.1400	0.0128	0.0063	0.0396	0.0275	0.0092	0.0120	0.0105	0.0368	1.5909
Geographical Criteria	Availability of governmental land	0.0192	0.0125	0.0164	0.0033	0.0205	0.0400	0.0160	0.1006	0.0264	0.0343	0.0122	0.0096	0.0084	0.0246	1.1986
	Proximity to Road	0.0160	0.0125	0.0164	0.0033	0.0103	0.0200	0.0128	0.0126	0.0396	0.0458	0.0122	0.0120	0.0105	0.0172	0.8618
	Distance from other healthcare institute	0.0240	0.0176	0.3279	0.1155	0.0821	0.1000	0.0641	0.1006	0.0264	0.2746	0.1101	0.1438	0.1266	0.1164	1.8159
	Proximity to Railway	0.0160	0.0146	0.0164	0.0924	0.0051	0.0400	0.0160	0.0252	0.0198	0.0686	0.0122	0.0240	0.0141	0.0280	1.1145
Environmental Criteria	Slope	0.1923	0.4391	0.0328	0.0462	0.0615	0.0400	0.1923	0.1006	0.0793	0.0458	0.0734	0.0958	0.0141	0.1087	1.3716
	Air Pollution	0.2885	0.2635	0.1311	0.1155	0.0821	0.0600	0.0321	0.0503	0.2378	0.1373	0.0734	0.0958	0.0844	0.1271	0.9254
	Green cover	0.0321	0.0220	0.0164	0.0924	0.0615	0.0600	0.0214	0.0755	0.0396	0.0686	0.0367	0.0160	0.0141	0.0428	1.1659
	Industrial area	0.0321	0.0220	0.0164	0.0924	0.1026	0.0800	0.0214	0.0503	0.0396	0.0686	0.1101	0.0479	0.1266	0.0623	1.3000
CHECK TOTAL	Water Bodies	0.0240	0.0176	0.0164	0.0924	0.1026	0.0800	0.0214	0.0755	0.2378	0.0686	0.1101	0.0160	0.0422	0.0696	1.6490
		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1	17.41885

Source: Author 2023

This value can indicate appropriate degree of  $j$ th location about  $i$ th criteria. In this method, total weight should be equal with 1, otherwise in last stage  $A_j$  should be divided on total of all weight thus  $A_j$  output will be between 0 and 1. Because higher or lower amount of output can be duo to an appropriate or inappropriate option, weight normalizing can be withdrawn. Weighted linear combination method can be performed by geographical information system and overlapping capacities of this system. Use of this method is practical in both raster format and geographical information system. (Zadeh et al., 2013)

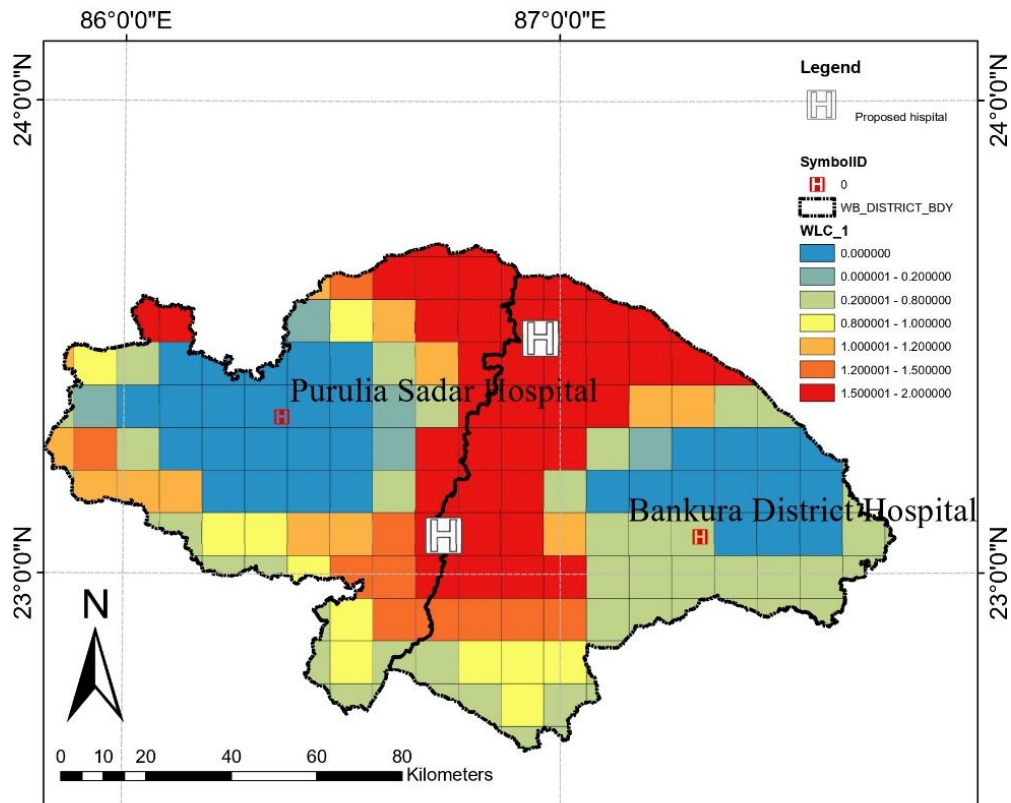
So, this WLC weightage are multiplied with the spatial area of  $i$ th criteria thematic map to obtain suitability map. The figure 5 showing the most suitable location for future hospital development and which will initially help to cater the desire population.

## 2. Process

The process of achieving the desire WLC map for identification of suitable location for healthcare infrastructure follows are:

- 1) Identification of existing healthcare facilities of the study area
- 2) Comparison with the standards and norms for gap identification
- 3) Identification of desire parameters as per land suitability and infrastructure.
- 4) Assigning weightage to individual Parameter X Parameter matrix to get the Normalization data.
- 5) Then in normalization matrix we need to find out the average of all matrix data and then after finding out the WLC weightage value.
- 6) By the help of Arc Map tool, we have divided the study area in 10km by 10km grid and assigning the desire weightage as per overlaying the existing maps.
- 7) By the interpolation tool we obtain the desire suitability map where the area is lacking behind in terms of healthcare infrastructure





**Figure 5:** Hospital Location suitability map using WLC weightage  
Source: Author 2023

### 3. Conclusion

Appropriate site selection calls for a scientific procedure to attain maximum efficiency. To do so using existing parameters need to be identified and subsequently a parameter vs parameter matrix has been formulated to arrive at appropriate weightage for each. The above - mentioned process is better known as AHP in scientific forum. In this paper the researchers have inlaid to better understand the AHP method and how the result of the same can be overlaid on physical attributes mapped through GIS mapping technique. Resulting to land suitability analysis. Thus, land suitability further gives an impression on locational choice for any particular use of land.

Taking the example of heath infrastructure in rural area of Bankura and Purulia of West Bengal the gap has been identified in terms of number of government / other hospitals as per benchmarks assigned by URDPFI and IPHS. The unserved geographical location has been identified lack in this infrastructure. This method shall be beneficial for the analysis to allocate appropriate location for inclusive development. The parameters which have been used to establish the process as developed method to extract maps above are schematic maps, Euclidian distance from road, types of habitable area, slope and couture, thereby give us to find out the normalization value of each parameters

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