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GEOECOLOGY OF CATARACT BLINDNESS IN INDIA

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Blindness is both a medical and social problem of considerable significance. This impairment may lead to partial or complete dependency of the affected people for the rest of their lives. This kind of impairment affects not only the person concerned but also their families on whom they are dependent. Increased dependency makes these people economically non-productive - a great stress on the staggering economy of the developing nations. It also has several social and psychological ramifications. It causes lot of physical and mental stress on individuals who are affected by it. It is also the leading disability in the world, with India alone accounting for one third of the total blindness in the country (Flaye and Foster 2000).

A review of the literature on the etiology of different kinds of blindness (Minassian and Chatterjee, 1990; Srinivas, 2001) points to the fact that the underlying factors for blindness are related to social, cultural, environmental and economic factors, thus making it a problem for geographic investigation. Blindness in different regions of the world varies by different types and associated causes. Higher prevalence of a particular type of blindness in a particular area can be related to various parameters such as climatic conditions, lifestyles, nutritional status of the population, access to health care delivery and so on. All these factors individually or cumulatively play a major role in different regions in the world (Taylor and Keefe, 2001).

It is important to examine questions pertaining to blindness such as the **prevalence** (in terms of distribution and causes) of blindness in the world. What are the factors that are responsible for its high incidence in certain parts of the world? Who are the people who are affected and where do they live? Why is the problem more acute in the developing, tropical countries with India alone accounting for the largest number of blinds in the world? The answers to the above quest leads us to another aspect of geographic research pertaining to **geoecology and epidemiology** of blindness in areas endemic

to it. The emphasis lies on understanding the various ecological domains, which may have a direct or indirect influence on high incidence of blindness in India. In keeping with the objective of this study it is important to first understand the prevalence of blindness in the world as a whole followed by its high incidence in certain parts of India.

1.1 PREVALENCE OF BLINDNESS IN THE WORLD

1.1.1 Global Pattern

Key facts

- 285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision.
- About 90% of the world's visually impaired live in low-income settings.
- 82% of people living with blindness are aged 50 and above.
- Globally, uncorrected refractive errors are the main cause of moderate and severe visual impairment; cataracts remain the leading cause of blindness in middle- and low-income countries.
- The number of people visually impaired from infectious diseases has reduced in the last 20 years according to global estimates work.
- 80% of all visual impairment can be prevented or cured.

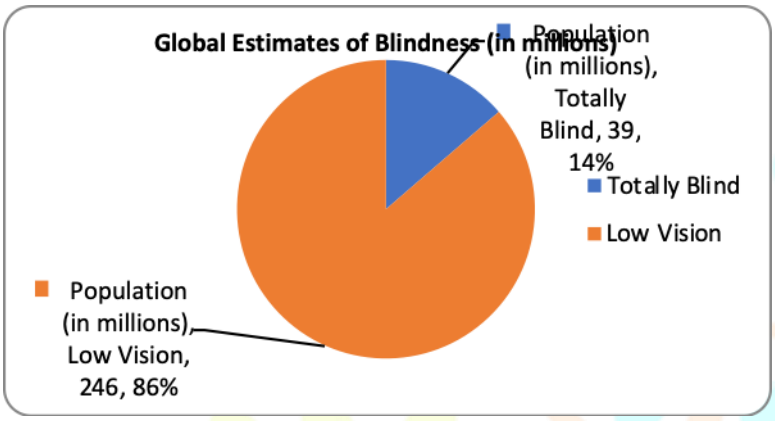
According to WHO estimates there are 39.36 million totally blind in the world of which nearly 8 million are in India alone thus accounting for nearly 20% of the world's blind population. It is pertinent to mention here that if the cases of low vision and visually impaired are also taken into consideration, then 285 million people are affected by visual impairment on a worldwide basis (Figure 1). Blindness is of various types but the most common type is cataract blindness accounting for more than 50% of total blindness in the world. Cataract blindness has higher incidence in the third world countries most of which are located in the tropical zone. Different regions in the world exhibit different kinds of blindness. Examples of some regions in the world associated with different types of blindness are given below:

- In **East Africa** river blindness and blindness due to nutritional deficiencies and measles amongst children are the most important causes.
- In **South East Asia** including India, blindness is mainly attributed to the development of cataract amongst the aging populations. Cataract blindness is a disease of the tropical countries. There is a substantially large population suffering from this kind of blindness that is related mainly to the

aging process. Besides cataract, infections of the eyes and trachoma are also major causes of blindness in the tropical lands.

- In **the developed world**, cataract blindness is well under control because of better health care delivery system. Here macular degeneration of the eye and diabetic retinopathy are the leading causes of blindness.

Figure 1



Source: www.who.int.org

There are two recent studies estimating the prevalence of blindness and vision loss. One was published by the World Health Organization Prevention of Blindness and Deafness Programme (WHO PBD) and the other by an expert group as part of the Global Burden of Diseases, Injuries and Risk Factors Study (GBD). The salient features of these two studies are:

• Both studies update the previous estimates by the World Health Organization (WHO) released in 1995, 2002, and 2004. These estimates provide point prevalence estimates globally and for each of the WHO regions. They also estimate the major causes of vision loss.

• The two studies differ in their analytic approaches, however.

• Therefore, the studies give different results for the estimates of global blindness and visual impairment.

The key findings of both studies are presented in Table 1. It is worth noting that both studies cite the need for better data, particularly a greater number of regular, nationally-representative surveys that use standardized methodologies as defined by the WHO and that report results disaggregated by age and gender. There is also a need for studies to include near vision, which is so important for people's daily lives at home and at work.

Table 1: Comparative Analysis of WHO PBD and GBD Findings

	WHO PBD	GBD
Global prevalence blindness and visual impairment	Total: 285 million Blind: 39 million Low Vision: 246 million	Total: 223.4million Blind: 32.4 million Moderate and severe visual impairment (MSVI): 191 million 95% uncertainty intervals: 29.4 – 36.5 million blind, 174 - 230 million visually impaired
Burden by gender		Women represent 60.0% of blindness and 57% of MSVI
Burden by age	≥50 years represent 82% of blindness and 65% of VI	≥50 years represent 84.6% of blindness and 77.5% of MSVI
Other key findings	The principal causes of blindness are: • Cataracts (51%) • Glaucoma (8%) • Age related macular degeneration (5%) • Childhood blindness and corneal opacities (4%)	A dramatic decrease (approximately 18 million cases of averted blindness) in the global age-standardized prevalence of blindness and MSVI for adults aged 50+ years: • 1990: 3.0% (2.7%-3.4%)

Source: www.who.int.org

1.1.2 Regional Burden of Blindness

On a global scale, there are widespread regional disparities as is seen in Table 2 below. Since WHO is the chief collector and custodian of health data including that of blindness in the world both globally and regionally, the analysis can be done on the basis of WHO regions as other estimates have been found to be not very scientific and robust.

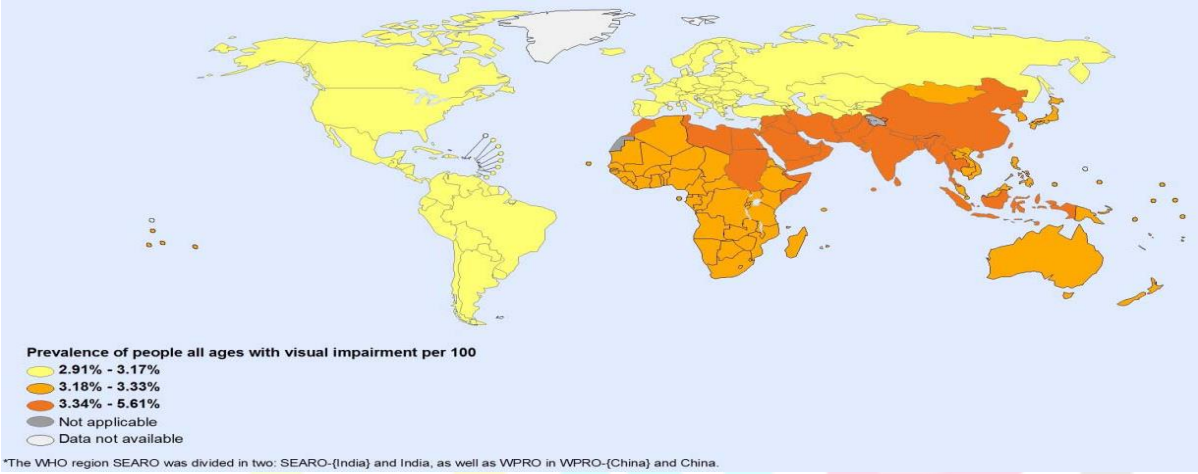
The following table indicates that the majority of blind population resides in India and China i.e. 20.5% and 20.9%. This is the precise reason why WHO has put forth separate for these two countries. Besides these two countries, African region, Eastern Mediterranean region and South East Asian region show high percentages of blind population.

Table 2: Number of Visually Impaired and Corresponding Percentages of the Global Impairment by WHO Region and Country, 2010

		Blindness	Low Vision	Visual impairment
WHO Regions	**Total population (in millions)**	**No. in millions (%)**	**No. in millions (%)**	**No. in millions (%)**
African Region	804.9	5.888 (15)	20.407 (8.3)	26.295 (9.2)
American Region	915.4	3.211 (8)	23.401 (9.5)	26.612 (9.3)
EasternMediterranean Region	580.2	4.918 (12.5)	18.581 (7.6)	23.449 (8.2)
European Region	889.2	2.713 (7)	25.502 (10.4)	28.215 (9.9)
South Eastern Asian Region (excluding India)	579.1	3.974 (10.1)	23.938 (9.7)	27.913 99.8)
Western Pacific Region (excluding China)	442.3	2.338 (6)	12.386 (5)	14.724 (5.2)
India	1181.4	8.075 (20.5)	54.544 (22.2)	62.619 (21.9)
China	1344.9	8.248 (20.9)	67.264 (27.3)	75.512 (26.5)
Total	6737.5	39.365 (100)	246.024 (100)	285.389 (100)

Source: WHO, 2010.

Figure 2: Global Prevalence Rate of Visual Impairment, 2010



Source: WHO, 2010.

People suffering from visual impairment per 100 population is an interesting measure to gauge the prevalence rate on a regional scale. WHO has been calculating this kind of data in the last few years (Figure 2) . The map clearly indicates that the continents of Asia and Africa have a much higher prevalence rate than other places like Americas or Europe. In Asia, the countries lying in the lower half of the continent and in Africa, the North Eastern side is worst affected. This aspect can be clearly attributed to the fact that these are first tropical countries receiving abundant sunshine and second both these areas have low income economies which are perennially poverty stricken and suffering from problems of malnourishment and undernourishment. Both these factors play a key role in prevalence of blindness as a whole.

1.1.3 Distribution of Blindness by Age

Blindness is most prevalent in the age group of 50 and older as shown in Table 3.

Table 3: Global Estimate of Number of People Visually Impaired by Age, 2010

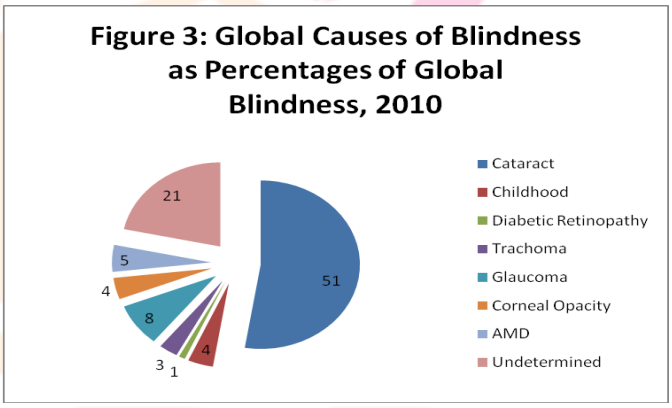
Ages	Population (in millions)	Blind (in millions)	Low Vision (in millions)	Visually Impaired (in millions)
0 – 14	1848.50	1.421	17.518	18.939
15 – 49	3548.2	5.784	74.463	80.248
50 and older	1340.80	32.16	154.043	186.203
All ages	6737.50	39.365	246.024	285.389

Source: WHO, 2010.

It is as high as 86.69% of the total blind population. This is a fairly high percentage of population and this can be attributed to senile cataracts which commonly afflict the aged population. This is followed by the age group of 15 – 49 years which accounts for 14.69% of the blind population in the world. The age group of 0 – 14 years accounts for the smallest proportion of blinds i.e. 3.6%.

1.1.4 Distribution of Blindness by Cause

The three main causes of blindness in the world are cataract, trachoma, and glaucoma that together account for 62% of all blindness as is shown in Figure 3. The relative importance of each of these three diseases varies greatly by region because of differences in demographic structures disease incidence and availability/ accessibility of eye-care services.



Source: WHO, 2010

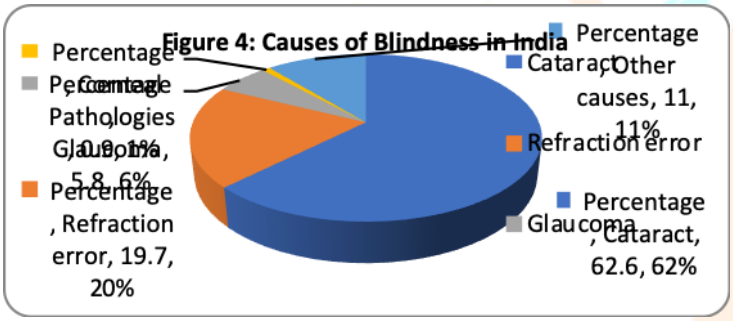
According to World Development Report 1998, prevalence of blindness was highest in India followed by Africa and China in 1998. The present Indian situation will be discussed in the forthcoming sections. According to WHO, it is estimated that there will be about 54 million blind people aged 60 and above by the year 2020 in the world, of whom more than 50 million would be in the developing countries.

The pace of demographic changes has been and is expected to continue to be faster in the developing countries as death rates are declining faster with rapid improvements in medical facilities. The life expectancy in these countries is also increasing at a faster rate as compared to the developed world. In these countries the projected increase of the aged population in the period 1980 to 2020 is likely to

be 356%. Therefore, the prevalence of blindness in senile population is definitely on the rise with their numbers increasing so rapidly.

1.2 PREVALENCE OF BLINDNESS IN INDIA

It is noteworthy that the scourge of blindness has assumed alarming proportions in some of the developing countries like India according to WHO estimates. Most of the blindness (cataract) occurs inevitably due to the aging process of the body. However, this aging process may start at different age for different individuals depending on the kind of environment in which an individual is living. According to WHO reports (Kupfer, 1998) the reason for high incidence of cataract blindness in these countries is because the aging process starts at a much earlier age due to geographical reasons. The Indian situation is no different. India accounts for one- fifth of the total blindness in the world. It is an enormous problem in India in terms of both economic loss and social burden. At present there are nearly 8 million blind eyes in the country and about 62.6% of this is because of cataract. Other reasons are refraction error (19.7%), glaucoma (5.8%), corneal pathologies (0.9%) and other undetermined causes (11%). It is estimated that nearly 30,000 blinds are added every year.

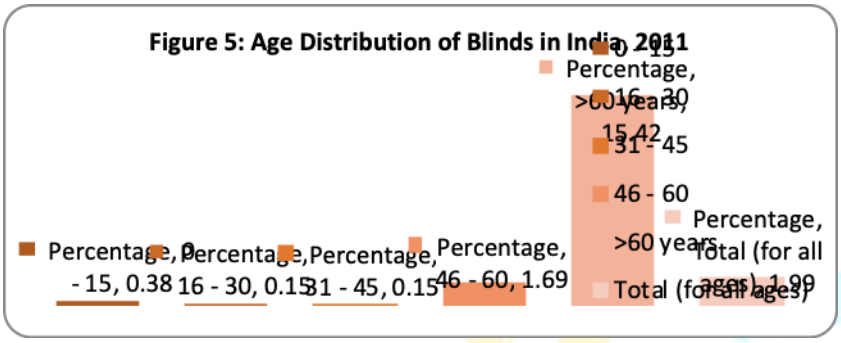


Source: Vision 2020India.org

Fortunately, cataract blindness is curable and eyesight can be restored in 90% of the cases that are operated (Kupfer, 1998). The technique of the cataract operation has improved tremendously over the years and the success rate is very high.

The present annual level of performance of cataract operation is in the order of 1.6 – 1.9 million. To clear the backlog of cataract cases by the year 2000 and to tackle the rising incidence, 5 to 6 million cataract operations annually will have to be performed (Vajpayee and Joshi, 1993). India, a vast tropical country has a wide range of variation in climate and relief. In various parts of the country one comes across adverse environmental factors, varied social and cultural patterns, illiteracy, superstitions, taboos, poor sanitation and low personal hygiene. No wonder, many diseases occur in high proportions in our country.

Although the problem of blindness in India has always been acute going by the absolute number of blind, in the country, little effort had been made by the Government to collect spatial and temporal data so that the actual magnitude of different kinds of blindness could be determined. Before independence blindness data for different regions was made available by the Census of India 1891.



Age-specific data is another important measure for introduction of interventions in this area.

Figure 5 shows that about 1.99% of the population is blind

Source: Borker, 2011.

out of the total population. To break this proportion into age-wise data, the maximum number of blinds i.e. 15.42% in the country fall in the >60 years group, which again reflects the dominance of cataract blindness that is directly related to older age. This followed by 46-60 years group, 0 – 15 years and 16 – 30 and 31 – 45 years.

A state-wise analysis reveals that the maximum number of blind persons/ 1000 population is seen in Assam (28.7) closely followed by Arunachal Pradesh (21.4). Uttarakhand and Kerala show the minimum number of blinds at 5.3 per 1000 population. As far as age wise analysis is concerned both Assam and Arunachal Pradesh have the highest number of blinds in almost all categories.

Table 5: State/UT Estimated Prevalence per 1000 population

No	States/UTs	0-14 years	15-49 years	50+ years	Male	Female	All ages
	India	**0.1**	**0.6**	**77.3**	**10.2**	**12.2**	**11.2**
1	Andhra Pradesh	0.1	0.7	89.2	12.4	14.3	13.3
2	Arunachal Pradesh	0.2	1.2	209.1	19.3	23.8	21.4
3	Assam	0.3	1.4	236.9	26.1	31.5	28.7
4	Bihar	0.1	0.4	55.6	6.6	8.1	7.3
5	Chhattisgarh	0.1	0.8	111.2	13.7	16.6	15.1
6	Goa	0.1	0.7	98.7	13.6	15	14.3
7	Gujarat	0.1	0.5	72.1	9.2	11	10.1
8	Haryana	0.2	0.9	133.8	15.8	20	17.8
9	Himachal Pradesh	0.1	0.4	43.7	6.3	6.8	6.6
10	Jammu & Kashmir	0.1	0.9	130.4	14.2	16.1	15.1
11	Jharkhand	0.1	0.7	100.6	11.9	14.7	13.3
12	Karnataka	0.2	0.8	107.9	15.5	18	16.7
13	Kerala	0.1	0.2	27.8	5	5.5	5.3
14	Madhya Pradesh	0.1	0.6	80.1	9.9	12	10.9
15	Maharashtra	0.1	0.4	57	8.2	9.8	8.9

16	Manipur	0.1	0.7	105.1	12.3	13.7	13
17	Meghalaya	0.05	0.4	73.4	6.6	7.3	7
18	Mizoram	0.1	0.4	70.3	6.8	7.8	7.3
19	Nagaland	0.1	0.5	91.1	9	10.8	9.9
20	Odisha	0.1	0.6	84.6	12.2	14.2	13.2
21	Punjab	0.1	0.5	63.5	8.5	10.6	9.5
22	Rajasthan	0.1	0.8	109.5	13.1	16.1	14.6
23	Sikkim	0.05	0.3	60.2	5.6	6.7	6.1
24	Tamil Nadu	0.1	0.3	38.3	6.8	7.9	7.3
25	Tripura	0.1	0.4	56.6	6.8	7.7	7.2
26	Uttar Pradesh	0.1	0.5	66.3	7.9	9.9	8.8
27	Uttarakhand	0.04	0.3	39.5	4.7	5.9	5.3
28	West Bengal	0.1	0.5	76.2	10.1	12.3	11.2
29	A & N Islands	0.1	0.5	117.9	9.1	11.8	10.3
30	Chandigarh	0.1	0.4	94.1	8.2	11	9.5
31	D & N Haveli	0.1	0.5	89.6	8.5	9.4	8.9
32	Daman & Diu	0.1	0.5	80.8	9.6	10.5	10.1
33	Delhi	0.1	0.5	102.5	9.5	11.9	10.6
34	Lakshadweep	0.04	0.3	43.2	5	5.5	5.3
35	Puducherry	0.1	0.4	51.3	7	7.6	7.3

Note: Estimates are based on various surveys conducted by the National Programme for Control of Blindness (NPCB)
Source: Centre for Chronic Disease Control, National Commission on Macroeconomics and Health (NCMH) Background Papers- Burden
of Disease in India, 2005 (Latest)

1.3 CATARACT BLINDNESS IN INDIA

Blindness due to cataract presents an enormous problem in India not only in terms of human morbidity but also in terms of economic loss and social burden. About 62.6% of blindness in India is due problems relating to cataract. The annual incidence of blindness is about 3.8 million. The present level of performance is in the order of about 1.6-1.9 million cataract operations. In order to tackle the rising incidence, 5 to 6 million operations will have to be performed annually.

Available data shows that there is a decrease in the prevalence of cataract blindness above 50 years of age from 7.6% in 1989 to 5.3% in 2001. In estimating the cataract blindness rates at different time periods, age-specific prevalence rates in the 1989 and 2001 surveys were used to estimate the number of cataract blind in the country over the period 2005-2020. Prevalence of cataract blindness in 2001 in the 50+ population was as follows:

- 50-59 years – 1.85%
- 60-69 years – 5.63%
- 70+ years – 13.3%

Computing the age-specific prevalence rates of cataract blindness it was observed that over the period 1989-2001, there was a 32% reduction in the prevalence of cataract blindness at age 50-59

years, 54% reduction at ages 60- 69 and 22% reduction at ages 70+ years over a one-year period. It has been assumed that this trend will continue till 2020 (Murthy, et.al, 2008).

It is pertinent to mention here that cataract blindness is an imposing health challenge in the country. In spite of this fact research in this field on a spatial scale is still in its nascent stage. This kind of a research requires involvement of dedicated researchers including doctors, statisticians, social scientists and also government patronage so that effective data is generated which can help in planning effective interventions and strategies to deal with the problem. One such study was undertaken in the past and some major findings of this 1986-87 NPCB Survey Report were as follows:

- Females were found to be afflicted more compared to males. 160 females as against 142 males among every 10,000 people of that sex examined.
- Scheduled castes had the highest prevalence of blindness of 200 persons among every 10,000 scheduled caste people examined.
- Pockets like inaccessible tribal areas and periods of famine/ drought/ floods e.t.c are associated with high prevalence of vitamin A deficiency
- Northern and western parts of the country have higher prevalence of both cataract and trachoma which may be attributed to geographical conditions such as high temperatures, less cloud cover, drought prone, reducing vegetation cover etc. Cataract prevalence is found to be high in Jammu and Kashmir, Rajasthan, M.P.,U.P., Maharashtra, Andhra Pradesh, Tamil Nadu and Orissa.

According to this survey report the major causes responsible for high prevalence of cataract in the country are:

1. Increasing life expectancy
2. Significantly more people in the risk group (> 40).
3. Poor access to eye care facilities
4. Misconceptions about cataract surgery
5. Compromised water quality and environmental conditions
6. Lack of effective eye health education programmes

Cataract, which is the major cause of blindness both in the world and in India is curable by a simple operation in which the affected lens in the eye is either removed or replaced by an artificial lens (IOL surgery). Even though there are a large number of trained ophthalmic surgeons in the country, they are grossly underutilized because of the poor infra-structural facilities, their concentrations in the big cities, poor accessibility to health care delivery system in the vast rural and remote areas of the country.

Lack of knowledge and concern on the part of large number of people about the nature and cause of blindness and possible preventive measures add another dimension to the problem. There is wide spread ignorance among the people even about simple eye-care, the role of nutrition, personal hygiene and prompt treatment. The progression of lens opacities is very variable. Some patients develop a mature cataract within a short period after the initial opacities are noticed. The exact etiology of cataract is not clear. UV radiation is the most commonly stated cause but available evidence is not sufficient proof. Similarly dehyderational cases associated with repeated episodes of diarrhea early in life exhibit high incidence of cataract blindness. Other factors may include exposure to domestic smoke from biogas fuels, nutritional status, smoking, diabetes and deficiency of antioxidant vitamins.

1.3.1 Comparison of Climatic Elements with Prevalence of Cataract Blindness in India

In this section the prevalence of cataract blindness in the country is compared with certain climatic elements which are likely to influence the distribution of blindness especially cataract.

Annual sunshine hours are highest in northwestern part of the country (Rajasthan and southern part of Haryana) extending in the form of a belt towards the south- eastern drier parts across the Deccan Plateau and including large parts of Telangana in Orissa and Andhra Pradesh. These are highly drought prone, critical or vulnerable zones of the country where annual precipitation is highly variable and unpredictable. The cloud – cover is very less for most part of the year. Persons working outdoors for most part of the day are exposed to UV radiation, dry and dusty weather conditions, which can harm unprotected eyes considerably. Thus geographical conditions seem to influence early development of cataract blindness in these pockets of the country. Some of these parameters are discussed below.

(a) **Temperature -** Generally speaking temperature is highly correlated with evaporation. Temperature varies from season to season and also depends on the cloud-cover in a particular area. Evaporation is higher when temperatures are high and cloud cover is low. Evaporation is more during summer months when the sun is strong.

(b) **Humidity and wind -** In areas with low humidity evaporation is faster because the air has more water holding capacity. Besides wind also plays an important role. Humid air is constantly replaced by dry hot air leading to more evaporation. Moisture availability is also seasonal. More moisture (water) is available during the summer monsoons, which brings rains to almost all parts of the Indian subcontinent. However, there is great variation in the amount of rain received in different parts. The pockets of high annual evaporation include the northwestern part of the country, which includes the

dry, sandy, savannah type plains of Haryana and eastern Rajasthan, the Thar Desert of western Rajasthan. Another region where annual evaporation exceeds 250 cm lies in the leeward side of the Western Ghats, which includes the Chota Nagpur Plateau, Southern part of Bihar and some parts of Orissa.

Cataract is a condition when a normal transparent lens of the eye becomes opaque (clouded) thus blocking out the light and interfering with normal vision. A normal lens in the eye allows the light rays to pass through, and focuses a clean image on the retina and enables us to see. A cataract is neither a film nor a new growth. It is neither an infection nor a contagious disease. Cataract blindness is also referred to as senile cataract because it develops with age. Societies, which age faster, develop cataract at a much earlier age than others. In most patients, it is just a normal age related change of lens, analogous to graying of hair. Cataract is one of the leading causes of reversible blindness in India. In 95% of the patients, it is just a normal age related change of lens, analogous to graying of hair. The distribution of this kind of blindness in the country through several surveys and experience of doctors in the field has shown that certain areas in the country are endemic to cataract blindness. These areas are characterized by particular geographic conditions (physical, social, economic and cultural), which seem to influence the early development of cataract. Several ophthalmologists (Dhir, Detels, 1970) have theoretically realized the importance of investigating the environmental, social, cultural and demographic factors leading to early cataract formation in many regions of India. They have, however not been able to do much empirical work in this field especially in India where the problem of senile cataract is most serious. The etiology and geoecology of cataract blindness can be understood better by using a geographical perspective as well. The possible relationships of cataract formation through the above dimension are given below: -

- High incidence of cataract is witnessed in regions where cloud cover is low or sunlight hours are more. This is because ultra-violet radiation (UVR) leads to early development of cataract.
- Cataract is also common in areas where people consume hard water and consume large quantities of yogurt.
- The rural areas have higher prevalence of blindness about 57% more than the urban areas.

- Poverty, low income and illiteracy are also seen to be to be highly associated with this disease. These factors have an indirect effect as these may lead to deprivation of proper health care facilities, healthy living conditions and healthy food.
- Various ethnic and cultural groups tend to have different food habits and living styles, which over the years get manifested into genetic cause of cataract blindness. The literature survey has shown that genetic cause is the most predominant amongst all the risk factors since all the environmental factors together get manifested into these. Certain communities are more prone than the others.

Besides genetic reasons, history of high blood pressure and diabetes has also been associated with cataract blindness. Gastro intestinal infections result in malnutrition, acidaemia, uraemia and dehydration. These cause certain chemical changes in the body, which facilitates the development of cataract (Chylac, 1984). There is also an association between cataract and low consumption of proteins and antioxidants such as Vitamin C and E (Taylor and Jacques 1995). Cataract blindness is a multifactorial disease and its etiology can only be understood by applying a disease ecology approach, which may help to find solutions to the problem in a more scientific and holistic manner.

1.3.2 Geo - Ecology of Cataract Blindness in India

Possible risk factors for cataract development

The high prevalence of cataract blindness in certain parts of India may be attributed to the interplay of various ecological parameters, which together create conducive conditions for the same. These ecological parameters have complex relationship with each other and it becomes difficult to isolate certain exposures from the influence of other exposures. The interaction with the environment is dynamic and ever changing.

Table 6

DRIVING FORCES ⇒	➢ High population growth ➢ Poor economic growth ➢ Low levels of technology
PRESSURE ⇒	Driving forces imposes different kinds of pressure conditions:- ➢ Environmental- high UV radiation, cloudless skies, lack of vegetation, deforestation ➢ Social- population pressure, culture, traditions, lifestyles ➢ Economic – due to poverty and occupations

STATE ⟹	These are conditions to which people are exposed in a particular milieu.
EXPOSURE ⟹	Actual amount of exposure which is dose related and varies from person to person
EFFECT ⟹	Exposures have a wide range of health effects. High exposure to UV radiation with low means of protection due to poverty, ignorance and poor diets may lead to early aging, which in turn leads to cataract development.
ACTION ⟹	After identifying the important links between different aspects of development, environment and health so that effective strategies may be formulated to control and prevent adverse health effects.

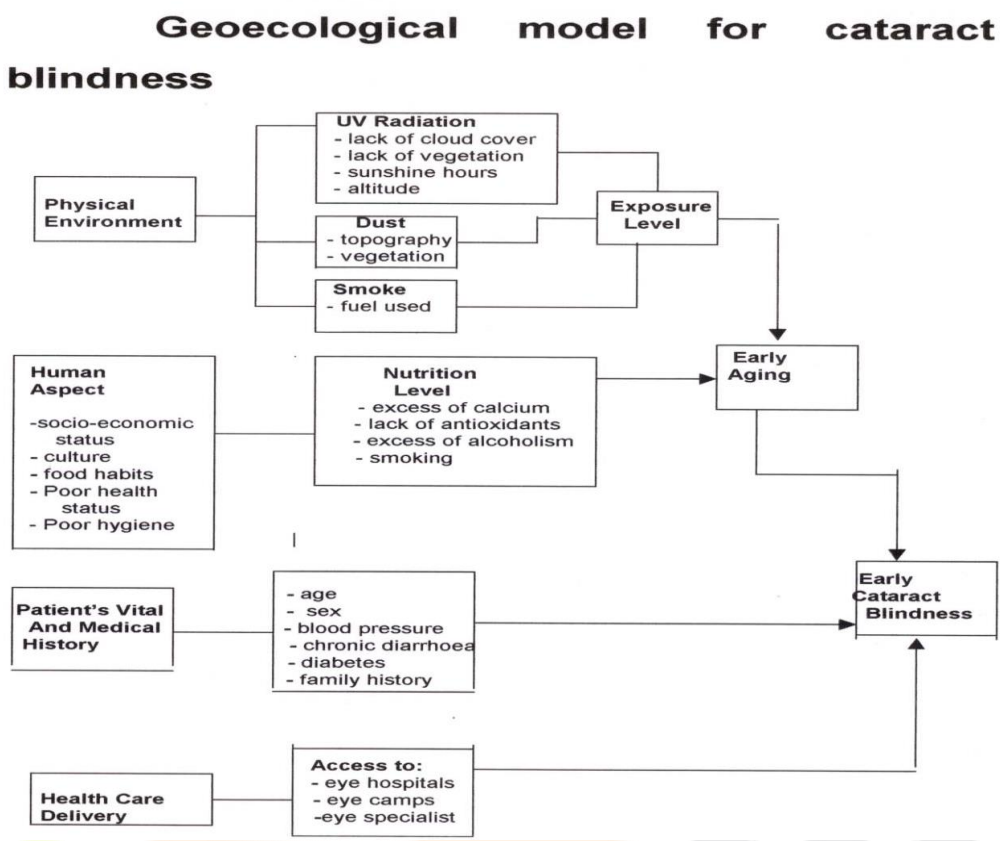
Different researchers have given different models for analytical work on multifactorial diseases . One such model was given by Briggs, Corvalan and Nuriman in 1996. This model is called THE CAUSE – EFFECT FRAMEWORK, which can also be applied to the study of cataract. This framework helps to identify driving forces, pressure conditions, state, exposure levels, effects and action plans associated with a particular disease. This model for cataract blindness is given in Table 6:-

In order to understand the exact role played by the different factors, there is need to develop a geo-ecological model (Figure 6). Senile cataracts are of known etiology. Few epidemiological studies of this common and heterogeneous condition have identified several factors associated with an increased frequency of lens changes. Some of these studies are listed below:-

1. In 1998 Ughade, Zodpey and Khanolkar associated age-related cataract in central India with 21 risk factors. Of which low socio-economic status, cheap cooking fuel, history of diarrhoea, smoking, diabetes, low body mass index and heavy alcohol consumption were significantly influencing early cataract development.
2. Madan Mohan, Angra and Sperduto earlier conducted such a study in 1989 in which cataract blindness was studied in relation to several factors.
3. Outside India similar risk factors were identified by Chylac and Leske (1991) in U.S.A and McCarty and Taylor (1999) in Australia.

Although most of the earlier studies recognize the contribution of such factors in influencing early development of cataract, few scholars have attempted a holistic treatment. Even health organizations like the WHO are advocating the use of this approach while formulating action programmes for the elimination of chronic diseases having multifactorial causation. The ecological and ecosystem perspective appears to be more appealing for nutrition analysis than the piecemeal approaches because of their holistic and integrative nature. A theoretical basis for such interactions and interrelations is presented in the following discussion.

Figure 6



The various risk factors that have been associated with early development of cataract may be grouped under four broad categories (Figure 6), namely physical environment, human aspect, patient's vital and medical history and health care delivery system. Of these, the first two are geographical factors, which assert influence on early aging process (oxidation of crystalline lens) and early development of cataract. The present study concentrates on these two aspects of cataract development.

1. Exposure to Physical Environment

The worldwide distribution of cataract and cataract blindness varies widely, with senile cataracts being especially common in developing countries located in tropical regions. A study conducted by Brilliant and Chatterjee (1983) reported higher incidence of cataract blindness (almost three times) in the Punjab plains lying in the hot and dry tropical zone as compared to Framingham (U.S.A) lying in the temperate zone. As shown in Figure 6 certain elements of the physical environment determine the exposure to high ultra-violet radiation, dust and smoke which are irritants to the eye and result in early aging and early development of cataract blindness. The various elements of the natural environment cannot be separated from each other since they influence one another.

a) Exposure to UV Radiation

There is evidence to suggest that exposure to radiation from almost all regions of the electromagnetic spectrum is capable of damaging the lens in the eye (Brilliant, 1980; Mohan, 1989; Chaudhary, 1988). This is of particular concern because the eye as the skin is exposed to a wide spectrum of natural and man-made radiant energy. The risk of lens damage from ionizing and infrared radiation is well known, but recent attention has focused on the cataractogenic potential of ultraviolet light and microwave radiation.

Ultraviolet light (that part of the electromagnetic spectrum between 100 and 400 nanometers) is a prominent component of solar radiation and is artificially produced for a variety of industrial and medical purposes. UVR (ultraviolet radiation) above 295 nanometers readily penetrates the cornea and efficiently absorbed by the lens. Laboratory studies have shown that exposure to sunlight near ultra violet light results in chemical and physical changes in lens protein and alterations in lens epithelial cells. Photochemical processes involving oxidation of tryptophan is related to cataract development (Peyman, 1986).

In the case of Himalayas there are four variables operative with respect to ultraviolet radiation (Chatterjee, 1973).

- **Effect of altitude**- It has been calculated that at 2000 mts, the ultraviolet flux may be 60% greater than at 2000 mts. for the same duration of sunlight much more UV exposure is experienced at high altitudes than at sea –level.
- **Duration of sunlight** - The regression of sunlight hours on altitude suggests that at 2000 mts, the average village in this study would receive about 8.5 hours of sunlight as compared to 12 hours of sunlight at sea level. This reduction of nearly 30% in sunlight hrs. partially offsets the gain in UV radiation associated with increasing altitude.
- **Latitude** - The higher peaks of the Himalayas are directly north of the plains further from the equator. The effect of latitude is a little difficult to ascertain in the presence of other variables.
- **Cloud cover-** There are fewer clouds over the unobstructed plains while more clouds accumulate over the hills and mountains. This is likely to widen the gap between radiant energy reaching hill villages and plain villages. This could be one of the reasons for low incidence of blindness reported in the north- eastern states of India where the terrain is hilly and skies remain cloudy for most part of the year.

b) Exposure to dust

Some studies in the past have also associated early cataract blindness with dusty conditions (Mohan 1989 and Ughade 1993)). Constant exposure to particle matter is common where sand blasting is common. Dusty conditions also prevail in arid areas where strong dusty winds raise dust from the ground into the atmosphere especially in the summer season.

c) Exposure to smoke

Here too the smoke particles cause the eye to have acute redness and dryness, which leads to early development of cataract. The ICMR study conducted by Mohan (1989) found higher instances of cataract blindness amongst women exposed to smoking chulhas (stoves) and using cheap firewood for cooking due to economic reasons. Likewise in many other Indian studies (Ughade and Khanotkar, 1999) it has been proved that use of cheap cooking fuels such as cow dung or wood leads to an increased risk of cataract.

Smoking is associated with cataract in a big way. It is believed that substances in inhaled cigarette smoke are carried internally to the eye and may cause the damage. It is felt that a similar pathway may be operating in the case of smoke inhaled from cheap cooking fuels. Smoking and tobacco chewing appear to induce oxidative stress and have been associated with both diminished levels of antioxidants, ascorbate and carotenoids and with enhanced cataract at a younger age (Flaye, Sullivan and Taylor, 2000).

Exposure has two dimensions – level and duration. Many environmental factors produce effects only after a long period of exposure. Many hazards (for e.g. radiation, noise) have a cummulative effect (WHO, 1980). For these hazards, the past exposure levels and the exposure duration are more important than the current exposure level.

2. Human Aspects

Literature survey of several studies on cataract blindness confirms the role of human factors (Fig. 9) to be equally important in the development of cataract in an early age. Human factors differ considerably from region to region especially in the case of developed and underdeveloped parts of the world. People belonging to developed economies, leading affluent lifestyles and maintaining a proper nutrition status are less exposed to the vagaries of the natural environment. Some of the human factors such as socio-economic status, health and hygiene levels of individuals, lifestyle, food habits, cultural practices and so on directly and indirectly influence the nutritional level of the affected populations which in turn influences the age of development of cataract.

a) Nutrition status

Nutrition level of the person plays a very important role in the development of cataract. Cataract formation like other age related symptoms are a result of oxidative stress. The lens has a very interesting structure. The lens fibers are continually replenishing throughout life. The lens actually grows. Its surface keeps getting compressed into the interior and new lens fibers grow outside. Once the lens fiber reaches its full length it begins to lose all its organelles, its mitochondria, its nucleus, its enzymes. So it is very vulnerable to any damage to its structure. The lens proteins have a certain size and there is accumulation of sulphur- hydrogen group at the center. With increased oxidation the S-H group drops its hydrogen and one gets S-S linkages with the increase in accumulation of these in the lens, it begins to turn opaque and a cataract is formed. UV radiation exposure actually accelerates the process of oxidation within the lens. Therefore UV radiation alongwith poor nutritional status enhances the development of cataract formation. Foods, which are antioxidant, are fresh vegetables and fruits with Vitamin A & E (these get destroyed on cooking). Intake of these in regular diet is quite essential to reduce oxidative processes taking place in the body (Mitchell 1935; Bunce 1979).

(i) Role of vitamins and antioxidants: Several recent scientific studies have shown that intake of large quantities of antioxidants slow down the aging process in the human body. They develop a natural defence mechanism by which the body is able to overcome the oxidative stress.

Previous studies have reported a relationship between nutritional status and cataract. There was an increased risk of cataract formation with low frequency of protein consumption. The proportion of insoluble protein in the lens of undernourished patients was significantly increased compared to well nourish patients while the total proteins remained unaltered, suggesting an increased insolubilization process. Patients with higher nutritional level have less risk of cataract development. Consumption of vitamins C, B and E along with luteins and carotenes have a protective effect as far as cataract is concerned. Some studies have also shown associations of mineral consumption with cataract development.

(ii) Role of calcium (milk): In 1935 Mitchell and Dodge reported that diets rich in lactose or galactose caused rapid and massive opacification of rat lenses. The sugar alcohol products accumulate in the lens since they are not efficiently metabolized and have relatively slower rates of diffusion out of the lens than the parent sugars. This accumulation in turn causes hyper tonicity and osmotic swelling which if sustained will bring about rupture of the fiber cells. Communities, which are more dependent on milk and milk products (curds, curd milk and other milk products), are at a higher risk as far as lens

opacities are concerned. This has been proved to some extent in a study that was conducted in Punjab by Chatterjee, Milton and Thyle, " Prevalence and etiology of cataract blindness in Punjab" in 1979.

Some established facts about nutrition status and cataract development are summed below: -

1. In general, the higher the nutritional level of an individual lesser the risk of cataract.
2. There is significant positive correlation between antioxidant levels measured as AO3 (referring to composite levels of vitamins C, vitamins E and luteins) and protection against various types of cataracts. Intake of carotenes (vitamin A) also prevents fast progression of cataract in human lenses.
3. There is also significant association between cataract and low frequency of current use of proteins.
4. High risk of cataract has also been associated with deficiency of vitamin B complex (riboflavin).
5. Higher intake of galactose (milk and milk products such as yogurt) is also positively associated with lens opacities. High intake of calcium leads to opacification of lens. This has been proved in a study conducted on the milk drinkers of a village in Punjab.
6. Deficiency of riboflavin leads to cataract formation. Riboflavin deficiency is not uncommon in alcoholics. Young people with senile cataract are often alcoholics.

(b) Patient's Vital and Medical history

Besides the above geographical factors there are several personal and medical parameters, which may cause development of cataract (Fig.9). These have been discussed below:-

(i) Age: The close association of cataract blindness with increasing age has been well documented in most studies. It is well established that cataract formation is a function of age. This fact has been proved by various cataract studies conducted all over the world irrespective of geographical conditions. It is well documented that senile cataract may serve as a marker for generalised tissue aging, since structural changes occuring in the protein of the lens during cataract formation are similar to those which occur elsewhere as part of the aging process (Medding and Hertzman 1998). The geographical factors in tropical countries like India, which lead to early ageing processes and therefore early development of cataract. It is estimated that a delay in cataract formation of about 10 years would reduce the prevalence of visually disabling cataract by about 45%. According to Kupfer C. (2000) such a delay would enhance the quality of life for much of the world's older population and substantially reduce the economic burden due to cataract related disability and cataract surgery.

(ii) Sex- Data from both Framingham Eye Study and Model Reporting Area for Blindness Statistics have shown that women over 65 years of age have higher rates of cataract blindness than men do. In the National Health and Nutrition Examination Survey for U.S.A (1981) lens opacities were

significantly more common in women than men. However, not many studies on the etiology of cataract blindness have shown any association of cataract with sex. However, a particular sex in a region may be more exposed to certain externalities for instance Ultra- violet radiation, dust and smoke. In such a case this particular sex may have a higher or an earlier development of cataract.

(iii) Medical factors- When sugar levels are elevated in the human body, glucose is converted by aldose reductase (enzyme which metabolizes aldose) into sorbitol; the accumulation of sorbitol has been shown to damage the lens. A long-standing clinical impression has been that cataracts are more frequent and occur earlier in diabetics than nondiabetics. However numerous clinical and epidemiological investigations have reported conflicting results.

The effects of excessive sorbitol and fructose in the diabetic lens result in increased quantities of Na+ ions (sodium) within the lens and subsequent loss of K+ ions, amino acids. The sodium ions draw water making the lens hydrated. This ruptures the lens fibers causing vacuolation in the lens cortex leading to opacity. The rate of cataract progression depends on the glucose levels in serum- the higher the glycerine, the faster the cataracts become mature. In the Framingham and Edinburgh studies high systemic blood pressure was associated with the presence of senile cataract. The contribution of genetic factors to senile cataracts also cannot be refuted. There are numerous reports of families with high cataract prevalence. Concordance of expression for cataract has been reported in monozygotic twins. Some studies suggest an association between cataract and genetically determined enzyme deficiencies

1.4 THE NEED FOR INTEGRATED POLICIES, STRATEGIES AND ACTION

The reasons for early cataract development are highly complex and multifaceted. The health or medical sector alone cannot address this problem on its own. New and innovative approaches are needed to integrate and operationalise effective action to tackle this problem. This effective action may incorporate –

- Action on the driving forces through policy development and implementation. This may include policies on population control, poverty elimination, literacy, arid-land management and land use management.
- Action on the pressures on environment through socio-economic development, improvement in quality of life, afforestation, soils conservation and sound agricultural practices.
- Action on the state of the environment through improvement in local participation in sanitation, sewage disposal, protection of flora and fauna for the protection of desert ecology, safe drinking water and use of non-polluting alternate sources of energy such as solar energy, biogas or LPG.

- Action on human exposure through education on personal protection and initiative such as protecting oneself from direct solar exposure and smoke, eating a diet which is protective and delays the onset of cataract
- Action on the effect i.e. extending the right kind of medical aid to cataract prone areas that is beneficial to all sections of the society. Efforts must be made, by a centralized body, for equitable distribution of foreign and government aid to combat the growing scourge of cataract blindness in India.

In order to find solutions to environmental health problems, interventions often corrective or remedial may be implemented at the source itself. The most effective long – term interventions aim to eliminate or reduce the effects of “driving forces” or “pressures” that produce the hazard.

Action on the driving forces, pressure and state of the environment eliminates the root causes of the problems associated with health-environment relationship. Actions on the specific exposures resulting in specific effects call for reactive approaches pertaining to the disease itself. Thus, a broad array of activities is clearly needed to solve the health - environment – development problems facing us today (Earth Summit Report 1992).

This type of blindness affects the aged population, which is growing in numbers all over the world with increasing life expectancy. More and more people are added on to the existing number of blind year after year. This is largely due to the degradation of environment, population pressure, climatic conditions and related geographical problems. Blindness has been mentioned as a major public health challenge and a debilitating factor for large elderly and other productive groups, but has not drawn much attention in social research and in health policies as it deserves. Blindness is also the leading disability faced by mankind and there is a need for understanding its etiology from the point of view of social scientist. All epidemiological studies on cataract blindness so far have adopted clinical approach because medical practitioners have conducted them. This is perhaps the reason why the programmes and policies adopted to overcome this growing scourge have not shown the desired results. There is need to adopt a disease ecology approach to identify the major factors which make a particular region endemic to a particular disease like cataract blindness. If in that particular region certain intervention policies are implemented to improve the geographic and social environment, it would help to find a more permanent solution to the problem.

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