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VOLUME 14

ISSUE 5

VERSION 1.0



GLOBAL JOURNAL OF HUMAN-SOCIAL SCIENCE: B
GEOGRAPHY, GEO-SCIENCES & ENVIRONMENTAL



GLOBAL JOURNAL OF HUMAN-SOCIAL SCIENCE: B
GEOGRAPHY, GEO-SCIENCES & ENVIRONMENTAL

VOLUME 14 ISSUE 5 (VER. 1.0)

OPEN ASSOCIATION OF RESEARCH SOCIETY

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GLOBAL JOURNAL OF HUMAN-SOCIAL SCIENCE: B
GEOGRAPHY, GEO-SCIENCES, ENVIRONMENTAL DISASTER
MANAGEMENT

Volume 14 Issue 5 Version 1.0 Year 2014

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-460X & Print ISSN: 0975-587X

Source Identification and Distribution of Toxic Trace Metals in Respirable Dust (PM₁₀) in Brasscity of India

By Raina Pal, Atul Kumar, Akhil Gupta, Mahima & Anamika Tripathi

Hindu College, India

Abstract- This study assessed the concentration of PM₁₀ and trace metals at six sites with different land uses during the period of one year. Metals concentrations of PM₁₀ were analyzed using ICP-OES. Highest concentrations of PM₁₀ were recorded in winter and lower in monsoon at all the study sites. The concentrations of trace metals in PM₁₀ were observed in the following order: Zn > Fe > Cu > Al > Pb > Cr > Mn > Cd > Ni. Overall concentration of PM₁₀ and heavy metals was found highest at industrial sites than the vehicular, commercial and residential sites shows the greater contribution of industrial and combustion process. Univariate (correlation study) and Multivariate statistical analysis were adopted including; factor analysis and enrichment factor analysis to identify the sources and their contribution to PM₁₀. The major source of airborne trace metals identified were brassware industries, illegal e-waste burning automobile emissions and combustion processes.

Keywords: *respirable dust, trace metals, principal component analysis, enrichment factor analysis, industrial activities, e-waste burning, automobile emissions.*

GJHSS-B Classification : *FOR Code: 040699*



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Source Identification and Distribution of Toxic Trace Metals in Respirable Dust (PM₁₀) in Brasscity of India

Raina Pal ^α, Atul Kumar ^σ, Akhil Gupta ^ρ, Mahima ^ω & Anamika Tripathi [¥]

Abstract- This study assessed the concentration of PM₁₀ and trace metals at six sites with different land uses during the period of one year. Metals concentrations of PM₁₀ were analyzed using ICP-OES. Highest concentrations of PM₁₀ were recorded in winter and lower in monsoon at all the study sites. The concentrations of trace metals in PM₁₀ were observed in the following order: Zn > Fe > Cu > Al > Pb > Cr > Mn > Cd > Ni. Overall concentration of PM₁₀ and heavy metals was found highest at industrial sites than the vehicular, commercial and residential sites shows the greater contribution of industrial and combustion process. Univariate (correlation study) and Multivariate statistical analysis were adopted including; factor analysis and enrichment factor analysis to identify the sources and their contribution to PM₁₀. The major source of airborne trace metals identified were brassware industries, illegal e-waste burning automobile emissions and combustion processes.

Keywords: *respirable dust, trace metals, principal component analysis, enrichment factor analysis, industrial activities, e-waste burning, automobile emissions.*

1. INTRODUCTION

Atmospheric particulate matter is considered as a prime pollutant of concern for urban cities, not only because of the adverse health effects, but also for the reducing atmospheric visibility (Grieken & Delalieux, 2004; Quinn et al., 2005). On a Global scale, particulate matter (PM) also influences directly and/or indirectly the Earth's radiation energy balance, and can subsequently impact on global climate change (IPCC, 2001). Atmospheric particulates are reported to affect ecosystems (Niyogi et al., 2004) and materials adversely. A number of studies have been undertaken focusing on the characteristics of aerosols in megacities of the world including Beijing, Colombo, Oxford, Amsterdam, Athena, Jeddah etc. (Sun et al., 2004; Seneviratne et al., 2011; Wojas and Almquist, 2007; Vallius 2005; Chaloulakou et al., 2003; Khodeir et al., 2012).

PM₁₀ particles (the fraction of particulates in air of very small size (<10μm) are of major current concern, as they are small enough to penetrate deep into the

lungs and so potentially pose significant health risks (Begum et al., 2004; Artinano et al., 2007; Guttikunda et al., 2014). The results of the long – term studies confirm that the adverse health effects are mainly due to particulate matter specially small particles – less than 10 microns in diameter, PM₁₀ (Schwartz et al., 1996). The particulate may include a broad range of chemical species, ranging from metals to organic and inorganic compounds (Tsai and Cheng, 2004; Park and Kim, 2005). Among the inorganic compounds, most important ones are the trace metals, which are emitted by various natural and anthropogenic sources such as crustal materials, road dust, construction activities, motor vehicles, coal and oil combustion, incineration and industrial metallurgical process (Quiterio et al., 2004; Shah et al., 2006; Park et al., 2008; Shah and Shaheen, 2010; Cheng et al., 2011). Industrial metallurgical process is regarded as one of the most important anthropogenic trace metal emission sources (Zheng et al., 2010) and produce the largest emissions of trace metals as As, Mn, Co, Cd, Cu, Ni and Zn (Vassilakos et al., 2006; Van et al., 2014).

Airborne particulate matter with elevated metals may have a serious impact on human health which mostly includes respiratory disease, lung cancer, heart disease and damage to other organs (Magas et al., 2007; Liu et al., 2009; Mavroidis and Chaloulakou, 2010). Within the European programme for monitoring and evaluation of the long – range transmission of air pollutants (EMEP), measurements of PM₁₀ and heavy metals, are highly toxic species have been introduced. These observations are influencing the environmental legislative authorities all over the world to update and modify their air quality standards (WHO, 2006; European Commission, 2004; USEPA, 2008). The recommended guidelines for maximum PM₁₀ concentrations are 50μgm⁻³ (24-h average) where as 20 μgm⁻³ for the annual average concentration.

Moradabad, the 'Brass city of India' is the second most populated city of state Uttar Pradesh and the most significant commercial centre of Northern India. More than 80 % of the total production of brass souvenirs and utensils of India is from Moradabad region alone. It is one of the largest producing and exporting center of brass-wares in India. The growth of the city over the last thirty years has been rapid and

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diverse, and continues to date. Unfortunately, due to lack of awareness and proper regulations, these developmental activities were accompanied by environmental degradation, and over the years the air quality is progressively deteriorated. The stationary sources of air pollution include brassware industries, large and small scale electroplating industries (Pathak et al., 2008) and illegal e-waste burning units in dense residential areas (Figure 1) while mobile source of pollution includes all forms of transportation. Vehicle fuels used in Moradabad are mainly unleaded gasoline and diesel although some lead is still permissible. Pollution assessment in this area is important since air quality has a major influence on workers of the industries and inhabitants living around the area.

The objective of the study was to assess air quality and to identify the main source by multivariate receptor modeling (PCA), enrichment factor (EF) calculation and analysis of meteorological effects. Anthropogenic enrichment of trace metals in atmospheric particulates were also envisaged along with the comparative evaluation of the estimated metal levels with those reported from other areas around the world. The results could be used as the baseline data for analysis of health risk due to inhalation of respirable dust (PM₁₀), and to provide scientific evidence for setting up an air pollution control.

II. MATERIAL AND METHODS

a) Geographical location and climate

Moradabad, estimated population 8,89,810 (census, 2011) is located in semi-arid zones towards the north-west of India. It is located at an average height of 76.19 mts above sea level in the western gangetic plain of Indian subcontinent at latitude 28.15N and 74.49E. It covers an area of 3516.62 km².

The general climate of Moradabad is cold and dry in winter (25-5°C), however, in summer it is characterized by high temperature (43-30°C) and humidity. During the entire sampling campaign the prevailing winds were North – West to West.

b) Site Description and sampling

For the study, six monitoring stations have been selected based on the predominance of residential, industrial, commercial and vehicular activities existing in the local areas. Taking the predominant land-use pattern as the selection criteria, PM₁₀ samples were simultaneously collected for three different seasons (summer, monsoon and winter) during one year period from March 2013- February 2014. The samples were collected with the help of Respirable Dust Samplers APM-460 NL (Envirotech, New Delhi) on Whatman glass fiber filter paper – GF-A. The instrument was operated at a flow rate of 1.0-1.5 m³/min and the monitoring of pollutants is carried out for 24 hours (8-hourly sampling for particulate matter) twice a week. Special attention

was paid while selecting sampling locations. Priority was given to guidelines prescribed by Central Pollution Control Board of India (CPCB, 2009) along with machine safety and availability of electricity. As per CPCB guidelines 104 observations are necessary in a year to analyze data over various reasons. But the guidelines also suggest in case of power shortage, machine safety or hostile weather conditions, to take a minimum of 40 observations for various seasons over the year. In the present study, 81 observations were made for various seasons throughout the year.

c) Analytical Technique

Before and after the sampling procedure, filters were kept for 48 h in desiccators in an environmentally conditioned room with a RH of 45±5% and a temperature of 20±2°C before being weighed by a microbalance (Sartorius BP160P). The difference in initial and final weight (gravimetric analysis) of the filter paper gave the total quantity of PM₁₀ collected over the 24 hours period. The values of PM₁₀ were reported in µgm⁻³. For analysis of metallic elements, total 72 square of 1×1 ins diameter (6 locations + 1 control/blank) of the fiber filter paper covered by particulates digested with nitric acid and perchloric acid in a ratio 1:3 on a 140°C hot plate till white fumes arose. Residues were then redissolved by 0.1M hydrochloric acid and the content was filtered through Whatman Filter no. 42 and finally made-up to 25 mL by double distilled water. The filtrate of each sample was examined for the concentrations of heavy metals by using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES; Spectro Analytical Instruments, West Midlands, UK) collected for each site at Metal Handicraft Service Centre, Peetal Nagari, Moradabad (Ministry of Textiles, Govt. of India). To get the final concentration results of the blank samples are subtracted from the exposed samples. For each of the metals the concentration of metals in the samples is then multiplied by the sample volume (i.e. 25 mL) to get the mass of each metal. These values are subsequently divided by corresponding total volume of sampled air to get the concentration of metals in the sampled air.

d) Data Analysis Techniques

Obtained data were processed for statistical analysis including univariate and multivariate methods. Basic statistical parameters such as mean and standard deviation are computed along with correlation analysis, while multivariate statistics in terms of Principal Component Analysis (PCA) as given by Lee and Hieu, 2011. Calculation of Enrichment Factors (EFs) was also performed using the SPSS version 16.0 statistical software.

III. RESULTS AND DISCUSSION

a) PM₁₀ concentrations

The site-to-site seasonal comparison of PM₁₀ mass concentration is statistically presented in Table 1. The range of mass concentrations varied considerably over time from 71 to 181 μgm^{-3} at Buddhi Vihar (SI, Residential) from 45 to 238 μgm^{-3} at Buddh Bazar (SII, Commercial), from 61 to 213 μgm^{-3} at Kapoor Company (SIII, Traffic density), from 54 to 174 μgm^{-3} at PTC (SIV, Residential), from 109 To 244 μgm^{-3} at Peetal Nagari (SV, Industrial) from 99 to 213 μgm^{-3} at Mughalpura (SVI, Industrial and illegal e-waste burning) and all the monthly mean values are found more than the recommended concentration of NAAQS (60 μgm^{-3}) except SII (45 μgm^{-3}) and SIV (54 μgm^{-3}) in the month of July and August respectively but all the values are high than the recommended concentration of WHO for PM₁₀ (20 μgm^{-3}) at all the study area (WHO, 2006). The annual average concentrations at each location were 124 ± 43 , 137 ± 59 and 131 ± 49 , 118 ± 45 , 193 ± 43 , 182 ± 39 μgm^{-3} respectively. The lowest concentration was found at PTC (SIV) the residential area which surrounds by greenery and the highest concentration was found at industrial area of Peetal Nagari characterized by industrial activity and soil dust.

The annual average values obtained from Peetal Nagari (SV) and Mughalpura (SVI) were higher than the USEPA recommended annual PM₁₀ ambient air quality standard, i.e. 150 μgm^{-3} (USEPA, 1999). However the value at the Buddhi Vihar (SI), Buddh Bazar (SII), Kapoor Company (SIII) and PTC (SIV) is lower than the USEPA PM₁₀ standard. The higher PM₁₀ concentrations at site Peetal Nagari and Mughalpura may reflect a significant contribution of anthropogenic sources compared to the other sites. High ambient PM₁₀ mass concentration peaks occurred at industrial sites, suggesting that contribution of stationary industrial emission were more important than the contribution of mobile sources even in areas with heavy traffic (Chen et al., 2008; Roy et al., 2012).

A seasonal variation was found as higher concentrations for PM₁₀ occurred in winter period (November-February) at all the study area than those of summer (March- June) which could possibly be attributed to the higher traffic density and combustion of fossil fuel for heating during winters as well as prevailed meteorological conditions (Table 2). The winter months of are relatively calm than other months thereby causing slow dispersion of pollutants generated and helps in buildup of pollutants in vicinity of the pollutant sources. Lower average mixing height in winter season results in less volume of troposphere available for mixing and hence higher PM₁₀ concentrations. The low temperature during winters lead to more energy consumption for industrial purpose resulting in emitting more emission of primary PM from the industrial sources (Lee & Hieu,

2011). Almost at all the sampling sites the concentration of PM₁₀ was found lowest (Table 1) in monsoon season (July-October) which usually has large amounts of precipitation and high relative humidity (Table 2). These meteorological conditions such as increased rainfall and humidity during the monsoon period can greatly decrease PM concentrations in ambient air via rainout or washout mechanism (Pillai et al., 2002; Glavas et al., 2008). Summer months (March-June) shows comparatively lower values than the winter may be due to high wind speed, causing dispersal of pollutants. Thus the difference in PM concentrations between the three seasons can be explained by the difference in weather pattern or meteorological conditions for each specific season.

Moradabad's PM levels were compared with those in different urban locations across Europe and Asia (Table 3). The average concentration of PM₁₀ i.e. 148 μgm^{-3} was recorded during this study which was significantly higher than the other studies of the world. It is near about the concentration found in Hyderabad i.e. 135 μgm^{-3} (Gummeneni et al., 2011), Cario i.e. 136 μgm^{-3} (Abu-Allaban et al., 2007) and Panzhuhua i.e. 137 μgm^{-3} (Yong-hua et al., 2010) but lower than the Beijing i.e. 209 μgm^{-3} (Sun et al., 2004). As the maximum average mass concentration during winter for PM₁₀ were 446, 573, and 631 μgm^{-3} at the traffic, industrial and residential sites in Beijing, respectively. These value were compared to the maximum PM₁₀ concentration of our sites which were 179, 203 μgm^{-3} at SI and SIV (compared to the residential site) respectively, 203, 213 μgm^{-3} at SII and SIII (compared to the traffic site) and 234, 213 μgm^{-3} at SV and SVI (compared to the industrial site). All these concentrations were less from the findings of Sun et al., 2004. As Moradabad is a small city comparatively to highly developed megacity Beijing, hence the sources are more in Beijing in comparison to Moradabad.

b) Trace Metal Concentrations

Considerable differences were noted with respect to metal content in samples of PM₁₀ from Buddhi Vihar (SI, Residential), Buddh Bazar (SII, Commercial) Kapoor company (SIII, Traffic) PTC (SIV, Residential), Peetal Nagari (SV, Industrial) and Mughalpura (SVI, Industrial and illegal e-waste burning). Heavy metals such as Fe, Al, Cu, Zn, Mn, Ni, Pb, Cr, and Cd concentration along with standard deviation were displayed in figure 2 at all the sampling sites. Among the trace metals Zn contributed the maximum concentration with annual average of 11.84 μgm^{-3} followed by Fe (9.41 μgm^{-3}), Cu (7.57 μgm^{-3}), Al (5.74 μgm^{-3}), Pb (1.99 μgm^{-3}), Cr (0.21 μgm^{-3}) Mn (0.11 μgm^{-3}), Cd (0.09 μgm^{-3}) and Ni (0.01 μgm^{-3}). Among all the six monitoring sites the highest concentration of Fe (18.43 μgm^{-3}), Al (10.08 μgm^{-3}) Cu (15.23 μgm^{-3}) and Cr (0.41 μgm^{-3}) was observed at Mughalpura (SVI) followed

by Peetal Nagari (SV) 17.07, 9.88, 14.84, 0.39 μgm^{-3} respectively while Zn (21.09, 21.21 μgm^{-3}) and Ni (0.031, 0.034 μgm^{-3}) was found almost same at both the site. The Mughalpura and Peetal Nagari sites were surrounded by many small and large scale brassware industries. In these industries, Brass (60% Cu and 40% Zn) and German silver (55% Cu, 35% Zn and 10% Ni) are the main alloys used for moulding purpose in making brassware items and other utensils in Moradabad. Brassware industries which are specialized in cutting, grinding, scraping, polishing etc. are the major cause of high concentration of these metals (Tripathi et al., 1990; Mahima et al., 2013; Pal et al., 2013; Pal et al., 2014). A lot of illegal e-waste is burned near the bank of river Ram Ganga i.e. Mughalpura area along with electroplating units of brassware industries. It is estimated that about half the circuit boards used in the appliances in India end up in Moradabad (Uttar Pradesh) also called the brass city of India (Down to Earth, 2010). The emission of toxic metal i.e. Ni, Cd, Pb, Cr, Zn, Hg, Co and As in the surrounding air by burning of e-waste affects the lungs, kidney, reproductive & nervous system, kidney and cause cancer (Brigden et al., 2005; Leung et al., 2008).

Peetal Nagari (industrial site), situated along the major road connected to Delhi is a major exporting centre of brasswares so the vehicular traffic as well as industrial activity could be the major source of Cu, Zn and Cr. As Cu is associated mainly with industrial activities, road traffic (diesel engine and wearing of brakes) could be the most important source in urban area. Zn is reliable tracer of unleaded fuel and diesel oil powered motor vehicles emissions (Monaci et al., 2000) and besides, it could be released in large amounts from tired friction or various industrial activities. Use of oil lubricants at the service centers, tire abrasions and vehicle exhausts are the possible sources of Cr at the study areas. Presence of such sources and their association with increased Cr and Zn concentrations comply with the findings of Karar et al., 2006 and Bhaskar et al., 2008.

Highest value of Pb (2.72 μgm^{-3}) and Cd (0.21 μgm^{-3}) was observed at Buddh Bazar (SII), a very busy commercial site along with vehicular activity throughout the day and night followed by Kapoor Company (SIII), 2.5, 0.17 μgm^{-3} respectively. The concentration of Pb in higher amount is mainly due to traffic volume (Tripathi, 1994; Xia and Gao, 2011). As lead pollution due to leaded gasoline still occurs in few cities (Prajapati et al., 2009; Andra et al., 2011). The major source of human lead accumulation in developing countries was found to be airborne lead and 90 percent of which comes from leaded gasoline (MECA, 2003). Cadmium, one of the most dangerous pollutants for organism, is mainly derived from combustion of accumulators and carburetors of vehicles (Divrikli et al., 2006). It is a major industrial pollutant particularly in areas associated with

smelting of zinc and heavy road traffic (Hassan et al., 2009). Mn which is mainly derived from the anthropogenic activities found highest mean value at Peetal Nagari followed by Kapoor Company. The residential sites showed comparatively the lower concentration.

c) Correlation Analysis

Correlation coefficient was used to establish interrelationship between metals (Table 4). The strong correlation (0.754, 0.729) was found between Fe-Al and Cu-Zn respectively in the study area. The significant correlation was found between Fe with Cu ($r=0.679$), Zn ($r=0.695$), Ni ($r=0.625$) and Cr ($r=0.504$). It is also found significant for Al with Cu ($r=0.688$), Zn ($r=0.581$), Ni ($r=0.643$) and Zn-Ni ($r=0.541$), Mn-Ni ($r=0.60$). It may be due to the industrial and anthropogenic activities like burning of fossil fuel. Zn-Cr ($r=0.433$), Al-Cr ($r=0.419$), Cu-Ni ($r=0.490$), Pb-Cd ($r=0.421$), Cr-Cd ($r=0.41$) showed the moderate correlation while the negative correlation was found between Ni-Pb and Ni-Cd. Based on the correlation study, it may be concluded that Fe, Al, Cu, Zn, Ni and Cr were contributed by some common sources, probably by industrial and anthropogenic Sources.

d) Factor Analysis

The principal application of factor analysis is to reduce the number of variables. This method focuses on cleaning up the factors. PCA was applied to determine the correlation between pollutants and to identify the source profile of heavy metals in PM₁₀. Table 5 describes the Principal Component (PC) loadings for the metal data of the study period with corresponding eigen values and variances. Based on this matrix three new sets of synthetic variables (Principal Component) were obtained. For interpreting of the data the method of Kaiser Criterion (Kaiser, 1960) is followed which retain only those factor having eigen value greater than 1 has been used for further interpretation. Factor loading > 0.71 are typically regarded as excellent and < 0.32 as very poor (Nowak, 1998). The 1st PC explains 40.113% of data variance and it is characterized by Fe, Al, Cu, Zn and Ni. These heavy metals are mainly related to the Industrial emissions, especially the metallurgical/ electroplating and e-waste burning units located in the industrial area of the city (Wang et al., 2001; Quiterio et al., 2004; Shah and Shaheen 2008). The 2nd factor characterized by Pb and Cd. These heavy metals are well known to be associated with the automobiles (Ayras and Kaushilina, 2000). The 3rd component is characterized by Mn, mainly derived from anthropogenic activities. The extracted components explain nearly 74.31% of the variability in the original 9 variables. The number of eigen values can be estimated from a scree plot demonstrated in figure 3. As shown in this figure, the eigen value sharply decrease within the first three

components and then slowly stabilize for the remaining ones.

e) *Enrichment Factor Analysis*

Enrichment factor (EF) analysis was used to differentiate between the metals originating from human activities and those of natural origin and to assess the degree of anthropogenic influence. By convention, the average metal concentration of the natural crust is used instead of the continental crust composition of the specific area, as detailed data for different areas are not easily available. There is no rule for the reference metal choice and Si, Al, and Fe have been used as the most common metals for this purpose (Lee and Hieu 2011). In this study, Fe used as the reference metal with upper continental crustal composition given by Taylor and McLennan (1985). Since iron (Fe) has been used as a reference metal for an EF evaluation, assuming that the contribution of its anthropogenic sources to the atmosphere is negligible (Nazir et al., 2011). The enrichment factor is calculated through the following equation:

$$EF = \frac{(E/R) \text{ air sample}}{(E/R) \text{ crust}}$$

EF represents the ratio of the fraction of the metal E with respect to reference metal R in the samples. (E/R) sample to the fraction of E with respect to the same R in the crust (E/R)crust. The EFs of individual metals are shown in Figure 4. According to the degree of enrichment, the metals were grouped as follows:

- Highly enriched (EF > 100) included Pb, Zn, Cu and Cd.
- Moderately enriched (EF between 10 and 100) none of them.
- Less enriched (EF less than 10) included Al, Mn, Ni and Cr.

In the present study, large variation of EF values was found for different metals in the respirable dust. Amongst these EFs of Cd and Cu are the highest followed by Zn and Pb. The higher EF values of these metals showed the anthropogenic sources (industrial, automobile and combustion emission) contributed a substantial amount of the metals in atmospheric particulates, which otherwise were difficult to justify on the basis of normal crustal weathering process. In contrast the less enriched metals were dominantly derived from earth crust, and re-suspension of soil dust. On the whole, all metals revealed EF greater than unity, thus predominantly contributed by the anthropogenic source.

IV. CONCLUSION

The study area covers a substantial portion of Moradabad city. Overall site specific analysis of PM₁₀

data reveals that Peetal Nagari is the most polluted area in terms of dust loading with a maximum concentration of 234 μgm^{-3} followed by Mughalpura. The concentrations of PM₁₀ in winter was higher than those in summer and monsoon. Increased energy uses, low temperature and low mixing height contributed to increasing PM concentrations in winter months while increased rainfall precipitation in monsoon period greatly contribute to decrease PM level. The concentration of PM₁₀ in Moradabad recorded high than those from the other sites in Europe and Asia except Beijing. The characterization of trace metal sources in the study area is quite challenging due to a large number of industrial and urban sources. High concentration of Zn, Cu, Cr and Ni at industrial site (Peetal Nagari and Mughalpura) was found mainly due to its use in brasswares and electroplating. Pb and Cd was found highest at traffic and commercial sites (Kapoor Company and Buddh Bazar) was due the vehicular emission and combustion process but the high concentration in Mughalpura area is mainly due to burning of e-waste near this site, which is brought from Delhi in an illegal way. Focusing our attention on metal source characterization, the multivariate techniques allowed us to identify three source components. The PC I (40.113%) is characterized by Fe Al, Cu, Zn and Ni which represents industrial emission and combustion of fossil fuel. The PC II (20.470%) is associated with vehicular traffic emission and characterized by Pb and Cd. The PC III (13.736%) is identified as anthropogenic sources and characterized by Mn. Calculation of enrichment factors (EF) of the trace metals showed high enrichment of Cd, Cu, Zn and Pb, indicating heavy contamination by anthropogenic sources. These results are also supported by correlation study. Hence we conclude that in the investigated areas the level of some trace metals are very high and the level of PM₁₀ was also found higher than the NAAQS and WHO standard even in the residential areas. Due to high pollution level the people of the study area are suffering from many diseases related to air pollution. This suggests that future strategies for air quality control on a local scale have to take into account not only the amount of atmospheric particles, but their chemical composition as well.

V. ACKNOWLEDGEMENTS

The authors gratefully acknowledge for the financial assistance provided by University Grant Commission, New Delhi and Uttar Pradesh Pollution Control Board, Lucknow (India). Thanks are also due to Dr. U. C. Shukla and Mr. V. K. Rajput, for their kind support in sampling and analyses.

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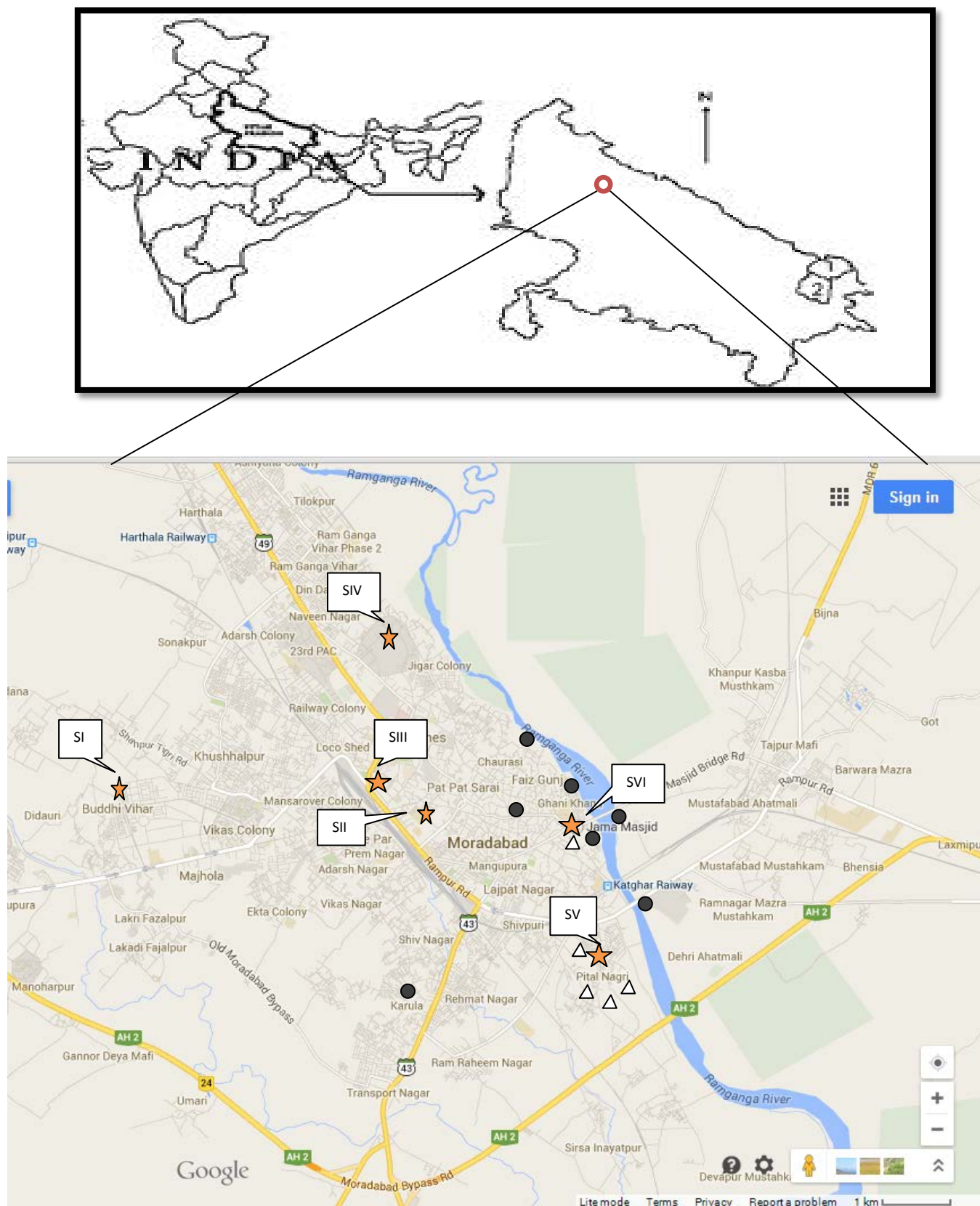


Figure 1 : Map of the study Area showing sampling locations (stars), brassware industries (triangle) and sites of illegal e-waste burning (circle)

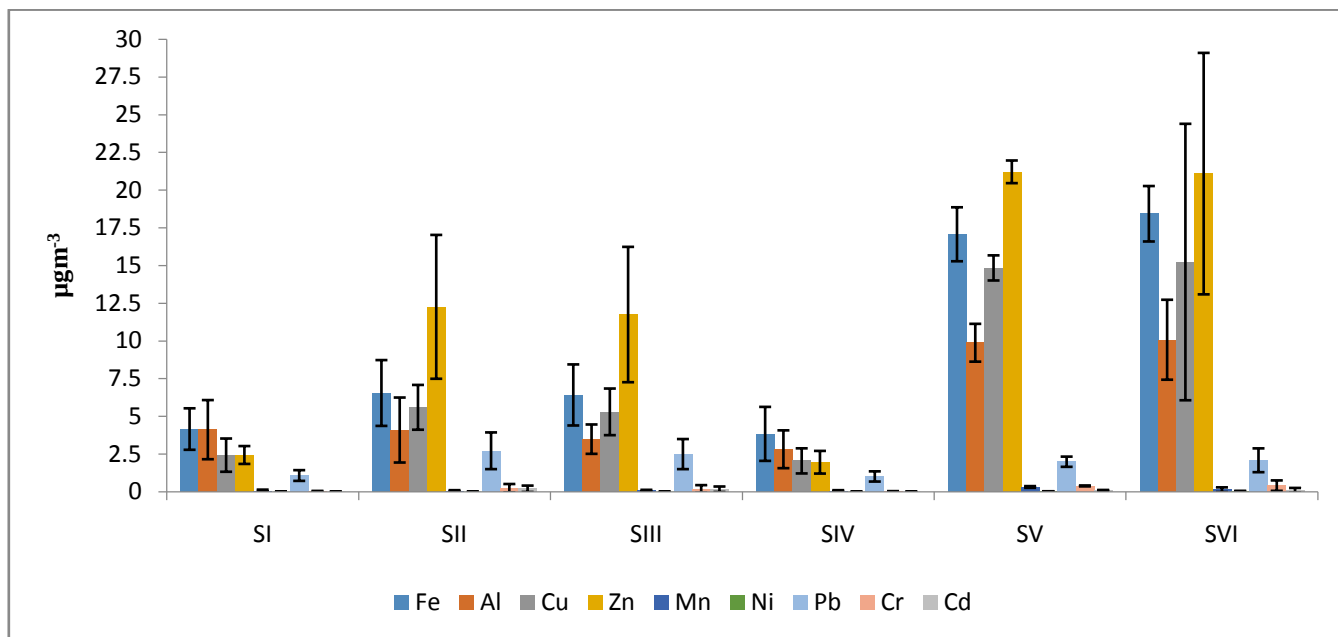


Figure 2 : Concentration of trace elements (Mean $\pm$ SD) at different study areas during the study period in Moradabad

Scree Plot

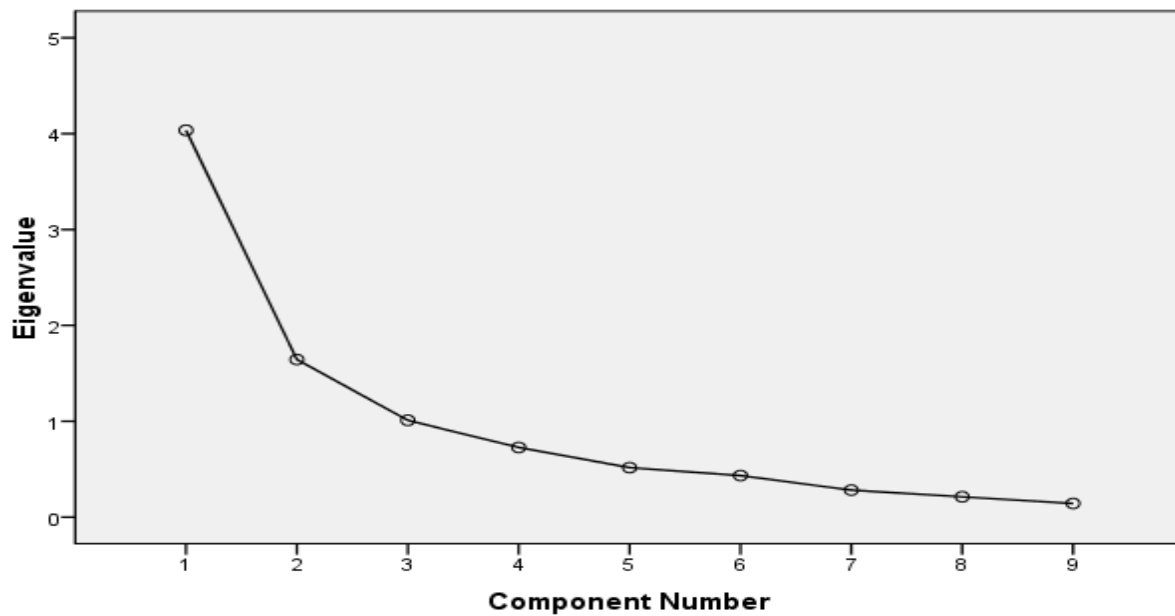


Figure 3 : Scree plot of metal concentration

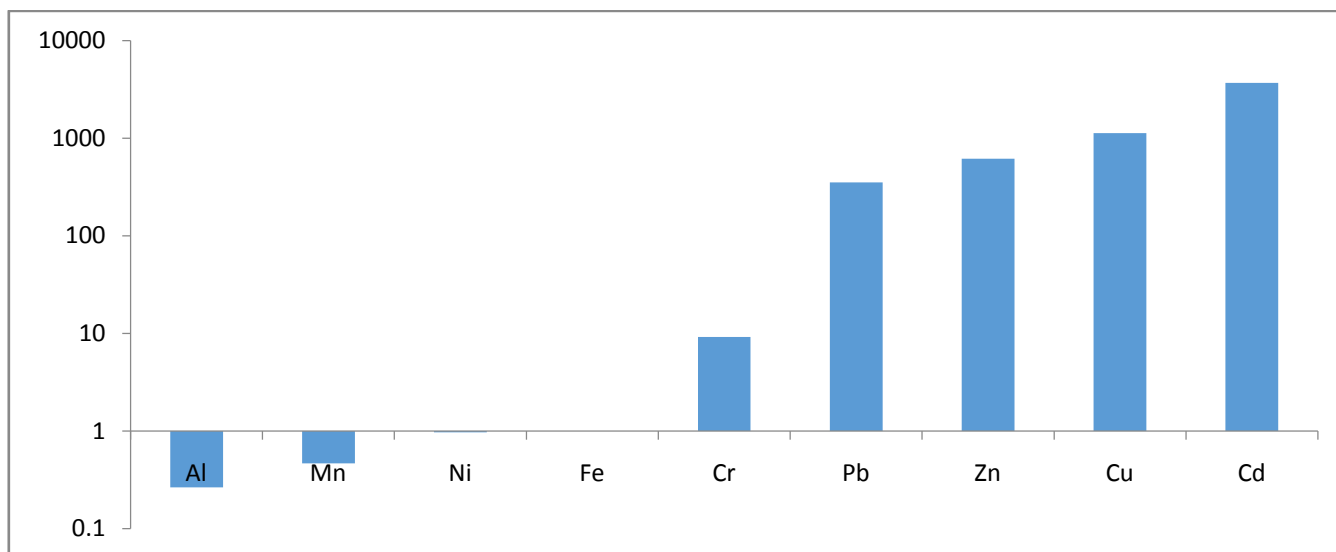


Figure 4 : Enrichment factor for trace metals in PM₁₀ with Fe as reference element in Moradabad

Table 1 : Statistical parameters of daily PM₁₀ mass concentrations (μgm^{-3}) in Moradabad from March 2013 – February 2014 (n=27 for each specific season)

Site	Period	X _A	S.D.	Max.	Min.	Median	98 th percentile
Residential (Site I)	Summer	115	34	157	86	109	155
	Winter	154	37	179	98	169	178
	Monsoon	105	51	181	71	84	175
Commercial (Site II)	Summer	176	45	238	138	164	234
	Winter	157	42	203	101	161	201
	Monsoon	78	41	139	45	65	134
Traffic (Site III)	Summer	123	35	172	75	134	151
	Winter	171	34	213	126	173	210
	Monsoon	100	53	177	61	70	172
Residential (Site IV)	Summer	108	35	151	71	103	150
	Winter	149	37	174	94	164	173
	Monsoon	98	55	161	54	69	171
Industrial (Site V)	Summer	223	26	244	188	230	243
	Winter	214	14	234	200	211	232
	Monsoon	141	28	178	109	161	176
Industrial Mix (Site VI)	Summer	202	5	209	198	200	208
	Winter	210	16	213	191	210	229
	Monsoon	135	29	170	99	155	168

Table 2 : Meteorological conditions at the study sites (mean) during sampling period

Meteorological parameter	Summer	Winter	Monsoon
Temperature (°C)	30.61±9.41	16.9±7.40	31.11±6.06
Humidity (RH) (%)	35.46±21.77	45.75±27.40	65.05±16.46
Wind speed (kmph)	9.53±0.99	8.33±0.65	7.86±1.88
Rain fall (mm)	1.82±3.21	2±3.01	9.99±9.69

Table 3 : Results of PM₁₀ concentrations in different urban cities

Locations	PM ₁₀ (µgm ⁻³)	Reference
Moradabad, India	148	Pal et al. (2014)
Panzhihua, China	137	Yong-hua et al. (2010)
Oxford, USA	16	Wojas and Almquist (2007)
Beijing, China	209	Sun et al. (2004)
Nepal	61-120	Giri et al. (2008)
Athens, Greece	76	Chaloulakou et al. (2003)
Amsterdam, Finland	36	Vallius (2005)
Erzurum, Turkey	31	Bayraktar et al. (2010)
Cairo, Egypt	136	Abu-Allaban et al. (2007)
Mumbai, India	61	Kumar and Joseph (2006)
Hyderabad, India	135	Gummeneni et al. (2011)
Colombo, Sri Lanka	50	Seneviratne et al. (2011)
Milan, Italy	63	Marcazzan et al. (2003)
Ulsan, Korea	37	Lee and Hieu (2011)
Jeddah, Saudi Arabia	87	Khodeir et al. (2012)

Table 4 : Spearman correlation coefficient matrix for selected metals in the airborne particulate matter (n= 72)

	Fe	Al	Cu	Zn	Mn	Ni	Pb	Cr	Cd
Fe	1.000								
Al	0.754	1.000							
Cu	0.679	0.688	1.000						
Zn	0.695	0.581	0.729	1.000					
Mn	0.271	0.289	0.135	0.153	1.000				
Ni	0.625	0.643	0.490	0.541	0.60	1.000			
Pb	0.236	0.030	0.152	0.374	0.096	-0.056	1.000		
Cr	0.504	0.419	0.330	0.433	0.273	0.276	0.217	1.000	
Cd	0.067	0.019	0.081	0.376	0.079	-0.109	0.421	0.411	1.000

r-values shown in bold are significant at $p \leq 0.001$

Table 5 : Principal component loading of trace metals in airborne PM₁₀

Rotated Component Matrix ^a			
Elements	Component		
	PC I	PC II	PC III
Fe	0.856	0.150	0.239
Al	0.852	-0.044	0.281
Cu	0.835	0.147	0.016
Zn	0.777	0.471	0.012
Mn	0.078	0.017	0.935
Ni	0.824	-0.170	-0.019
Pb	0.072	0.783	-0.020
Cr	0.397	0.449	0.463
Cd	-0.033	0.854	0.103
Eigen values	3.610	1.842	1.236
% Variance	40.113	20.470	13.736
%Cumulative variance	40.113	60.584	74.319
Possible Sources	Industrial emission	Vehicular emission	Anthropogenic activity
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			



GLOBAL JOURNAL OF HUMAN-SOCIAL SCIENCE: B
GEOGRAPHY, GEO-SCIENCES, ENVIRONMENTAL DISASTER
MANAGEMENT

Volume 14 Issue 5 Version 1.0 Year 2014

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-460X & Print ISSN: 0975-587X

Sensitivity Maps in Environmental Impact Studies

By Virgili Núñez

Salta National University, Argentina

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A case study is presents for the installation of production infrastructure; environmental sensitivity is analyzed through physical, biological and socioeconomic factors (landscapes): surface runoff, topography, soil type, flora - wildlife and land uses. For the generation of environmental sensitivity maps a weighted polynomial was used whose weights were defined on the basis of consultations with experts.

Four alternatives for an aqueduct were compared, which are analyzed according to the environmental sensitivity of the areas traversed. The alternative path was defined by the engineers, in charge of the hydraulic project aspects, and the application of the optimal path algorithm, using the environmental sensitivity map as friction, to determine traces of each alternative with less sensitivity. Environmental Sensitivity Maps showed consistency in the analysis of alternatives for the location of new infrastructure.

Keywords: *environmental sensitivity maps, environmental impact studies, landscapes, gis, optimal path.*

GJHSS-B Classification : *FOR Code: 059999*



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I. INTRODUCTION

Environmental Sensitivity (ES) is defined as the susceptibility showed by the different components of natural and built environment for the purpose of further action of man or the influence of climatic factors on the system.

'Landscape sensitivity relates to the stability of character, the degree to which that character is robust enough to continue and to be able to recuperate from loss or damage. A landscape with a character of high sensitivity is one that once lost would be difficult to restore, and, must be afforded particular care and consideration in order for it to survive'. (Bray, 2003 cited in Tartaglia Kershaw L, et al., 2005, p.7).

The new sustainable development paradigm, provides the necessary balance between productive activities, social welfare and environmental conservation.

ES models are the first step in finding this harmony. (Rebolledo, 2009).

Thomas and Allison (1993), consider landscape sensitivity as the potential and magnitude of change likely to occur within a physical system, and its ability to resist it, in response to external effects. These may be natural or man induced.

The environmental components present unequal levels of prior alterations and different capacities to absorb or assimilate new impacts to which they are subjected. Is now accepted that man has some influence over climatic factors.

From the ecology perspective, ES is defined as the ability of an ecosystem to withstand alterations or changes caused by human actions, without suffering drastic alterations that prevent you from achieving a dynamic balance that maintains an acceptable level in structure and function; their identification and measurement depend on the scale of observation (Meentemeyer and Box, 1987).

The level of Sensitivity depends on the degree of environmental and ecosystem conservation, especially, of the presence of external actions (anthropogenic).

ES is closely linked to the concept of reception capacity (Environmental Tolerance) that the environment (Landscapes), these capabilities must be addressed in a holistic and integrated perspective for the analysis of constructive alternatives to be incorporate in the infrastructure. Quantification landscape reduces the complexity of a set of numerical values or index (Matteucci, 1998).

All of the above requires a combination of tangible and intangible aspects in a valid scale for decision-making, according to a new rationality (Saaty, 1996 cited in Moreno Jiménez et al., 2001, p.6).

II. ENVIRONMENTAL SENSITIVITY MAPS (ESM) ON ENVIRONMENTAL IMPACT STUDIES (EIS)

'The Environmental Impact Assessment (EIA) is a legal administrative process that concerns the identification, prediction and interpretation of the Environmental Impacts (EI) to be produce when a project or activity should be executed, and the prevention, correction and evaluation of such EI, all in order to be accepted, modified or rejected by several Government Authorities.' (Conesa Fernandez Vitoria, 1997).

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Within the general framework of the EIS, the Environmental Sensitivity analysis (ES) is incorporated in the Effects Prevention Stage, hand in hand, as the prospective process, with the members of the working group for further evaluation of EI. Moreover, the ESM are instrumental simulation models (Moldes, 1995) itself,

which can be the base for a preliminary assessment of the current conditions of the environment against the actions foreseen in the project's idea stage. ESM also represent an input to perform reports on Environmental Impact Statement (EIS), as required by the relevant public authorities for smaller projects.

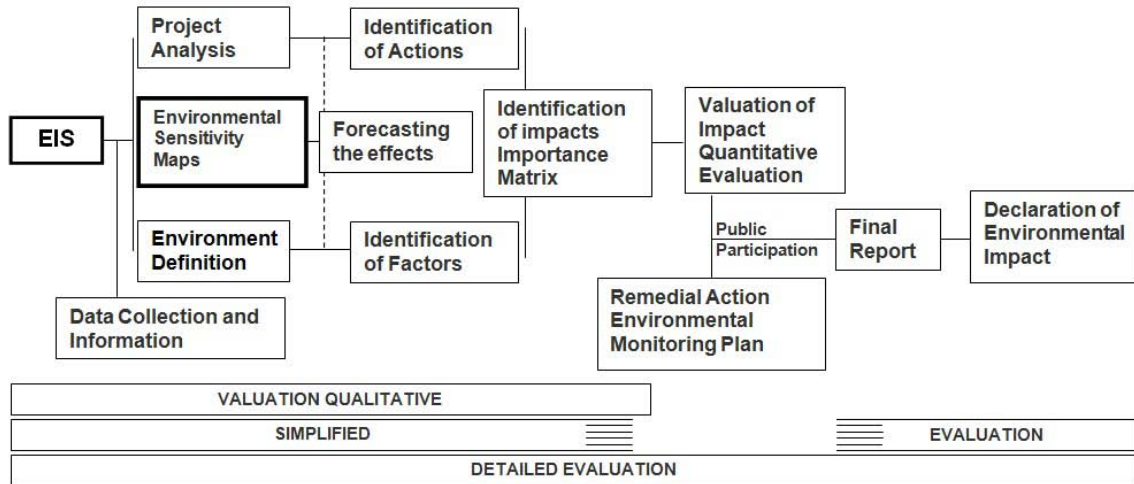


Figure 1 : General outline of the EIS. Modified of Conesa Fernández Vitora (1997)

a) Case Study

In Salta, Argentina, relevant government agencies require the completion of Environmental and Social Impact Studies (ESIS) to enable the development of productive activities or to implement infrastructure projects.

A case study is presented for the implementation of an ESM for the construction and operation of a aqueduct for the provision of water for an ammonium nitrate production plant, located nearby the town El Tunal, Metán Department, Salta Province, Argentina (Figure 2). Four alternatives were analyzed for mentioned aqueduct traces, depending on the environment sensitivity.

The area under analysis is presented in Figure 3, showing the site where the ammonium nitrate production plant will be installed, which requires a permanent water supply.

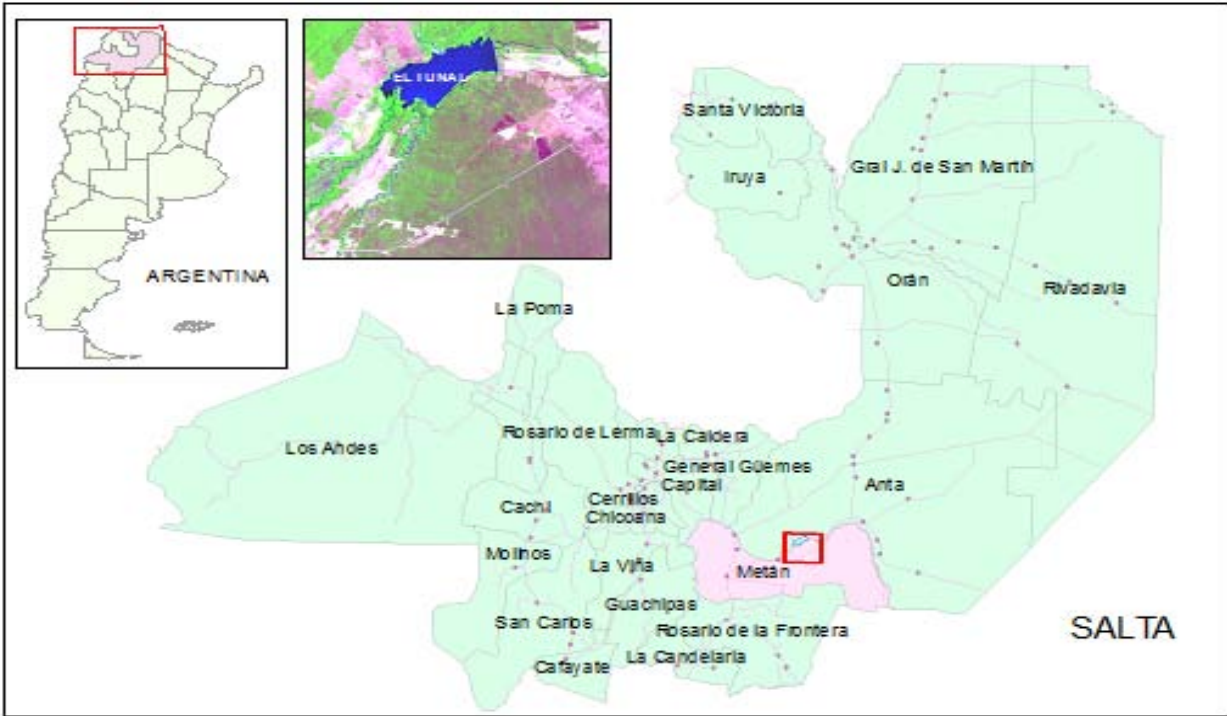


Figure 2 : Location

The main urban center corresponds to El Tunal town (470 inhabitants), Metán Department. Adjacent to El Tunal is the dam that has the same name which has multiple purposes, such as water provision for irrigation and power generation with a capacity of 10.4 MW.

El Tunal dam is located on Juramento River, about 200 km southeast of the Salta City. The dam

regulates the mid-basin Juramento River, which has an area of 6320 km². El Tunal dam, commissioned in 1991, presented in 2005 a volume of 175 hm³ and an annum reduced rate of 1.7%, and an area of 2748 ha with a 16% reduction.

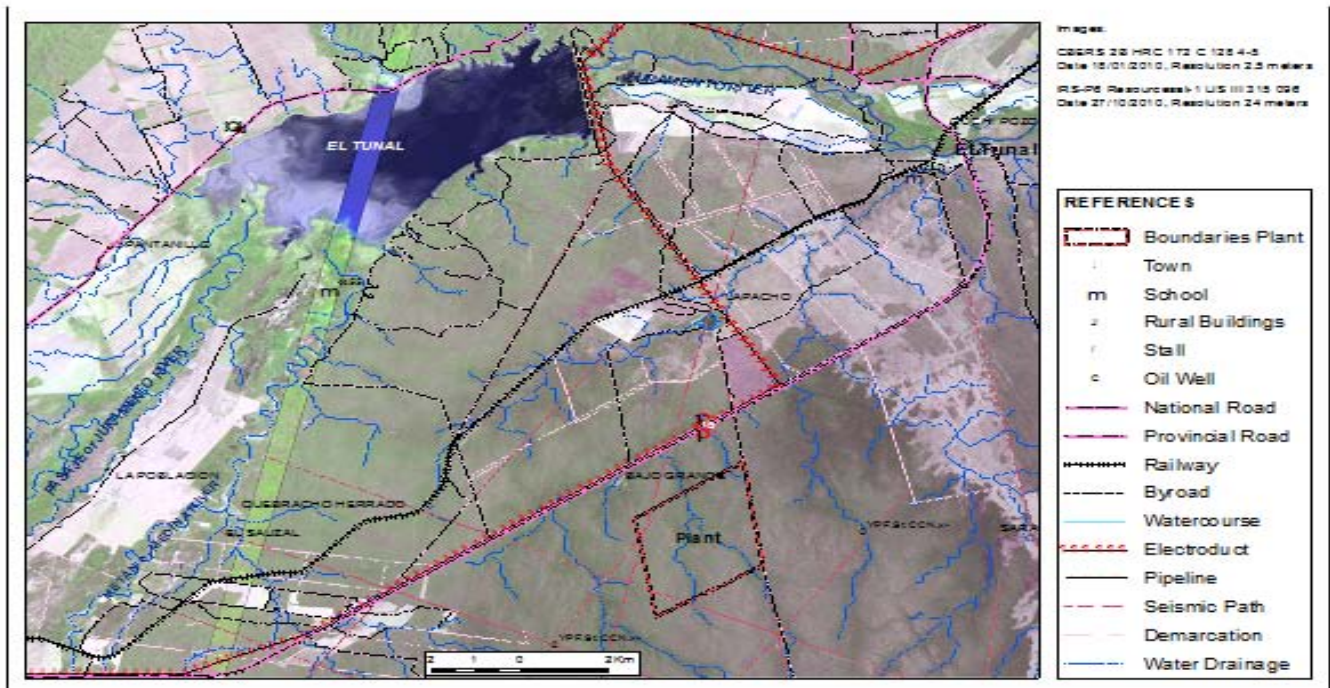


Figure 3 : Charter of Satellite Image

III. METHODOLOGY

For Environmental Sensitivity analysis an index has been designed, in which three components of Environmental System Matrix Importance (physical, biological and socioeconomic) were considerate.

To evaluate Physical Environment sensitivity, these factors were established: hidrology - surface runoff (lotic) and surface water (lentic) -, topography - through the slope - and finally, soils (Soil Groups and Suitability Classes).

To construct the factor for Biological Environment a combination of conservation value index, obtained for plant communities and birds, was used.

The Social-economic Environment was assessed in terms of the different land uses in the area and its related infrastructure, reflecting also on the degree of involvement that economic activities may suffer.

Factors (criteria) were selected by specialists from an initial hierarchical list, according to the relevance defined for the project objectives.

Environmental Sensitivity map (Figure 16) was obtained by the weighted sum of the sensitivity maps for each factor, as shown in Figure 4. Maps of sensitivity for each factor were standardized on a scale of 0 - 10, 10 being the maximum value.

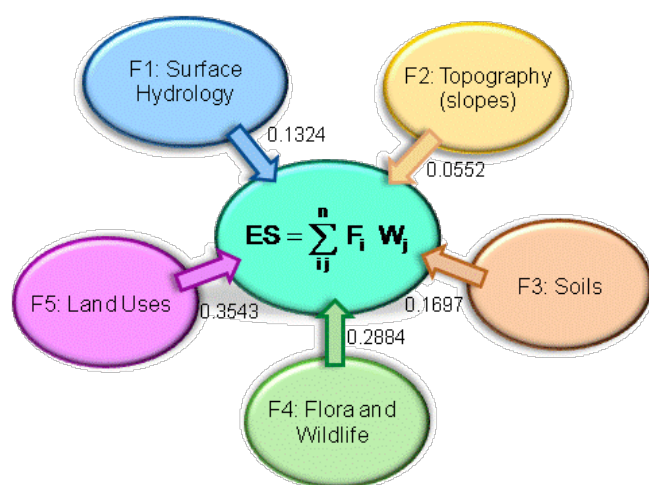


Figure 4 : of operation between layers in a GIS

The relative weights of factors was calculated using the method of Analytical Hierarchy proposed by Saaty, 1977 (WEIGHT: IDRISI Taiga V. 16.05). The weights obtained with an acceptable consistency ratio of 0.03; this value indicates the probability that the ratings were randomly assigned. Values less than 0.10 indicate a good consistency (Saaty, 1977 cited in Eastman et al., 1995, p.542).

Analytical Hierarchy Process copes with using original data, experience and intuition in the same model in a logical and through way (Forman, 1999 cited in Büyükyazici, Sucu, 2003).

Comparisons are made in pairs and concern the relative importance of the two criteria involved in determining suitability for the stated objective. Ratings are provided on a nine-point continuous scale (Eastman et al., op. cit.).

Then, a set of weights for each of the factors was established. The analyst worked in group with specialists to complete the comparison matrix in pairs. Wondered to each specialist individually to estimate a rating and the group if it was agreed to start the debate. The consensus was not difficult to achieve with this procedure.

a) Factor 1 - Surface Hydrology

The drainage network was derived from a Digital Terrain Modeling (ASTER satellite, resolutions 30 m - Figure 5) and interpreted from high spatial resolution images (CBERS 2B HRC, resolutions 2.5 m Figure 3).

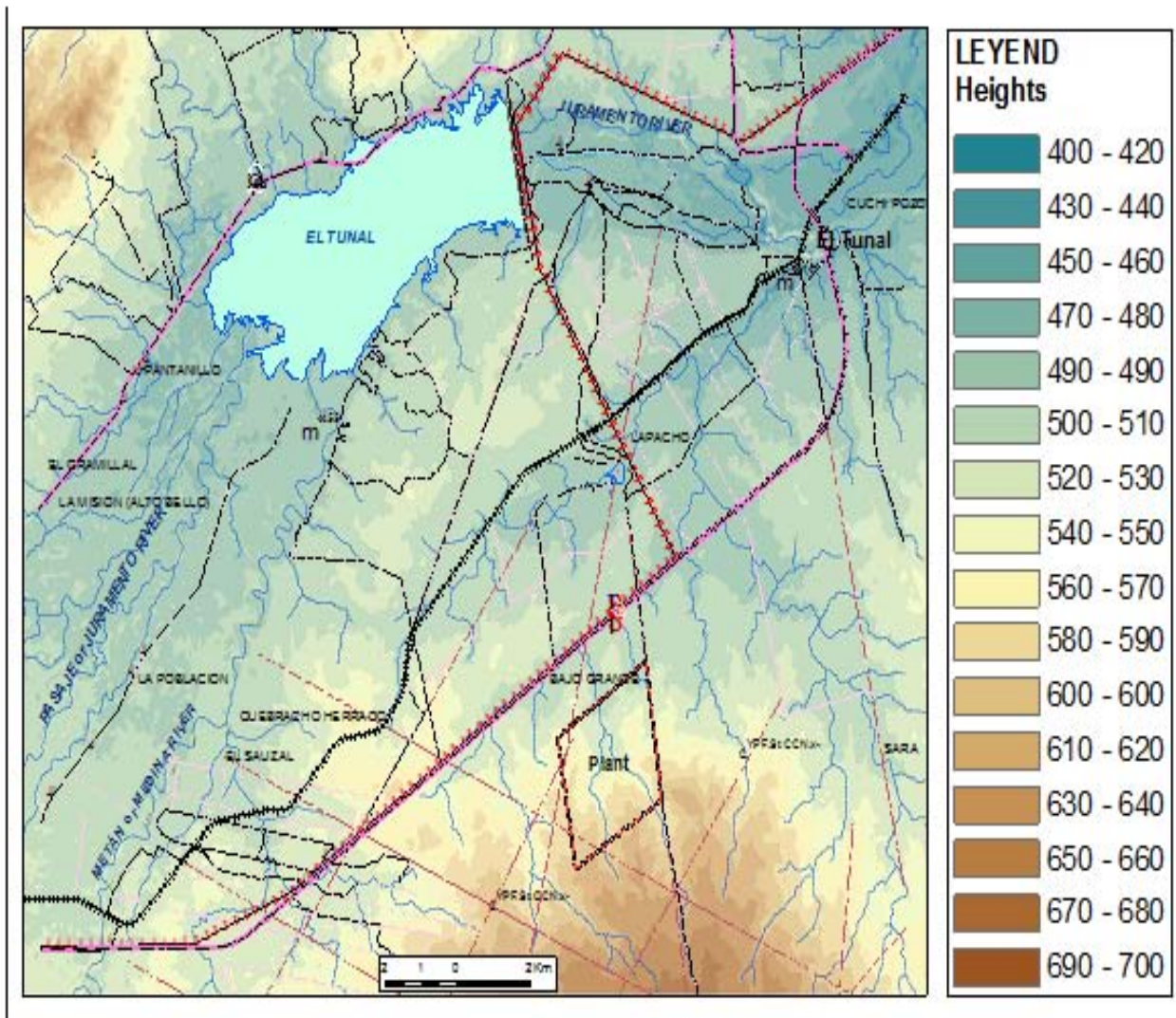


Figure 5 : Digital Terrain Model

For the generation of Hydrology Sensitivity Map the following equation was applied:

$$HS = \left[\cos\left(\frac{D}{m}\right) \right]^x 10$$

were:

HS: Hydrological Sensitivity

D: Drainage network distance

m: maximum value of D

x: exponent

The equation was developed to mitigate the sensitivity to drainage networks environment and to achieve a gradual reduction in sensitivity as a function of distance from the axis of each drainage (talweg). The exponent allows to adjust the spatial scope of sensitivity according to the importance of the hydrology factor in the environmental context (Figure 5).

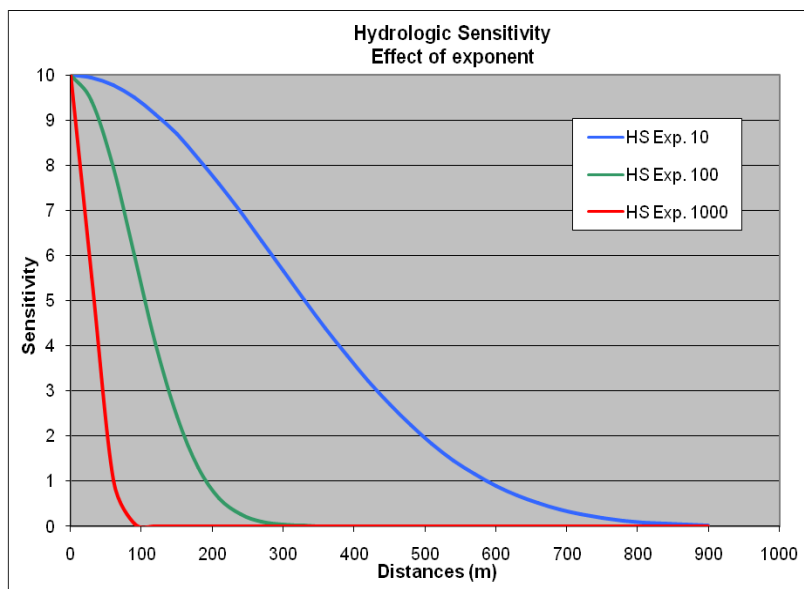


Figure 6 : Effect of the exponent in the calculation of the Hydrological Sensitivity

Table 1 : Values assigned to the categories of factor 1: Hydrological Sensitivity

Lentic and lotic environments	Sensitivity
Permanent and temporary courses, places with standing water at some time during the year	10
No surface water	0

b) Factor 2 – Topography (Slope)

The environmental sensitivity for the physical environment, was directly related to the environmental susceptibility to erosion, capable of generating economic or social involvement and in whose prediction, prevention or correction geomorphologic criteria should be used.

Table 2 : Values assigned to the categories of factor 2: Topographic sensitivity (slope).

Class	Slope (%)	S Factor RUSLE	Sensitivity
1	0.0 - 0.3 %	0.06	0.01
2	0.3 - 0.6 %	0.09	0.08
3	0.6 - 1.2 %	0.16	0.27
4	1.2 - 3.0 %	0.35	0.64
5	3.0 - 6.0 %	0.68	1.25
6	6.0 - 9.0 %	1.01	2.16
7	9.0 - 12.0 %	1.50	3.43
8	12.0 - 25.0 %	3.57	5.12
9	25.0 - 50.0 %	7.01	7.29
10	> 50.0 %	11.38	10.00

For the orderly classification of slopes an exponential function was used $y = 0.1749 e^{0.6409x}$. Then S factor (steepness: Revised Universal Soil Loss Equation - RUSLE -) was calculated (Foster et al., 2003). Finally, the following linear equation was used: $y = 0.882x + 0.745$, with an $R^2 = 0.942$, for assigning values of topography sensitivity by the S factor.

c) Factor 3 - Soils

Considering the characteristics of Soil Associations (Nadir and Chafatinos, 1995) present in the area under analysis the Soils Sensitivity map was generated (Figure 13). In this case, the Soils Group, the Suitability Class and the type of landform that corresponds to each unit were considerate (Table 3).

Table 3: Values assigned to the categories of factor 3: Soils Sensitivity.

Code	Soils Associations	Soils Group	Sensitivity
Ao-Lpb	Arrocera - La Población	C	3.92
Cho	Chorroarín	C	3.92
Lvi	Las Víboras	E	1.68
Oll-Etu	Olleros - El Tunal	B-C	5.28
Sig	San Ignacio	B	7.22
Sma	Santa María	C	3.92
Ts-Sun	Tuscal - Sunchal	C	3.92

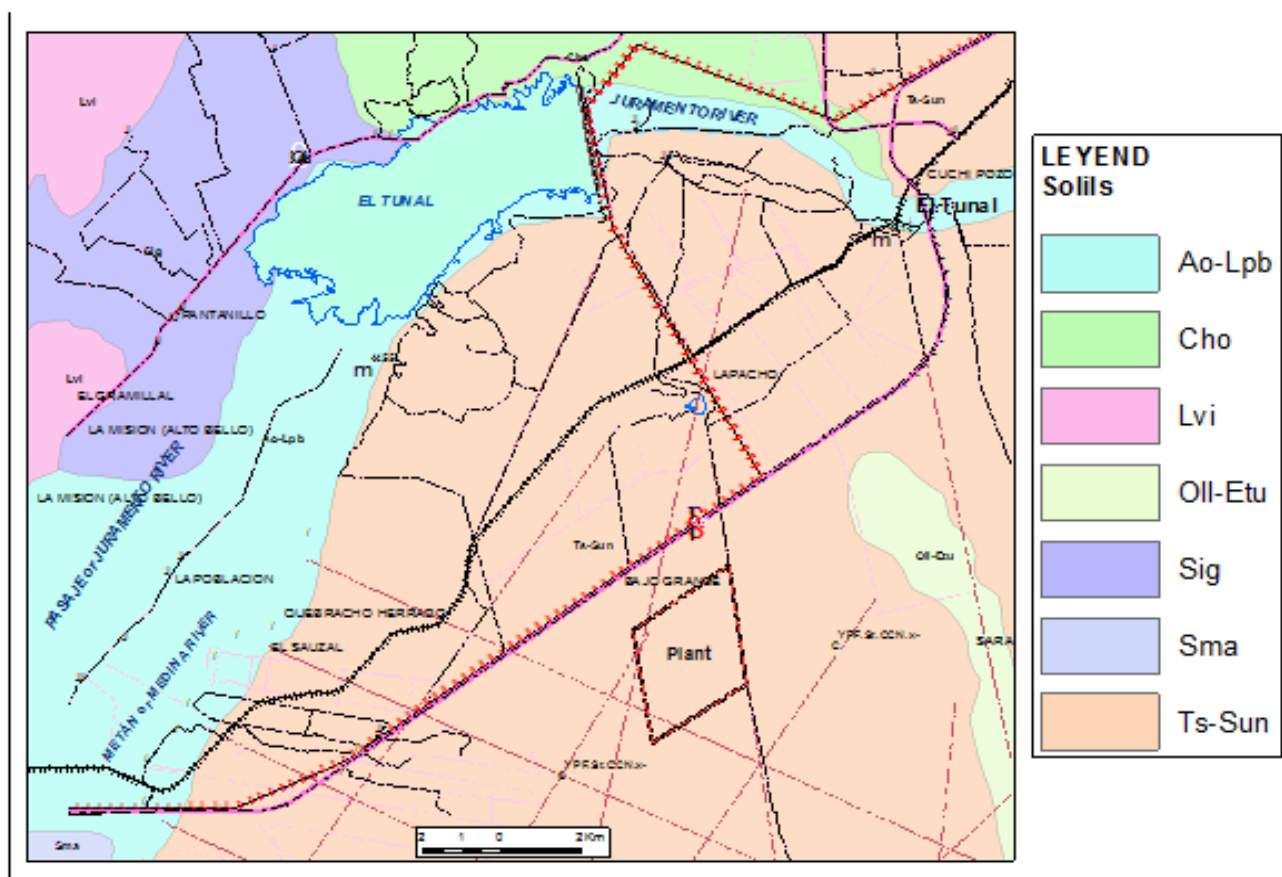


Figure 7: Soils Units

To assign soils sensitivity, taking into account the features mentioned in the previous paragraph, an exponential series $y = 13.084e^{-0.2974x}$ with a $R^2 = 0.9985$ was used.

d) Factor 4 - Flora and Wildlife

Considering both, the importance and the conservation status of different flora and wildlife - represented mainly by birds as indicators of environmental condition-, the fourth factor was built (Table 4). A good environmental quality has a greater number of animal populations.

Table 4 : Values assigned to the categories of factor 3: Sensitivity for Flora and Wildlife Units.

Flora and Wildlife		Sensitivity
1	Under Wet Forest Transition: BOSTRAN	10
2	Dry Forest Mountains: CHACSER	7
3	Plain Dry Forest: QUE2QUE	8
4	Riparian Forest and Floodplain: BOSRIBE	5
5	Grassland Fire: PASPIRO	3
6	Agricultural Patch: AGRICOLA	1
7	Lentic and Lotic Environment: AGUA	6
8	Urban Area: URBANO	1
9	Route, Road and Footpath: RUTA-CAMINO	2

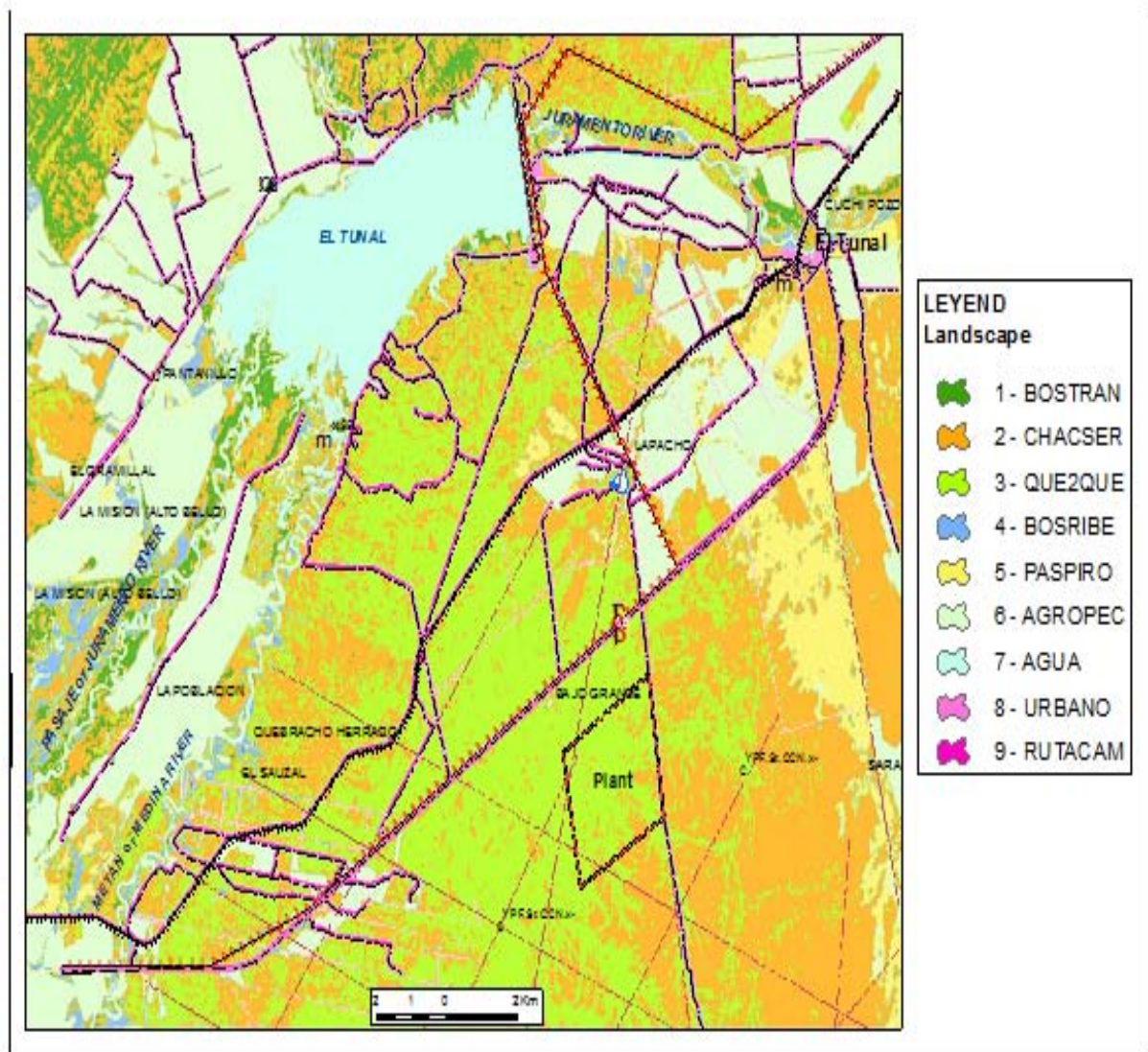


Figure 8 : Flora and Wildlife Units

e) *Factor 5 - Land Use*

Considering Land Use, the fifth sensitivity factor was created that includes the categories listed and valued in Table 5.

Table 5 : Values assigned to the categories of factor 5: Sensitivity for Land Use.

	Land Use	Sensitivity
1	Dense and scattered urbanization: housing complexes, hotels, schools, gas stations and railway stations: RESIDENTIAL.	10
2	Rural towns and natives communities: RURAL TOWNS.	9
3	Gas and oil pipelines, electricity and optical fiber networks, waterways: DUCTS.	10
4	Surface infrastructure: oil wells, hydro generators, sheds, stockyards, silo and greenhouses. INFRASTRUCTURE.	8
5	Traditional and recreational fishing: fish farming, fishing and camping clubs: FISHING.	7
6	Roads, ways and railways: ROADS.	5
7	Cattle ranching and forest extraction: woodlands, shrub lands and grasslands: CATTLE RANCH.	4
8	Intensive and extensive farming, intensive livestock: patch, dams, paddocks, stockyards, drinking trough, electric herdsman, ponds: FARMING.	3
9	Purpose without: exploration path, demarcations and badlands: BADLANDS.	1

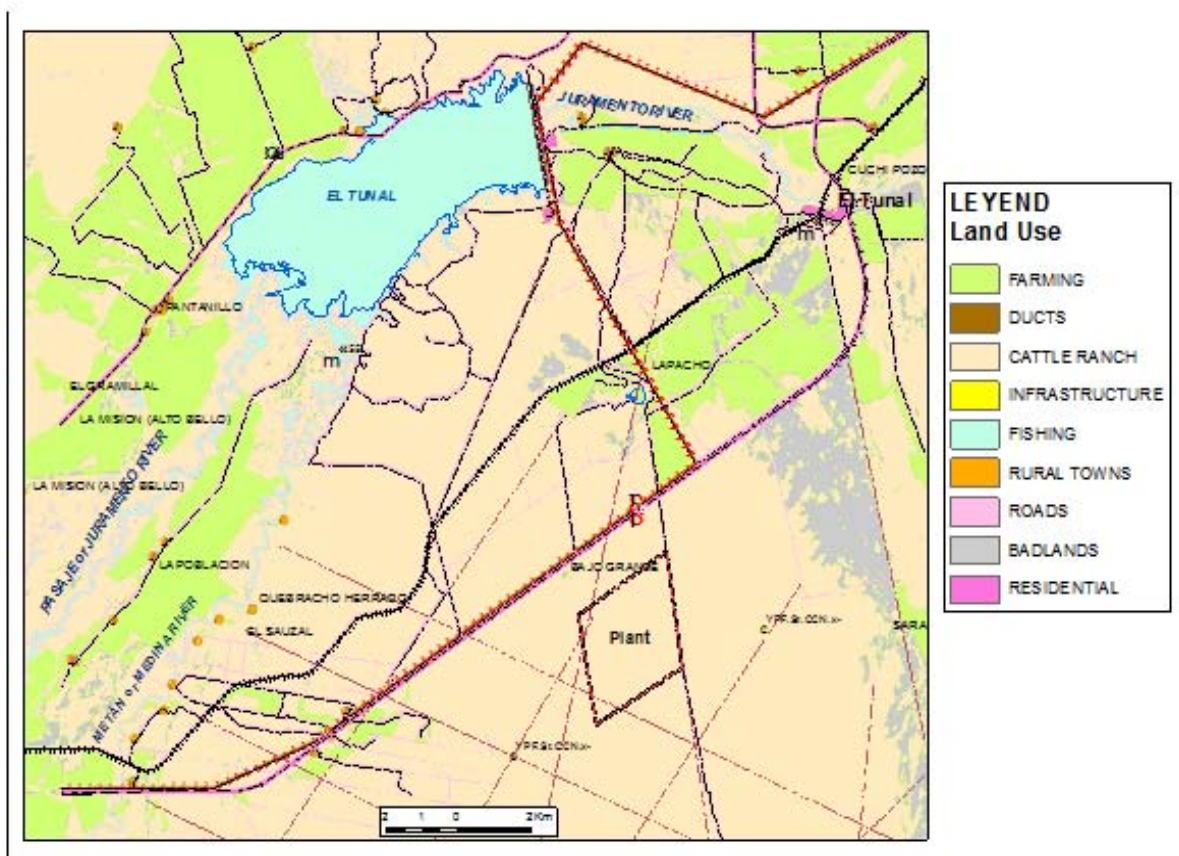


Figure 9 : Land Use Units

f) *Alternatives Trace*

As it has already been said, four alternatives of the aqueduct trace were compared, such alternatives are analyzed according to environmental sensitivity of

the areas traversed. The alternative path was defined by the engineers in charge of the hydraulic aspects project, taking into consideration the possible water taking sites (Figure 10).

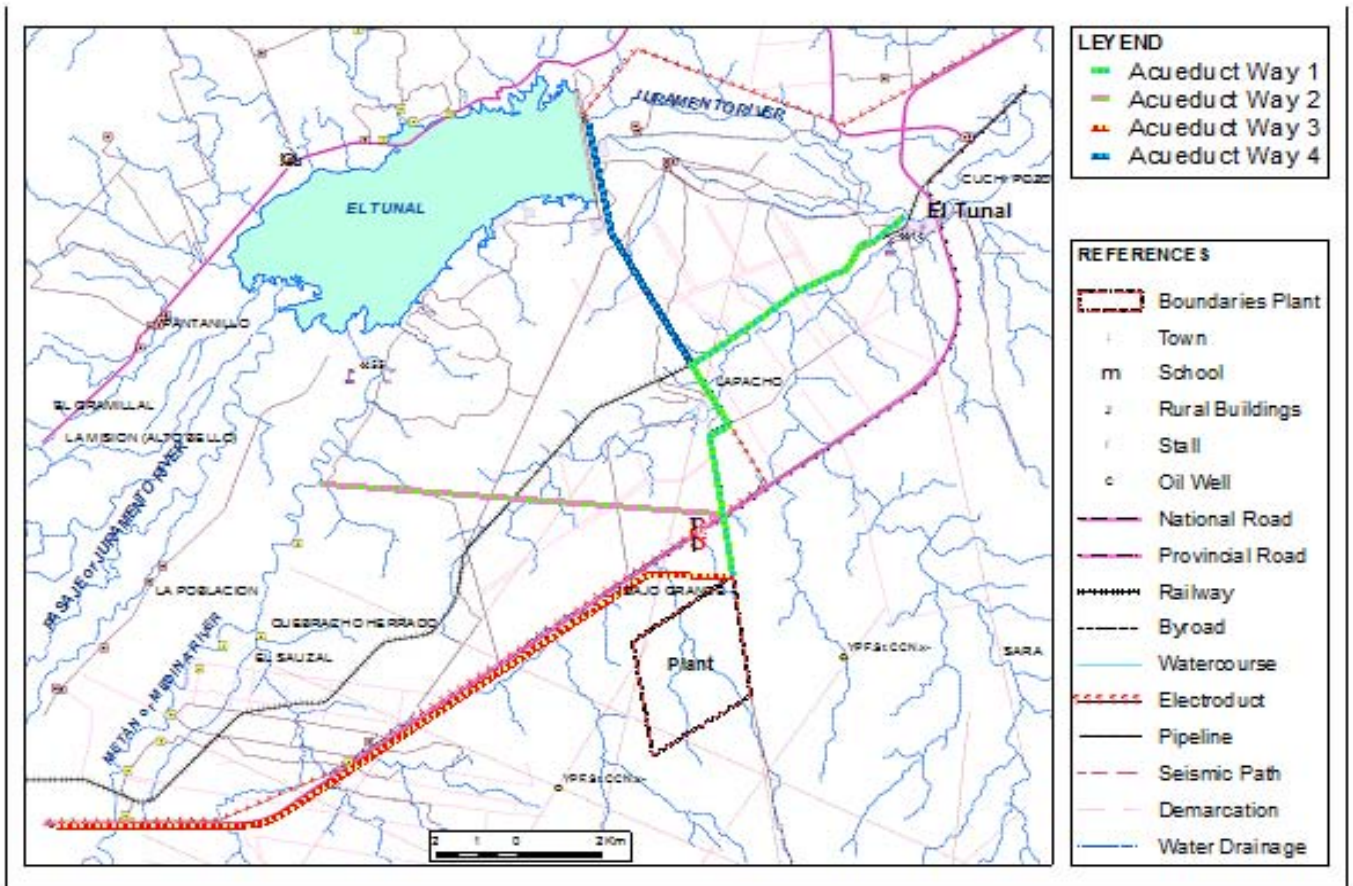


Figure 10 : Alternative aqueduct way defined by engineers

As part of alternatives analysis, the optimal path algorithm (PATHWAY: IDRISI Taiga V. 16.05) was applied, using the Environmental Sensitivity map as friction (Figure 16).

IV. RESULTS

Below are the sensitivity maps obtained for each factor.

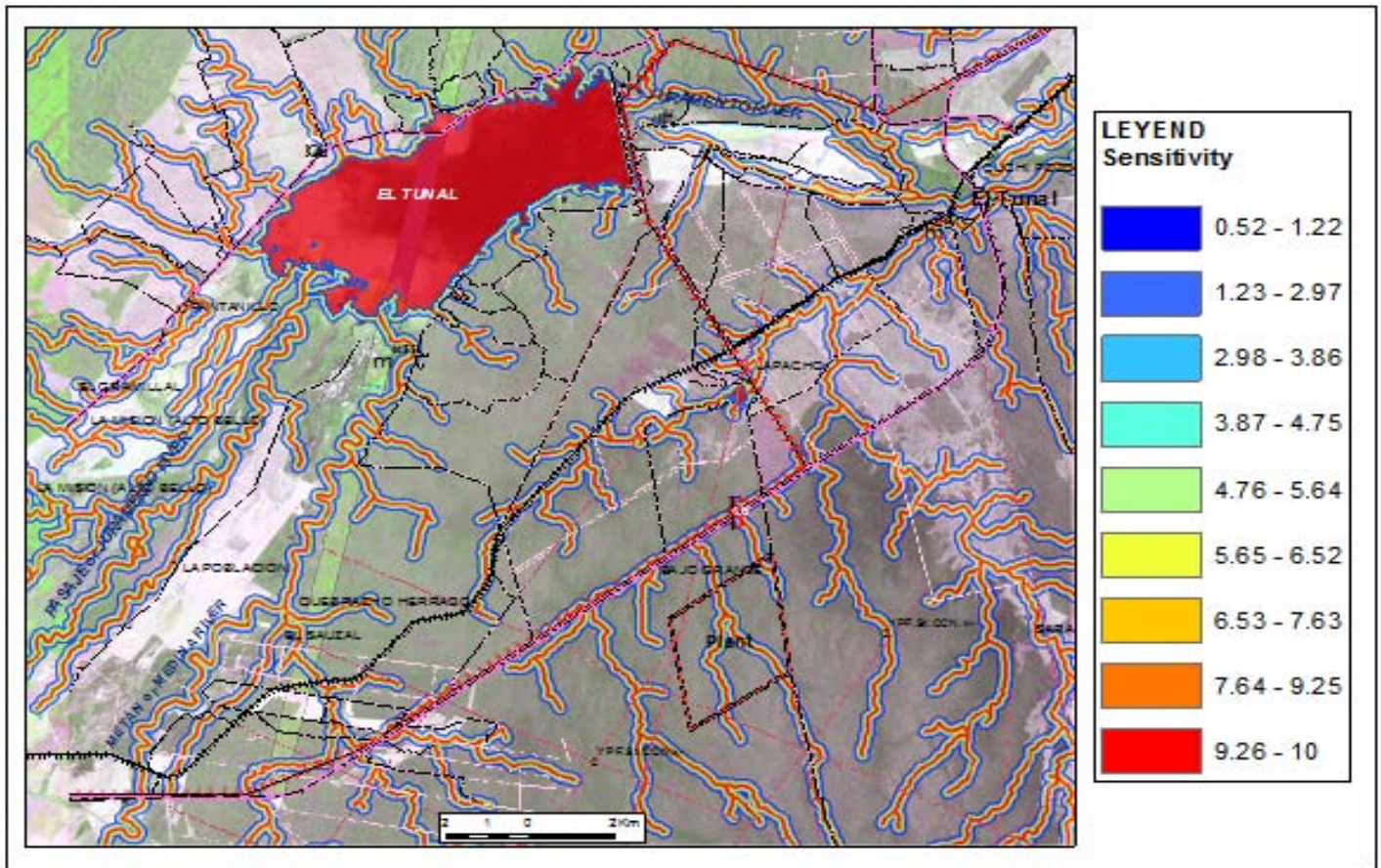


Figure 11 : Hydrological Sensitivity

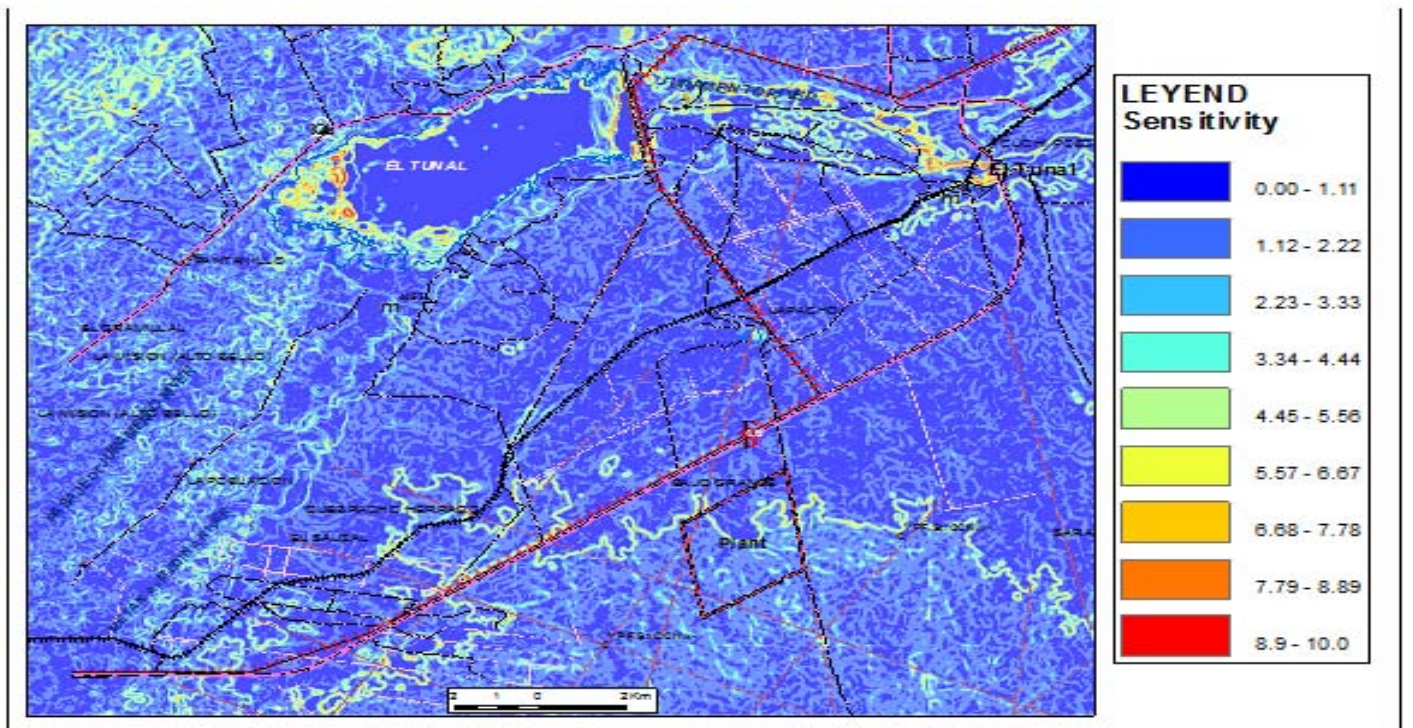


Figure 12 : Topographic Sensitivity





For Environmental Sensitivity analysis a sample at random points 100 was extracted, probability distribution is shown in Figure 17, while the descriptive statistics are presented in Table 6.

Table 1 : Descriptive statistics.

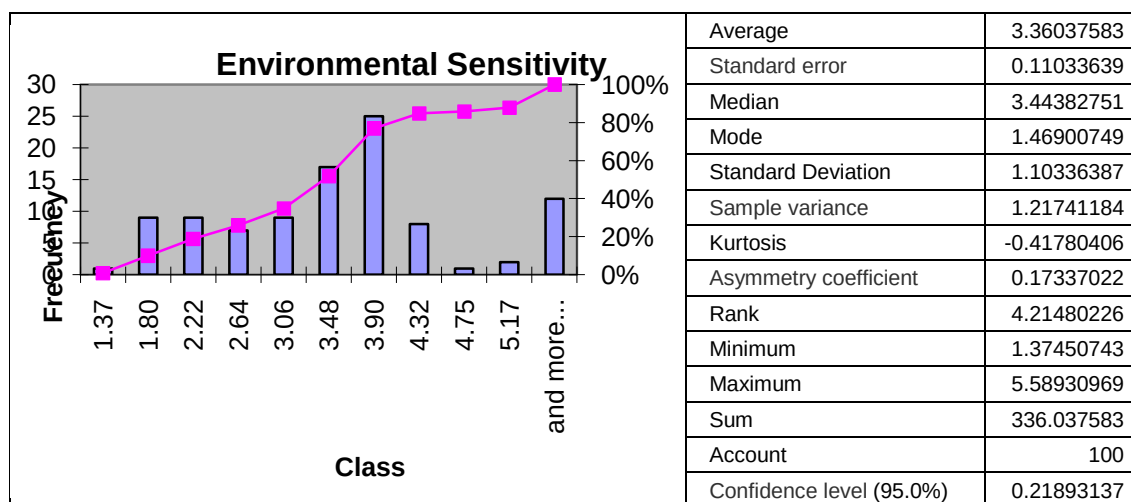


Figure 1 : Probability distribution.

The average of environmental sensitivity is within the interval ± 0.22 respect to the average of the sample with a probability of 95%.

a) Alternatives Trace Analysis

All alternatives trace run through areas with medium to low environmentally sensitivity. The greater

environmental sensitivity is present in the trace for Alternative 3, followed by 4, then 2 and finally 1. It should be taken into account that: Alternatives 1, 2 and 4 have values close to environmental sensitivity and did not differ between them in more than 23.7%. (Table 7 and Figure 18).

Table 7 : Weighted Environmental Sensitivity for each alternative trace defined by engineers.

Environmental Sensitivity	Defined by Engineers			
	Alternative Trace: Area (ha) * Sensitivity			
	1	2	3	4
10	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
6	0.00	1.62	3.24	8.64
5	6.75	18.45	71.10	52.65
4	28.80	81.36	115.56	42.84
3	72.90	30.51	18.36	39.15
2	1.80	0.00	0.00	1.26
1	0.00	0.00	0.00	0.00
Total	110.25	131.94	208.26	144.54
Length (m)	12735	11513	18599	13032

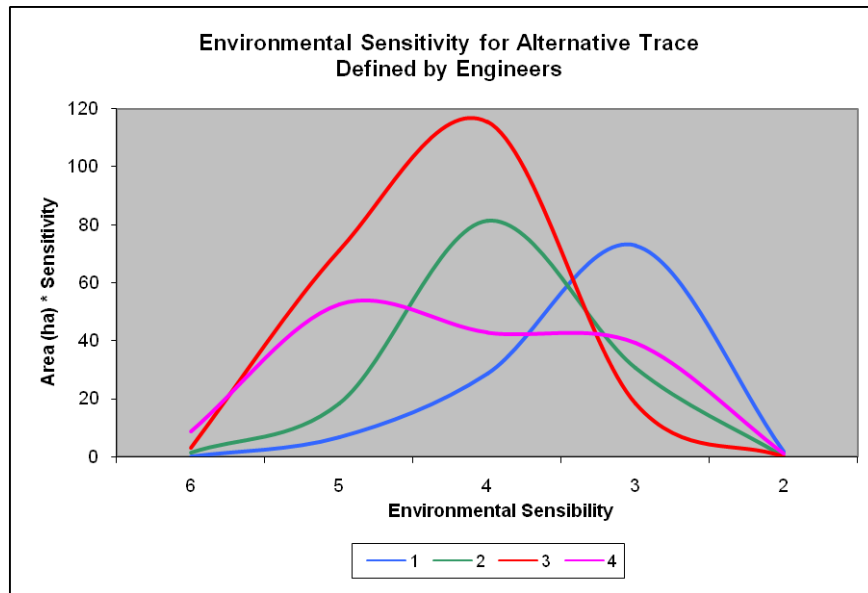


Figure 18 : Environmental Sensitivity for each alternative trace defined by engineers

Moreover, the environmental sensitivity of alternative would be the least desirable from the Alternative 3 outstrips the other three, why, this environmental point of view.

Table 8 : Weighted Environmental Sensitivity for each alternative trace, Optimal Path defined (PATHWAY).

Environmental Sensitivity	Optimal Path defined (PATHWAY)			
	Alternative Trace: Area (ha) * Sensitivity			
	1p	2p	3p	4p
10	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
6	0.00	2.16	0.00	1.08
5	3.15	11.25	24.30	3.15
4	6.84	79.20	95.40	13.32
3	24.03	23.76	38.07	29.16
2	44.46	0.00	17.82	47.16
1	0.00	0.00	0.00	0.00
Total	78.48	116.37	175.59	93.87
Length (m)	12135	11074	19486	14873

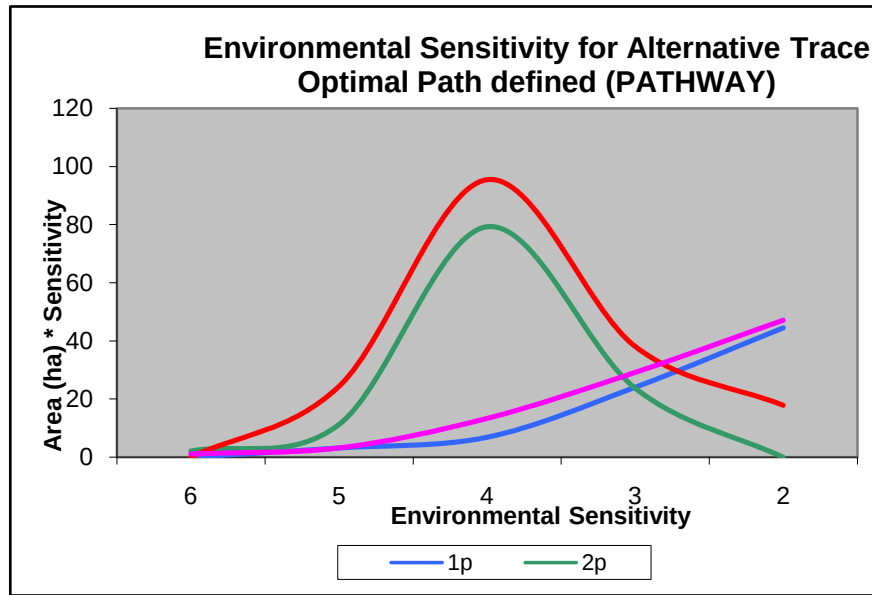


Figure 19 : Environmental Sensitivity for each alternative trace, Optimal Path defined (PATHWAY)

To the traces defined by Optimal Path, Environmental Sensitivity decreases for all alternatives, although that increases the length of the trace 3p and 4p. (Table 7 and Table 8). Comparing the alternatives 1 and 1p, the second reduced 29% environmental sensitivity respect to the first.

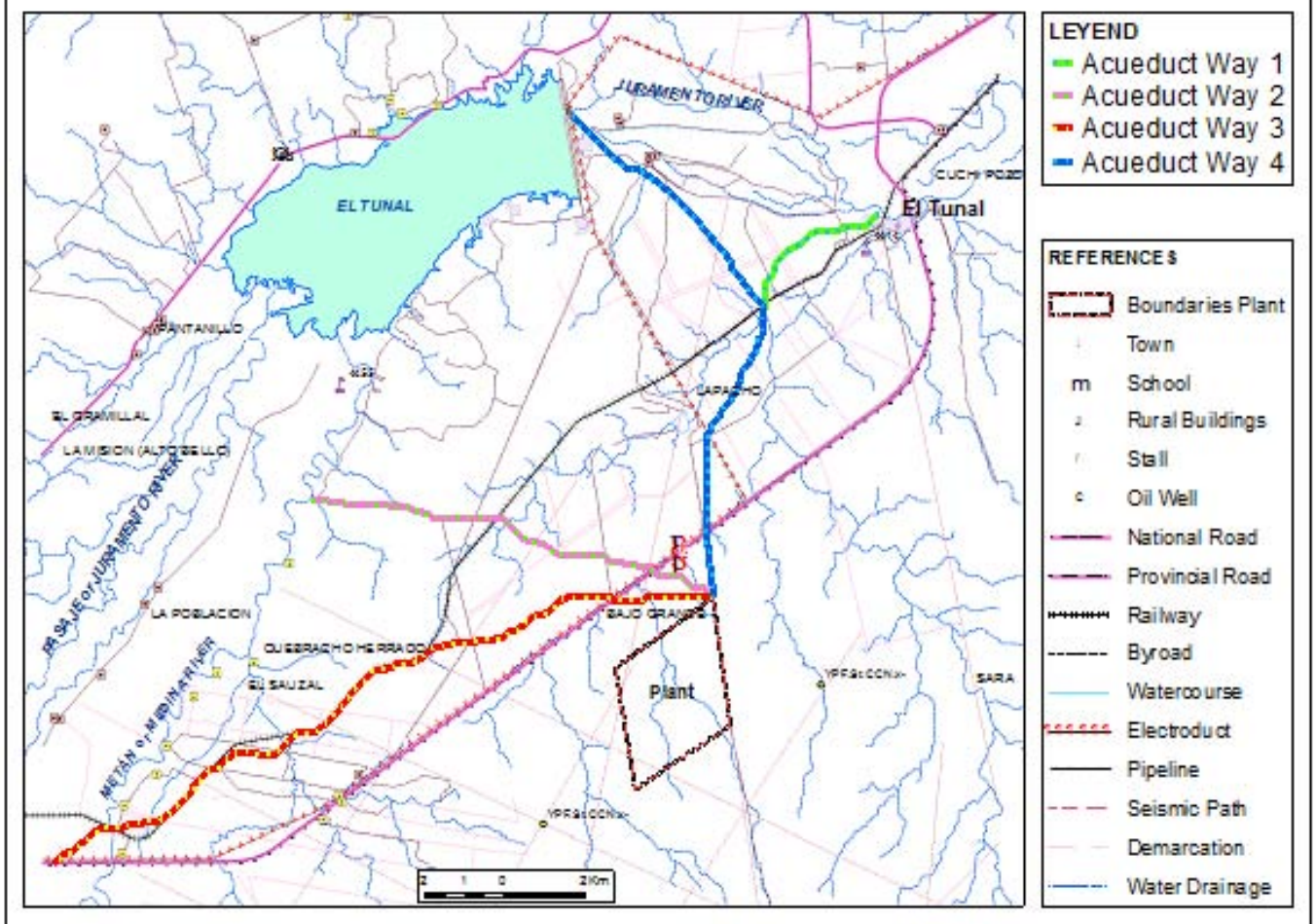


Figure 20 : Alternative aqueduct way, Optimal Path defined (PATHWAY)

Finally we conclude that the trace 1 and 1p presents the lowest environmental sensitivity. Managers must be decide what is the final trace, taking into consideration other criteria such as the costs of construction and operation.

V. DISCUSSION

Environmental Sensitivity is a concept closely linked to landscape as a complex system. Quantifying the landscape through indexes, reduces system complexity allowing spatial pattern analysis, and process alterations under study.

Environmental Sensitivity Maps are an instrumental model that provides adequate and sufficient information for understanding current conditions and the ability of the landscape to absorb new actions.

Environmental Sensitivity analysis can be incorporated into the forecast stage of Effects on Environmental Impact Studies. Environmental Sensitivity Maps represent an input for carrying reports on Environmental Impact Statement.

Hydrological Sensitivity equation allowed to integrate spatially the hydrologic factor as a decreasing continuous variable from drainage networks and water bodies. This function solves the problem of localized effect of the valuation of discrete entities.

Environmental Sensitivity Maps showed consistency in the analysis of alternatives for the location of new infrastructure. The combined use of environmental sensitivity map and the Pathway method allowed to define alternatives of trace for the aqueduct more efficiently from environment perspective.

VI. ACKNOWLEDGEMENTS

To María Laura Núñez and Claudia Rodas for her collaboration in the translation review of the manuscript. To the Salta National University Research Council for the financial support. To the National Institute for Space Research (Brazil) for the satellite image provision. To Adolfo Colina, Nestor Ilvento and Gabriel Guillén, who were in charge of delineation of aqueduct traces. To Juan Sauad, Miguel Menéndez, Héctor Regidor and Alejandro Núñez for their participation in the assessment of factors.

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GLOBAL JOURNAL OF HUMAN-SOCIAL SCIENCE: B
GEOGRAPHY, GEO-SCIENCES, ENVIRONMENTAL DISASTER
MANAGEMENT

Volume 14 Issue 5 Version 1.0 Year 2014

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-460X & Print ISSN: 0975-587X

Mapping the Spatial Distribution of Health Care Facilities of the Millennium Development Goals (MDGs) in Kaduna North and South Local Governments, Kaduna State, Nigeria

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Keywords: health care, facilities, mapping, GIS, MDG.

GJHSS-B Classification : FOR Code: 160499, 160401



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RESEARCH | DIVERSITY | ETHICS

Mapping the Spatial Distribution of Health Care Facilities of the Millennium Development Goals (MDGs) in Kaduna North and South Local Governments, Kaduna State, Nigeria

Abbas, Idowu Innocent ^α, Abdulqadir, Hussain Zaguru ^σ & Bello, Mohammed Nanoh ^ρ

Abstract- This research focused on the identification and mapping of the spatial distribution of health care facilities of the Millennium Development Goals (MDGs) projects in Kaduna North and South Local Governments, Kaduna State, Nigeria.

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I. INTRODUCTION

Mapping enables professionals to understand complex spatial relationships visually so as to plan effectively and efficiently.

Similarly, Hirschfield et al (1995) estimated that nearly 80% of the information need of local health system decision and policy makers involves geographical positioning. Health mapping utilizes the technology of Geographic Information Systems to add value to information for public health planning and decision making. Geographic Information Systems (GIS) provides useful techniques regarding capturing, maintaining and analyzing of spatial data.

The role of monitoring and evaluation is that of coordinating all activities in order to create an efficient and aesthetically pleasing physical environment for all

forms of human activities in order to create an environment which has quality of acceptable standards for health and efficiency, and which enable individuals, families and communities to live and work in a satisfactory manner (Vagale, 1971).

Attention is focused here on the spatial distribution of health care facilities of Millennium Development Goal Projects, which are Boreholes, Primary Health Centers (PHCs) and Ventilated Improved Pit (VIP) latrines in Kaduna North and South local government areas of Kaduna state, Nigeria. This is viewed with keen interest because it pertains to one of MDGs goals, which has been the development of the rural and urban areas under the Direct Relief Grant (DRG) Scheme Program aimed at providing sustainable water and hygiene to the public. As a result, there is the need for accurate mapping and monitoring of the spatial distribution of health care facilities of the Millennium Development Goals (MDGs) projects in Kaduna North and South Local Governments.

In Kaduna North and South Local Governments, few health care facilities were located very far away in the headquarters of the Local Governments with few rural areas that having Primary Health Centers that were ill-equipped and under staffed. Some communities covered long distance to seek medical services (MDG Report Card, 2008). Therefore, the mapping and monitoring of the health care facilities will provide an opportunity for maintenance and effective distribution and re- distribution of the health care facilities, so as to create a new landscape that will bring about lasting solution to the problem of health care delivery in the study area. In the light of the above, one expects that the health care facilities under the MDGs project would be made available to an extent, especially the basic amenities of life such as safe drinking water and hygienic environment.

In view of the above, the study therefore identified and mapped health care facilities of the MDG available in Kaduna North and South Local Government Areas with the view to monitor health care delivery in the study area. National Planning Commission (2006) stated that the rural populace in developing countries has been

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suffering from different kinds of deprivation yet; they constitute the bulk of the population, which is about 75% in Nigeria. For effective and functional health care delivery, spatial data is required on location and changes taking place within and around the communities to be able to carry out planning. Hence, there is a need to introduce scientific mapping technique that would reveal the impact and essence of mapping and monitoring the health care facilities. And this scientific technique is Geographic Information System (GIS).

Conditional Grant Scheme (CGS) is a federal government of Nigeria support from the Debt Relief Gains to the lesser tiers of governments to scale up and assist in improving Primary Health Centers (PHC), Water and Sanitation among others to meet up with the MDG goal number one (MDGs Report Card, 2008).

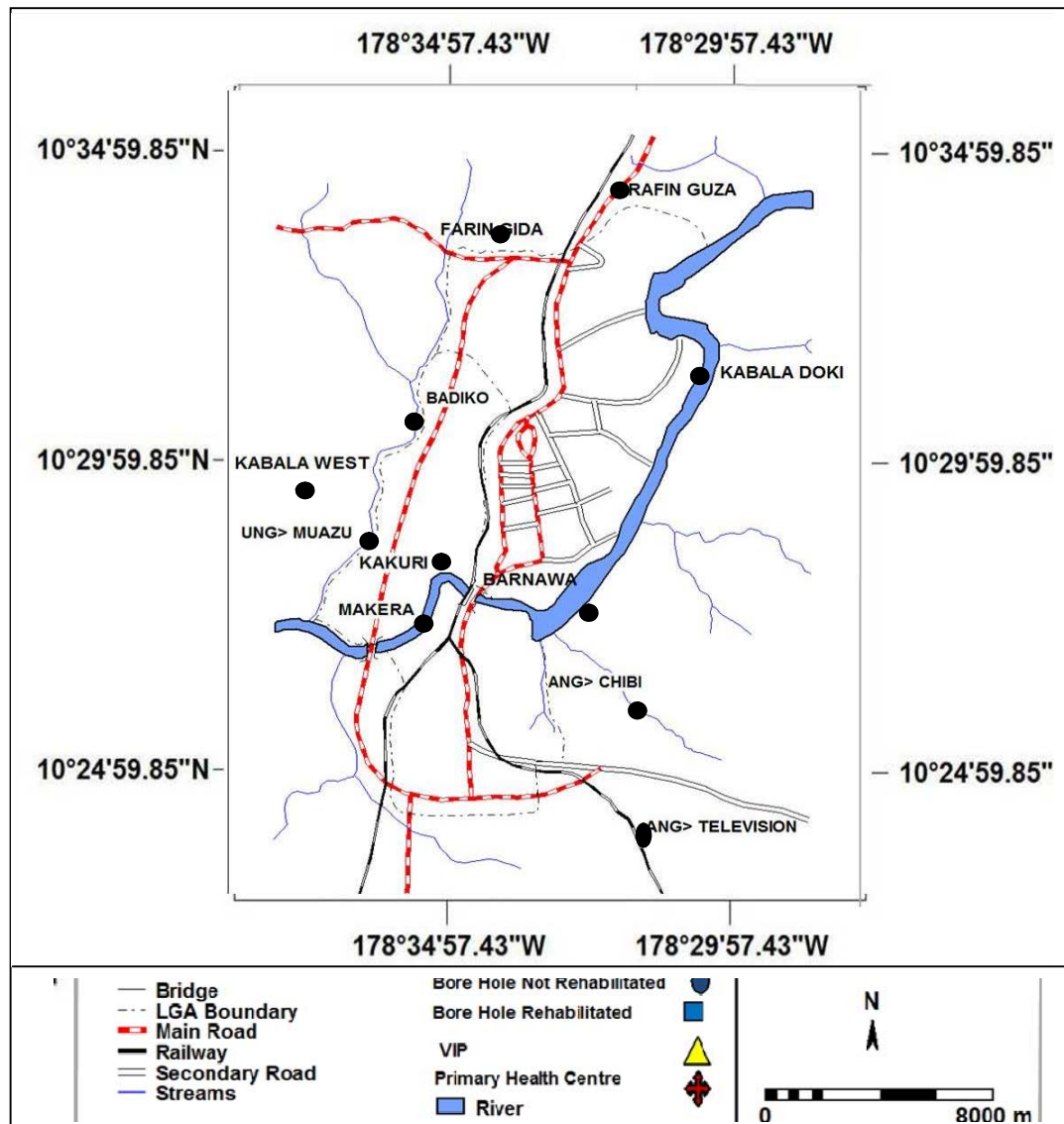
Several studies were conducted in which GIS was used to identify environmental indicators and spatial location of health facilities such as the GIS-based

application shown in a study of access to health care facilities when geographic information was used to link data from a population-based survey with an independently sampled health facility survey (Hong, 2006). Onsi, (2004) also used remote sensing and GIS technology to identify health facilities and delineate associated health risks, demonstrated the practical and successful application of remote sensing and GIS in assisting decision-making for health and development and the effectiveness of map making.

II. THE STUDY AREA

The study covers Kaduna North and South Local Government Areas of Kaduna State. The study area lies between latitudes 10° 24', 59.85", N and 10° 34', 59.85" N and longitudes 178° 29' 57.43" E and 178° 34' 57.43" E with total area coverage of 131 km² and population of 760,084 (National Population Commission, 2006 and 2007).

Figure 1 : The Study Area.



Source: GIS Analysis

III. MATERIALS AND METHODS

The data types used in this study are topological base map of Kaduna North and South Local Governments sourced from the archive of the Department of Geography, Ahmadu Bello University, Zaria. The coordinate information of the health care facilities was sourced using the GPS on the field. Apart from the coordinate data, the researcher also assessed the conditions of the health care facilities. This was important in complementing the data collected from MDGs Office (names and addresses of the health care facilities). There were twenty three (23) health care facilities in the study area out of which sixteen (16) were boreholes, four (4) were Primary Health Centers (PHC) and three (3) were Ventilated Improved Public Toilets (VIPs).

The health care facilities coordinate data collected from the field using GPS were plotted on the base map that has been scanned, geo-referenced and layers extracted. All data gathered were analyzed using Ilwis 3.2a GIS Software. The analyzed data are presented using tables and maps.

IV. RESULTS AND DISCUSSION

The health care facilities identified in the study area are in three categories. They are the Primary Health Centers (PHC), the Boreholes and the Ventilated Improved Pit (VIP). This is shown in Table 1. Table 1 shows that the number of boreholes identified were sixteen (69.56%), Primary Health Centers (PHC) were four (17.39%) and Ventilated Improved Toilets (VIP) were three (13.04%). The total numbers of the healthcare facilities of the MDGs were twenty three (23).

From the observation of the researcher, the PHC were all constructed by the MDG and were in good status. They were beneficial to the host community. The

PHCs were located at Kabala Doki and Badarawa all in Kaduna North L.G.A. The Ventilated Improved Toilet (VIP) of the Health care facilities of the MDGs were also in good working condition and located in Kaduna North L.G.A. It is evident that most of the Health Care facilities of the MDGs were located at the North-Western section (Kaduna North LG.A)

Table 1 : Inventory of health care facilities of MDGs Projects in the study area.

S/N	Health Care Facility	Absolute No	Percentage
1	Primary Health Centers	4	17.39
2	Boreholes	16	69.56
3	VIP latrines	3	13.04
	TOTAL	23	100.00

Source: MDGs report card, 2008

The databases, which were created in tabular formats, are presented in Tables 2, 3 and 4. The database carries basic information about the attribute data of the Health Care facilities ranging from their local government location, stations, coordinates, and status (working condition). Table 2 shows the total number of boreholes of MDGs, addresses and their respective geographical locations. Out of the sixteen (16) boreholes, seven (7) were not rehabilitated and not in good working condition. Most of the boreholes were located in Kaduna South L.G.A.

The Primary Health Centres and VIP toilets were very few in number as seen in tables 3 and 4 compared to the number of boreholes. The PHC were four (4) and the VIP toilets were just three (3). The VIP toilets were entirely located in Kaduna North local government area while the PHCs were equally located in both local government areas. They were also in good working condition and beneficial to the host community.

Table 2 : Spatial distribution of Boreholes of MDGs Projects in Kaduna North and South LGAs in 2008

	S/No	L.G	Station	Coordinates Gps Lat. (E)	Coordinates Gps Long.(N)
	1	Kaduna North	Farin Gida	10 ⁰ 34' 46.4"	07 ⁰ 25' 05.6"
	2	Kaduna North	Hayin Banki	10 ⁰ 34' 40.8"	07 ⁰ 26' 39.1"
	3	Kaduna North	Angwan Yero	10 ⁰ 33' 22.9"	07 ⁰ 26' 16.8"
	4	Kaduna North	Kwaru	10 ⁰ 33' 58.3"	07 ⁰ 27' 41.0"
	5	Kaduna North	Rafin Guza	10 ⁰ 35' 17.4"	07 ⁰ 28' 06.5"
	6	Kaduna North	Ungwan Dosa	10 ⁰ 34' 13.0"	07 ⁰ 27' 40.0"
	7	Kaduna South	Down Quarters	10 ⁰ 29' 05.7"	07 ⁰ 24' 52.6"
	8	Kaduna South	Makera	10 ⁰ 28' 21.2"	07 ⁰ 24' 34.2"
	9	Kaduna South	Kinkinau	10 ⁰ 29' 07.8"	07 ⁰ 24' 12.0"
	10	Kaduna South	Kabala West	10 ⁰ 30' 14.0"	07 ⁰ 23' 39.0"
	11	Kaduna South	Ungwan Sanusi	10 ⁰ 31' 42.9"	07 ⁰ 24' 34.0"
	12	Kaduna South	Kasuwar-Barchi	10 ⁰ 31' 0.9"	07 ⁰ 24' 40.2"
	13	Kaduna South	Tudun Ilu	10 ⁰ 30' 39.5"	07 ⁰ 25' 02.8"
	14	Kaduna South	Badiko	10 ⁰ 32' 04.2"	07 ⁰ 24' 38.0"

15	Kaduna South	Kurmin Mashi	10° 33' 16.0"	07° 24' 58.0"
16	Kaduna South	GGSS Barnawa	10° 28' 55.4"	07° 26' 05.9"

Source: Field Survey, 2010.

Table 3 : Spatial Distribution of Primary Health Centers (PHCs) of MDGs Projects in Kaduna North and South LGAs in 2008.

S/No	L.G	Station	Coordinates Gps Lat. (E)	Coordinates Gps Long.(N)
1	Kaduna North	Health Centre Kabala Doki	10° 33' 24.5"	07° 28' 09.2"
2	Kaduna North	Health Centre Badarawa	10° 33' 32.3"	07° 26' 04.2"
3	Kaduna South	Lea U/Chibi	10° 27' 10.6"	07° 25' 55.3"
4	Kaduna South	Health Centre U/Muazu	10° 29' 52.0"	07° 23' 37.0"

Source: Field Survey, 2010

Table 4 : Spatial Distribution of Ventilated Improved Pit (VIP) toilets of MDGs Projects in Kaduna North and South LGAs in 2008

S/No	L.G	Station	Coordinates Gps Lat. (E)	Coordinates Gps Long.(N)
1	Kaduna North	Lea Rafin Guza	10° 35' 18.8"	07° 28' 25.7"
2	Kaduna North	Lea U/Kudu	10° 33' 48.7"	07° 27' 49.5"
3	Kaduna North	Lea Malali	10° 33' 46.0"	07° 28' 10.6"

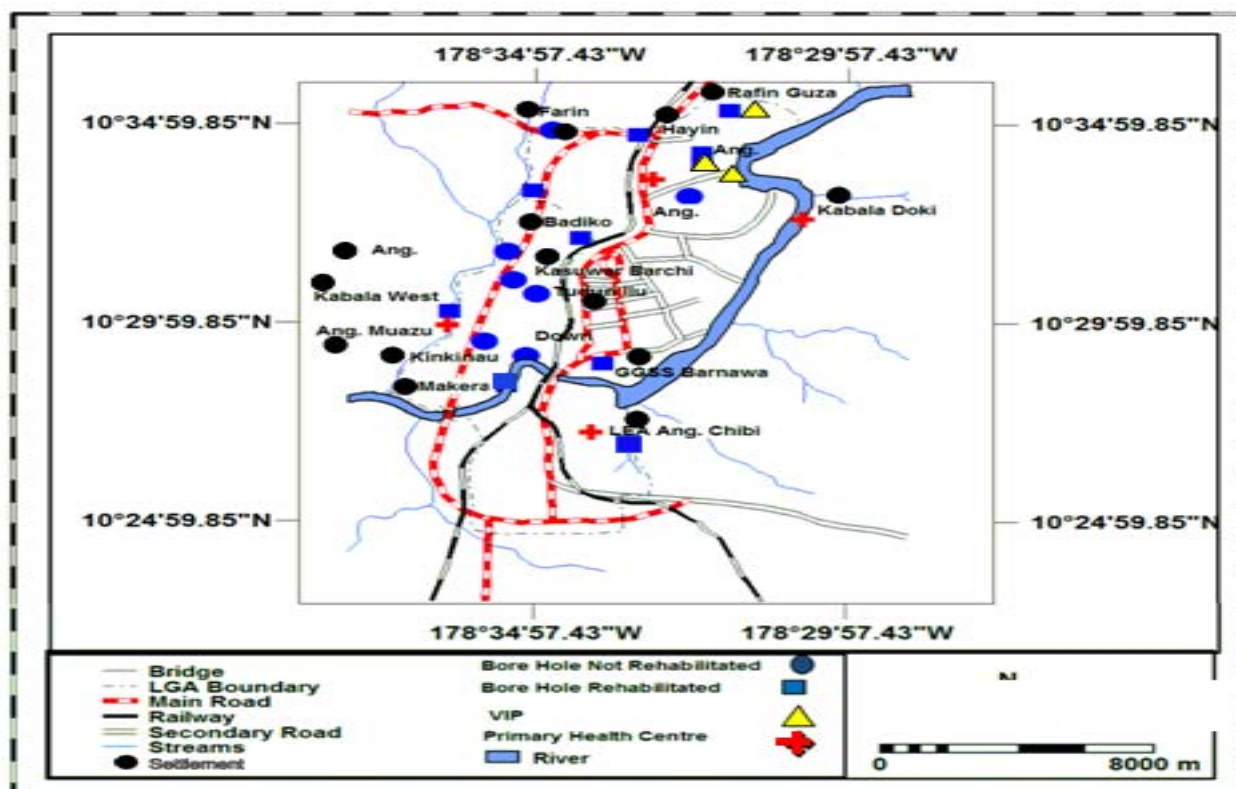


Figure 2 : The spatial distribution of the MDGs health care facilities in 2008

Source: GIS Analysis.

The spatial locations of the Health Care Facilities of the MDGs were plotted on the base map of the study area to produce the map (figure 2). The map shows the extent of the distribution of the Health Care Facilities of the MDGs within the study area. Most of the Health Care Facilities of the MDGs were spatially located at the North-Western section of the study area.

V. CONCLUSION

GIS provides a reliable base for mapping health care facilities with regular information updating. Distribution of Health Care Facilities remains a problem in Nigeria particularly in rural areas. There were no detailed working plans and criteria for the provision of healthcare facilities at the local level peculiar to the need of the generality of the people in the past. The challenge of health care delivery at the local level is how to get physical planners and communities involvement in decision regarding the location and distribution of health care facilities. This will enhance the provision of health care facilities in locations which are accessible to the generality of the populace. GIS however, will solve the problem of adequate spatial distribution of Health Care Facilities.

Due to the ever increasing number of population, more health care facilities need to be provided. In terms of "status", there were problems of malfunctioning of some of the Health Care facilities most especially the boreholes. Some of them were not well maintained and some not working at all. There are three important factors that affected the level of accessibility of the facilities. These were the capacity of the facilities, the demand for the facilities and the transportation network that communicated such demand to the relevant capacity. A good network of transportation provided easy access to these Health Care facilities. The study area had a good network of transportation with most of the Health Care Facilities spatially located in proximity to roads, railways and even part of the River Kaduna course.

Based on the strength of this study, it is recommended that 5km should be the service radius through which a Primary Health Centre (PHC), VIP Toilet and borehole should be provided. Based on the above service radius, one PHC will be provided in every community of every ward in the study area; one VIP toilet will be provided in every community of every ward in the study area; one borehole will be provided in every community of every ward in the study area. And this will help in meeting the MDG that is targeted with the provision of the health care facilities in the first place.

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GLOBAL JOURNAL OF HUMAN-SOCIAL SCIENCE: B
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Volume 14 Issue 5 Version 1.0 Year 2014

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

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`Analysis of Residents' usage of Household Materials and Vulnerability to Indoor Pollution in Ogbomoso, Nigeria

By Abolade Olajoke, Odunjo, Oluronke Omolola & Kehinde, Olamiju John

University of Technology Ogbomoso, Nigeria

Abstract- The paper investigates the residents' level of usage on sources and vulnerability of urban residents to indoor pollution in Ogbomoso. It utilized multistage method of sampling to distribute a total of three hundred and seventy three (373) structured questionnaires to residents in the selected forty eight localities. Likert scale rating was employed to examine resident's perception on the impacts of indoor air pollution. Resident Usage Index (RUI) and Residents Perceived Effect index (RPEI) with scale rating ranging from Not agreed (2), Partially Agreed (3), Agreed (4), Very much agreed (5) were developed to ascertain rating value placed by each resident. The average weight for each variable was computed. The findings reveals, highest index value of 2.30 usage in perfume, germicides (2.61) insecticides (2.29) building materials (2.71) asbestos, lanterns (2.38), charcoal (2.20). The high perceived usage suggests most frequently used household materials that constitute indoor air pollution in the study area. The general effect from use of household materials varies from sneezing eye irritation, dizziness headache among others. Continuous usage and exposure to such household materials will undoubtedly cause major damage to organs of the vulnerable group if appropriate action are not put in place. The paper therefore, recommends use of local household material that are less free of pollutant and cleaner fuel should be made available by concerned Government. Also awareness programme to sensitize populace on associated danger of exposure to household materials that are prone to generate indoor pollution should be adopted.

GJHSS-B Classification : FOR Code: 899899, 700401



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'Analysis of Residents' usage of Household Materials and Vulnerability to Indoor Pollution in Ogbomoso, Nigeria

Abolade Olajoke^p, Odunjo, Oluronke Omolola^o & Kehinde, Olamiju John^p

Abstract- The paper investigates the residents' level of usage on sources and vulnerability of urban residents to indoor pollution in Ogbomoso. It utilized multistage method of sampling to distribute a total of three hundred and seventy three (373) structured questionnaires to residents in the selected forty eight localities. Likert scale rating was employed to examine resident's perception on the impacts of indoor air pollution. Resident Usage Index (RUI) and Residents Perceived Effect index (RPEI) with scale rating ranging from Not agreed (2), Partially Agreed (3), Agreed (4), Very much agreed (5) were developed to ascertain rating value placed by each resident. The average weight for each variable was computed. The findings reveals, highest index value of 2.30 usage in perfume, germicides (2.61) insecticides (2.29) building materials (2.71) asbestos, lanterns (2.38), charcoal (2.20). The high perceived usage suggests most frequently used household materials that constitute indoor air pollution in the study area. The general effect from use of household materials varies from sneezing eye irritation, dizziness headache among others. Continuous usage and exposure to such household materials will undoubtedly cause major damage to organs of the vulnerable group if appropriate action are not put in place. The paper therefore, recommends use of local household material that are less free of pollutant and cleaner fuel should be made available by concerned Government. Also awareness programme to sensitize populace on associated danger of exposure to household materials that are prone to generate indoor pollution should be adopted.

1. INTRODUCTION

a) Background to the Study

The connection between the use of a building either as a workplace or as a dwelling place and the appearance, in certain cases, of discomfort and symptoms of illness is a fact attributable to indoor air pollution (WHO, 200, EPA, 1987). Indoor air pollution (IAQ) is a phenomenon recognized to be a major health problem worldwide because more than 3 billion people around the globe depend on solid fuel (WHO, 2007). The use of solid fuel within indoor environment for purposes including cooking and heating among others has been known to produce noxious fumes which are

injurious to human health (Bruce 2005; Ettati, 2005; WHO, 2007; WEC, 1999; EPA, 1987). This pollution largely affects a considerable number of dwellers, mostly women and children, because it has been established that they spend between 58 and 78% of their time in an indoor environment (Hoffman, 2003). These problems have been worsened with the construction of buildings that are poorly ventilated and badly aerated such that the circulation of fresh air is marred. Consequently, buildings with inadequate natural ventilation present risks of exposure to severe air-borne diseases and infection.

Indoor air pollution however, is not limited to use of biomass fuels. Other sources include particles from household materials (synthetic carpets and furniture, paints, asbestos), pesticides, insecticides, air fresheners (naphthalene ball) domestics appliances, and cosmetics products (body spray, perfumes anti aspirant) among others (Adigun et al 2011). Unknown to many dwellers, exposure to and inhalation of these fumes and dangerous gases from workplaces, homes and other indoor environments have been responsible for severe health cases such as respiratory infections (WHO, 1997), chronic lung diseases such as asthma and bronchitis, lung cancer, nose and throat irritation, and still-birth (Ayars, 1997), eye disorder, conjunctivitis, blindness and low birth weight (Traynors et. al., 1985), low ventilation rates (Menziez et al., 1993) and physiological discomfort among others (Tawari and Abowei, 2012).

Though outdoor air pollution poses severe health risks most of which are linked with the urban environment, yet, some of the highest concentrations of risks have occurred in indoor environment especially in most Sub-Saharan African countries like Nigeria (Oguntoke et. al., 2010; Theuri, 2009 and EPA, 2003). Smith and Mac (2009) also opined that the devastating effects of air pollution in the indoor environment are more flagrant than the outdoor environment owing to the length of stay in the former.

The World Resource Institute (WRI) in 1998 established that threats to human well-being are constantly being generated from two categories of human-environment interactions. Firstly, lack of development; owing to man's inability to maximize natural and environmental resources sustainably.

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Secondly, through threats produced when the by-products of resource exploration and transformation are not manageably rid of in a manner that will forestall its negativities.

Against this background, the problems of indoor air pollution becomes of great concern in this paper because those affected are less aware, ill-equipped and ill prepared for the menace and there are little or no provisions (facility-wise) in their communities to help cope with the impact. Consequently, the level of vulnerability and susceptibility to the scourges are pronounced (Akande and Owoyemi, 2008; Hoffman, 2003). An observable level of variations in what is experienced across geographical space as cited in existing literature have some cultural, demographic and environmental undertone among other things (ISOCAP, 2008). The need to investigate empirically, the resident's knowledge on sources and associated negativities of indoor air pollutant as well as the vulnerability of urban residents in a medium sized city is of both scientific and practical importance and therefore the major purview of this paper.

II. LITERATURE REVIEW

Indoor Air pollution has often been described as an urban problem globally. As dangerous as polluted outdoor air can be to human health, indoor air pollution actually poses a greater health risk on a global level. About 2.8 million deaths per year results from breathing elevated levels of indoor smoke from dirty fuel. Although, many people associate air pollution with outdoor urban environment, some of the highest concentrations actually occur in rural areas (Sinton and Weller, 2003; Mac, 2009 and Theuri, 2009).

The greatest threat of indoor air pollution occurs in the developing countries of the world, where some 3.5 billion people mostly in rural areas continue to rely on traditional fuel for cooking and heating. According to a World Bank Report, indoor air pollution in developing countries is designated as one of the four most critical global environmental problems (Carter, 1998 and Mac, 2009). Burning biomass fuel indoor is a major source of large amounts of smoke and other pollutants in the confined space of the home, thereby providing a perfect avenue for human exposure. Liquid and gaseous fuels such as kerosene and bottled gas, although not completely pollution free, are many times, less polluting than unprocessed solid fuels.

Indoor air pollution can be traced to prehistoric times when humans first moved to temperate climates and it became necessary to construct shelters and use fire inside them for cooking, warmth and light. Fire led to exposure to high levels of pollution, as evidenced by the soot found in prehistoric caves (Albalak, 1997). Approximately, half the world's population and up to 90% of rural households in developing countries today,

still rely on unprocessed biomass fuels in the form of wood, dung and crop residues (World Resources, 1998). These are typically burnt indoors in open fires or poorly functioning stoves. As a result, there are high levels of air pollution, to which women, especially those responsible for cooking, and their young children, are most heavily exposed. However, in developed countries, modernization has been accompanied by a shift from biomass fuels such as wood to petroleum products and electricity; while in developing countries, households often continue to use simple biomass fuels, despite the fact that, cleaner and more sophisticated fuels are available, (Smith, 1987). Although the proportion of global energy derived from biomass fuels fell from 50% in 1900 to around 13% in 2000, there is evidence that their use is now increasing among the poor (Albalak, 1997).

Poverty is one of the main barriers to the adoption of cleaner fuels. The slow pace of development in many countries suggests that biomass fuels will continue to be used by the poor for many decades. Biomass fuel is any material derived from plants or animals which is deliberately burnt by humans and wood is the most common example, but the use of animal dung and crop residues is also widespread (De Koning et al, 1985). China, South Africa and some other countries also use coal extensively for domestic needs and despite the significance of exposure to indoor air pollution and the increased risk of acute respiratory infections in childhood, the health effects have been somewhat neglected by the research community, donors and policy-makers (Smith, 1997 and Chen et al, 1990).

In general, the types of fuel used become cleaner and more convenient, efficient and costly as people move up the energy ladder (Smith, 1994). Animal dung, on the lowest rung of the ladder, is succeeded by crop residues, wood, charcoal, kerosene, gas and electricity; thus, people tend to move up the ladder as socio-economic conditions improve. Other sources of indoor air pollution in developing countries include smoke from nearby houses, the burning of forests, agricultural land, household waste and the use of kerosene lamps (Smith, 1994; and McCracken and Smith, 1998) as well as industrial and vehicle emissions. Also, indoor air pollution in the form of environmental tobacco smoke can be expected to increase in developing countries. It is worth noting that fires in open hearths and the smoke associated with them often, have considerable practical value, for instance in insect control, lighting, the drying of food, fuel, and the flavouring of foods (Smith, 1997).

III. RESEARCH AND METHODS

Structured questionnaire was employed to obtain information relating to morphology and

environmental characteristics of the study area from residents in various residential densities. This information include: perception of residents on level of usage of sources of indoor air pollutants, and impacts of indoor air pollution particularly on the vulnerable group.

The whole of Ogbomoso Township constitute the sample frame for this research. This comprises of two local government areas (Ogbomoso North and Ogbomoso South). The local government areas form the hub of development of the city with dense heterogeneous population characteristics in terms of income, education background, tribe, and types of building among others. The city is observed to be a medium developing urban centre with unprecedented growth both in population and spatial extent (Adeboyejo and Abolade, 2006). The growth of the city has been undoubtedly attributed to its educational function which has attracted new generation banks and establishment of new hospitals. It is also recognized to be the second largest indigenous city in Oyo State after Ibadan; this further enhances its selection for the research.

Multistage method of sampling shall be employed for collection of primary information for this study. Using the existing spatial structure of the city, both stratified and systematic random sampling technique was employed. The inventory of localities from the twenty wards of both LGAs, their residential densities and population figures was sourced from National Population Commission (2006). The localities in the twenty (20) recognizable wards within the study area was identified by residential densities (high, medium and low) using ratio 3:2:1 in that order in consonance with Adeboyejo (2002); Afon (2005); and Singleton et.al. (1989).

Forty eight (48) localities stratified into high, medium and low residential densities was randomly selected and systematically sampled for questionnaire administration. The first resident was picked at random and subsequent ones at an interval of two (2) buildings apart. A total number of three hundred and seventy three (373) structured questionnaires was administered to the residents in the selected localities. This represents 0.1% of the projected population for 2013. To examine resident's perception of the impacts of indoor air pollution on their health, certain indices shall be developed. These include: Awareness Index (i.e. IIEA) to examine its level of awareness on its associated impacts within the indoor environment. This was measured through Likert scale rating from Not agreed (0), Agreed (3), Very much agreed (5). The average weight for each variable shall be computed as individual index required for the study.

IV. DISCUSSION OF FINDINGS

a) Residents' Perception on Usage of Household Materials and Indoor Air Pollution

Likert scale rating was employed to ascertain the frequency of the use of house materials that generate indoor air pollution in the area. The responses of the respondents' were rated into four classes respectively to calculate Residents' Usage Index (RUI). Thirty four identified variables were examined to determine the frequency of residents' usage of materials that generates indoor air pollution. Each of the variables will be rated in respect to Likert Scale (1961) as either "very frequent", "frequent", "not frequent", "none", to indicate the level of respondents' usage and each of the rating was assigned a weight value of 4,3,2, and 1 respectively in decreasing order of relevance.

Resident Usage Index (RUI) was each variable, was calculated, the weight value was summed up and divided by the total number of the respondents. The usage weight value (UWV) was obtained by adding the products of the numbers of responses in each of the identified variables and the weight attached to each rating. The mean of RUI distribution was derived by dividing the total UWV by total number of questionnaire. The deviation about the mean was calculated. The standard deviation (S.D) and variance of the distribution were also calculated to measure how they are scattered around the mean as illustrated in Figure 1 and 2 (i.e how small or large the observations fluctuate below or above the mean). The co-efficient of variation was determined to measure the usage in the data relative to the mean in percentage. A positive calculated deviation indicates a high level of usage of the interested variables. When the deviation is negative it denotes a poor level of usage of the concerned variables.

RAI= Residents Usage Index

UWV=Usage Weight Value

NR=Number of Respondents

$\sum (UWV/N) = RAI$

Or $RUI = a/NR$ ($a = UWV$)

S/N=Number of materials that generate indoor air pollution as deodorants

b) Usage of Cosmetics

The use of "perfume" as cosmetics have the highest index value of (2.30) compared to other categories. This implies that it is the most frequently used in the study area that contributes to indoor pollution. This is probably because larger proportions of the respondents are female and they use perfume to expel body odour. This is followed sequentially by the use of "perfumed cream" (2.18), and use of Deodorants (1.90). The use of "roll on" is the least used among the identified variables under deodorants (1.60). The RUI distribution recorded a variance of 0.2024 and the standard variation of 0.22. The coefficient was 18.33% (table 1).

c) *Usage of Cleaning Agents*

Among the variables employed to examine level of usage of cleaning agents, "germicides" has the highest index value of (2.61) as shown in Table1, which implies that it is the most frequently used household materials that constitute indoor air pollution in the study area. Most respondents use it because it helps in the prevention of germs especially in toilets and bathrooms. It is followed by the use of "bleach" (2.00). Harpic is the least used among the identified variables (1.76). This is because harpic is only common with the high income earners and those with high education standard. who use modern toilet as against those with low socioeconomic status. The excess use of such materials will lead to respiratory disorder and sometimes skin irritation most especially when it comes in contact with skin. The RUI distribution recorded a variance of 0.3841 and the standard variation of 0.31. The coefficient was 19.38%.

d) *Usage of Odour Expeller*

The usage of odour expeller was also examined as one of the categories of household materials liable to generate indoor pollution. Among the variables identified, in the use of air fresheners which recorded the highest usage index value of (2.30) as shown in Table 1. This implies that it is most frequently used household materials that constitute indoor air pollution in the study area. This is followed by the use of naphthalene having (1.97). Incense is least used among the identified variables under odour expellants (1.79). The excess use of all these materials has serious health implications. The RUI distribution recorded a variance of 0.1338 and the standard variation of 0.18. The coefficient was 11.11%.

e) *Usage of Insecticides and Rodenticides*

The use of insecticides like mobil, raid among others, has the highest index value of (2.29). The incidence of high index value is premised on the poor hygienic and unsanitary nature of most houses and other environment which allows for infestation of insects like mosquitoes, cockroaches and flies. Consequently, the need for insecticides of various grades and types is necessitated. On the other hand some household have employed the use of mosquito coils which has index value of 2.23 and mosquito repellent leaf RUI (1.79.) where available because it is cost free and less harmful. Similarly rodenticides have been put in use to control; the breeding of rodents and other pests. Rodenticides use had an index value of 2.14 as indicated in table 1. The Residents Usage Index with a mean value of 2.11 has a standard variation value of 0.33 and corresponding coefficient of variation of 15.64%. The exposure of humans to such materials like insecticides without adequate ventilation in building will lead to several respiratory problems, which will undoubtedly lead to irritation of the lung.

f) *Usage of Fuels and Lightening Materials*

The use of kerosene, lanterns, charcoal and generators all have high RUI index values of 2.57, 2.38, 2.20, and 2.15 respectively which imply that they are frequently used in the study area. All these are however sources of noxious indoor pollutants. Others like candle, firewood and sawdust have a relatively low RUI value (1.75) when compared with the mean value. Exposure of eyes and nose to cooking fuels can generate oxides of carbon, which often results to eyes and lung problems. The RUI distribution recorded a variance of 1.127 and the standard variation of 0.22. The coefficient was 12.87.

g) *Usage of Household Equipments*

Among other variables employed for measurement for household equipments, use radio has the highest index value of (3.09). It is followed sequentially by the use of "electric iron" having (3.00), the use of television (2.97), the use of standing fan (2.71), and the use of refrigerator (2.57). The use of "air conditioner" has the least RUI value of 1.78. This is because it can only be afforded by the high income earners. The high usage of household equipment like radio television, use of electric iron will increase indoor temperature and sometimes emit waves that may likely heat up the body, this consequently leads to damage of cells in the body. The RUI distribution recorded a variance of 1.214 and the standard variation of 0.42. The coefficient was 15.79

h) *Usage of Building Materials*

Among variables examined under the use of building materials " asbestos" as building material have the highest index value of (2.71). It is the most frequently used household materials that constitute indoor air pollution in the study area. It is followed sequentially by the use of paints having (2.49). The use of POP is the least among the identified variables in the use of building material with (1.36). The least proportion recorded for POP is expected because it is highly expensive when compared with other roofing materials like asbestos or modern roof; consequently it is mostly used by affluent or rich people. Exposure to particles from asbestos and POP can results to cancer of the lung. The RUI distribution recorded a variance of 0.0783 and the standard variation of 0.020. The coefficient was 6.39%.

Table 1 : Perception on Usage of Household Material and Indoor Pollution

Household Materials	Respondents Opinion				NR	AWV	RAI	(A-A)	(A-A) ²
	4	3	2	1					
Perfume	78	76	83	123	360	829	2.30	-0.3	0.00
Perfumed cream	100	85	55	120	360	785	2.18	-0.18	0.0324
Deodorants	34	72	70	184	360	676	1.90	0.1	0.01
Roll on	35	51	72	202	360	567	1.60	0.4	0.16
Germicides	113	89	61	97	360	938	2.61	-0.49	0.2401
Bleach	32	89	86	153	360	720	2.00	0.12	0.0144
Harpic	42	56	77	185	360	633	1.76	0.36	0.1296
Air Fresheners	90	67	65	136	360	827	2.30	-0.28	0.0784
Naphthalene	50	70	60	180	360	710	1.97	0.05	0.0025
Insecticide	47	51	43	219	360	646	1.79	0.23	0.0529
Insecticides	45	129	71	115	360	824	2.29	-0.18	0.0324
Mosquito coil	62	92	74	132	360	804	2.23	-0.12	0.0144
Rodenticides	55	87	72	146	360	771	2.14	-0.03	0.0009
Mosquito Repellent leaf	36	70	36	218	360	644	1.79	0.32	0.1024
Rechargeable Lantern	144	93	38	85	360	1016	2.82	-0.66	0.4356
Kerosene	111	91	49	109	360	924	2.57	-0.41	0.1681
Lantern	88	96	41	135	360	857	2.38	-0.22	0.0484
Charcoal	67	87	56	150	360	791	2.20	-0.04	0.0016
Generator	94	93	41	132	360	775	2.15	0.01	0.001
Candle	43	69	48	199	360	674	1.87	0.29	0.0841
Firewood	60	48	33	219	360	669	1.86	0.3	0.09
Naked Fire	42	61	40	217	360	648	1.80	0.36	0.1296
Saw Dust	50	39	43	228	360	631	1.75	0.41	0.1682
Radio	172	107	23	59	360	1114	3.09	-0.43	0.1855
Electric Iron	157	108	32	63	360	1079	3.00	-0.34	0.1154
Television	177	75	29	79	360	1070	2.97	-0.31	0.0988
Standing Fan	131	85	51	93	360	974	2.71	-0.05	0.0025
Refrigerator	135	63	35	127	360	926	2.57	0.09	0.001
Coal Iron	102	94	37	125	360	889	2.47	0.19	0.0361
Air conditioner	62	36	23	239	360	641	1.78	0.88	0.7744
Asbestos	141	80	31	108	360	974	2.71	0.02	0.004
Painting	108	87	39	126	360	897	2.49	-0.3	0.09
Furniture	106	89	45	12	360	793	2.20	-0.01	0.0001

Source: Authors' Field Survey (2014)

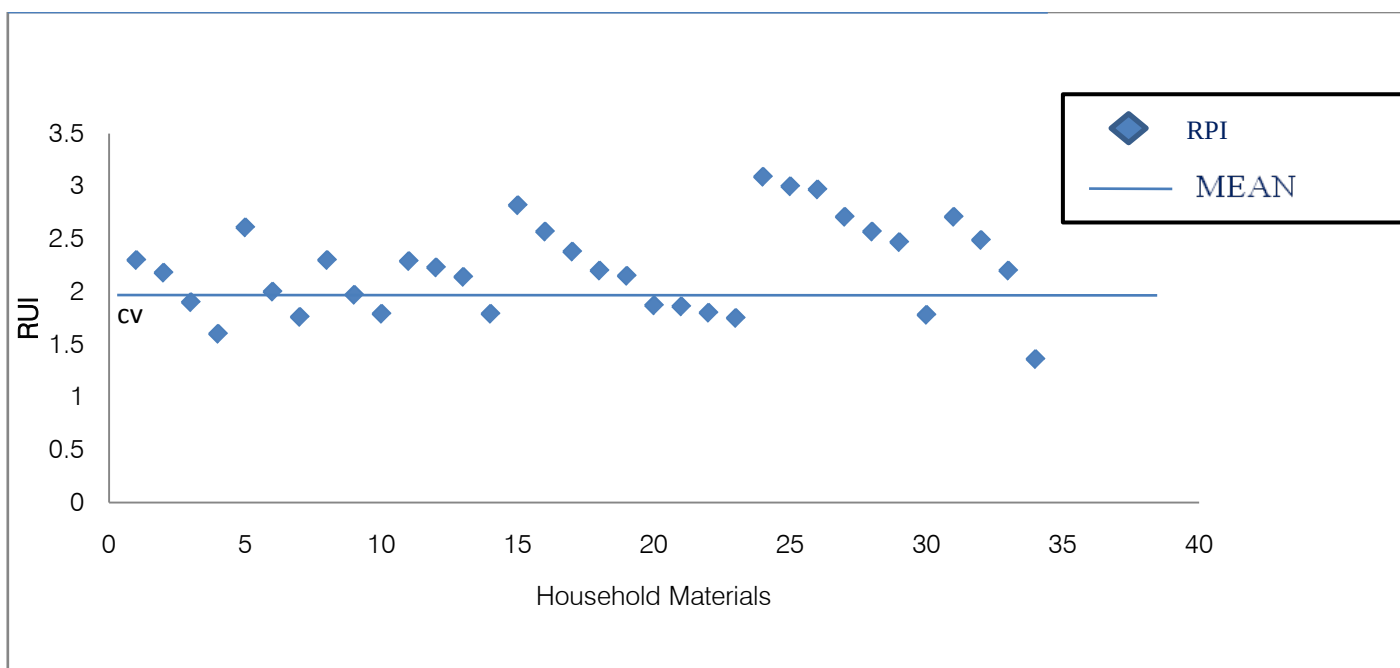


Figure 1 : Scattered diagram on Usage of Household Materials and Indoor Pollution

i) *Health Effects Associated with Household Sources of Indoor Air Pollution*

Table 2 summarizes responses of residents and their vulnerability to various ailments from the use of selected household materials. The results of analysis reveals that use of Odour expeller such as air fresheners, incense and naphthalene by residents in the study area causes discomfort such as sneezing (47.0%) and eye irritation (35.3%) problems. The same pattern of ailment was observed for fuel and lightning materials like charcoal, firewood, saw dust, kerosene, generators, naked fire lamps, lantern and others where larger proportion of residents also experience sneezing (47.8%) and eye irritation (43.9%). Similarly the responses on effect of building materials (asbestos, pop plywood among others) and cleaning reagents like bleach, happic etc reveals that most residents experience sneezing, eye irritation, dizziness while some reported symptoms of headache. On the contrary, the ailments experienced from the use of insecticides and rodenticide differs slightly from the pattern recorded for other household materials. It is equally revealed from result of analysis in Table 2 that use of insecticides causes sneezing (40.5%), dizziness (33.0%), breathing problems (31.4%) while use of electrical equipments like radio often cause headache (23.2%) compared to proportion of other ailments experienced by residents. This is expected because of the high noise level mostly produced when the instrument is put to use. Generally, the ailment experienced by use of household materials liable to cause indoor pollution varies from sneezing, eye irritation, dizziness headache and breathing problems. The symptoms of sneezing associated with most household materials is established in literature that

nasal irritation and neurological damage is associated with the use of asbestos ceilings. Further analysis reveals that the proportion of ailment among residential density varies and decreases from Brazilian, flat compound and flat residential unit. The distribution of diseases among different building type is an indication of building characteristics vis a vis design pattern type of sources of household materials and socioeconomic characteristics of residents.

j) *Residents' Perception on the Level of Exposure of Household Members to Indoor Air Pollution*

Analysis on household members' vulnerability to indoor air pollution in the study area, was analyzed using the Likert scale. Four level of perception were used to rate respondents' level of agreement on selected household members' exposure to indoor air pollution. They include "Strongly agree", "Agree", "Strongly disagree" and "Disagree" with the ratings being from 4 to 1 in order of agreement. Residents' responses to these were rated numerically to calculate Residents' Agreement Index (RA_gI). Four basic household members were identified (namely fathers, mothers, male and female children). These were cross matched to derive seven different suppositions on which respondent's level of agreement can be queried and rated using the Likert scale. Resident's Agreement Index (RA_gI) of each supposition and the calculated weight value (WV) of each was summed up to get the Total Weighted Value (TWV). This was divided by the total number of the respondents. Calculated Weighted Value (WV) was derived by adding the products of the numbers of responses for each supposition and the weight attached to each rating.

$$TWV = \text{Total Weight Value} = (WV \times \text{rating})$$

NR = Number of Respondents

WV = Weighted Value

$RA_gI = TWV/NR$

RA_gI = Residents Agreement Index

Table 1 shows the respondents' level of agreement on which household members are most susceptible to indoor pollution. A critical examination of the result of analysis reveals low Agreement index (RA_gI) of 1.85 for response "on male children are more exposed to indoor air pollution than the female". This implies that majority of the sampled population do not agree that male children are more exposed to indoor air pollution compared to the female. This explains why the supposition that female children are more exposed to indoor air pollution has a very high (RA_gI) of 2.72. The same trend is shown in the third supposition with majority not agreeing that fathers (RA_gI of 1.81) are more exposed than mothers but agreeing that mothers are the

ones really exposed with a very high RA_gI value of 2.97. Moreover, the table further suggests that parents (RA_gI of 2.28)) are more exposed to indoor air pollution than children (RA_gI of 2.21) in the study area. Conclusively and deducing from the (RA_gI) values in order of decreasing magnitude, the most susceptible to indoor air pollution within the residential environment are mothers with the highest RA_gI value of 2.97. Next are the female children with (RA_gI) of 2.72. This certainly owes to the fact that girls whether directly or indirectly share the mother's duty in the home. Then the male children are next to the female in susceptibility with RA_gI value 1.85 while the fathers are the least affected probably because they are less involved with household chores. The distribution of of calculated RPI is illustrated in Figure 2, where majority of RPI values fluctuate above the mean. This implies they were highly perceived by residents as vulnerable group to indoor pollution

Table 3 : Household Materials and the Associated Ailments

Odour Expellers	Frequency	Percentage
Dizziness	85	25.0%
Eye Irritation	120	35.3%
Sneezing	160	47.0%
Head Ache	74	21.8%
Breathing problems	66	19.4%
Fuel and Lightening materials		
Dizziness	73	21.7%
Eye Irritation	148	43.9%
Sneezing	161	47.8%
Head Ache	82	24.3%
Breathing problems	100	29.7%
Building Materials		
Dizziness	24	7.1%
Eye Irritation	62	18.2%
Sneezing	88	25.9%
Head Ache	42	12.4%
Breathing problems	35	10.3%
Insecticides/Rodenticides		
Dizziness	78	23.1%
Eye Irritation	62	18.3%
Sneezing	137	40.5%
Head Ache	61	18.0%
Breathing problems	89	26.3%
Cosmetics		
Dizziness	114	33.0%
Eye Irritation	111	32.1%
Sneezing	142	41.1%
Head Ache	42	15.7%
Breathing problems	106	31.4%
Cleaning Reagents		
Dizziness	104	30.9%
Eye Irritation	101	29.7%
Sneezing	123	36.2%
Head Ache	56	16.5%
Breathing problems	52	15.3%
Electrical Equipment	Frequency	Percentage
Dizziness	43	12.7%
Eye Irritation	68	20.1%
Sneezing	59	17.4%
Head Ache	79	23.2%
Breathing problems	41	12.0%

Source: Authors' Field Survey (2014)

Table 4 : Residents' Perception on Vulnerability of Household Members to Indoor Pollution

Vulnerable Group	WV for Respondents' Level of Agreement				NR	TWV	RPI	Remark
	4	3	2	1				
Male children are more exposed than female children	88	135	108	125	246	456	1.85	Low
Female children are more exposed than male children	348	225	24	72	246	669	2.72	Very High
Mothers are more exposed than fathers	560	297	22	70	320	949	2.97	Very High
Fathers are more exposed than mothers	120	174	102	176	315	572	1.81	Low
Children are more exposed than parents	276	240	36	150	317	702	2.21	High
Parents are more exposed than children	228	297	78	123	318	726	2.28	High
All are equally exposed	340	156	110	148	340	754	2.21	High

Source: Authors' Field Survey, (2014)

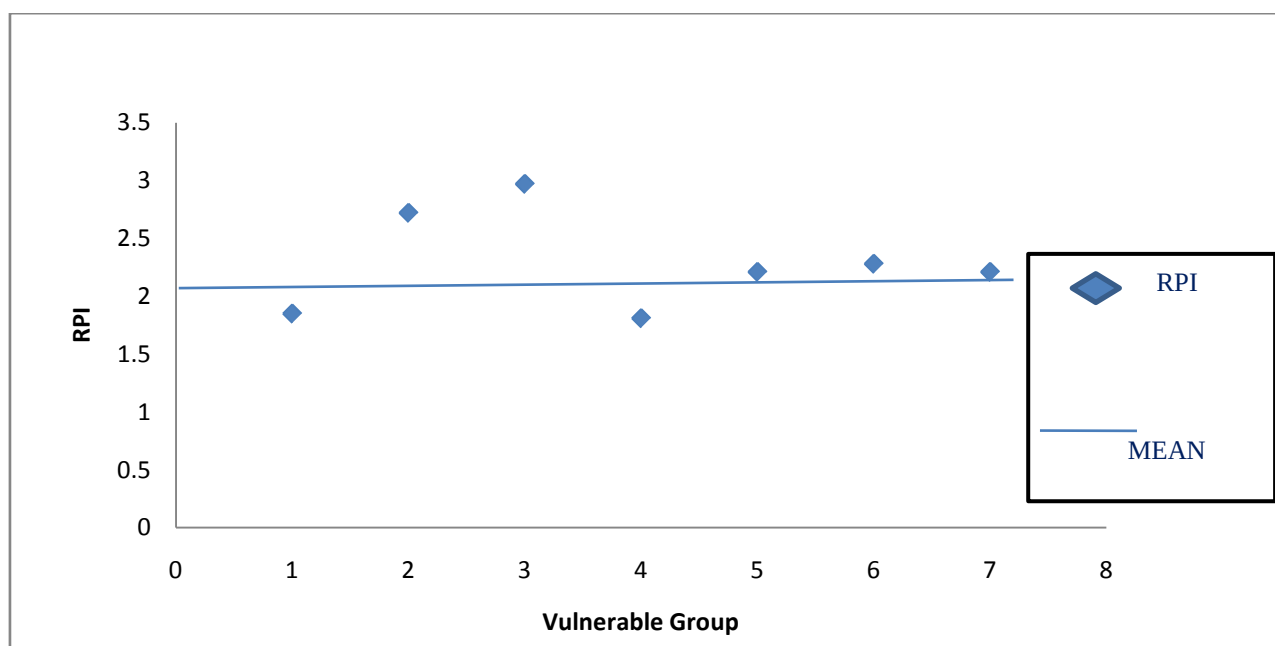


Figure 2 : Scattered Diagram of Residents Vulnerability to Indoor Pollution

V. RECOMMENDATION AND CONCLUSION

The paper has established that usage of most household materials that are liable to generate pollution is mostly used by residents. Continuous usage and exposure to such household materials will undoubtedly cause major damage to organs of the vulnerable group if appropriate action are not put in place. The paper therefore, recommends use of local household material that are less free of pollutant and cleaner fuel should be made available by concerned government. Also proper awareness programme should be carried out to sensitize populace on associated danger on exposure to household materials the are prone to generate indoor pollution.

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GLOBAL JOURNAL OF HUMAN-SOCIAL SCIENCE: B
GEOGRAPHY, GEO-SCIENCES, ENVIRONMENTAL DISASTER
MANAGEMENT

Volume 14 Issue 5 Version 1.0 Year 2014

Type: Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals Inc. (USA)

Online ISSN: 2249-460X & Print ISSN: 0975-587X

Women's Vulnerabilities due to the Impact of Climate Change: Case from Satkhira Region of Bangladesh

By Md. Sanaul Haque Mondal

East West University, Bangladesh

Abstract- Bangladesh is recognized as one of the worst affected countries of the world due to climate induced disasters. The disadvantageous geographical setting along with various socio-economic factors is triggering the vulnerabilities of people. The impacts of climate change are multifaceted and disproportionately distributed regardless of race, caste, ethnicity, sex and level of income. The perception and impact of climate change is completely gender differentiated. Women are ever more vulnerable to the impact of climate change than men, because they have very limited access to financial resources, land, education, health services and in decision making process. All these insufficiencies make women vulnerable to climate induced disaster than men. This study has found an appealing relationship between climate change impact on women's livelihoods and health. Climate change adversely impact on women's livelihoods and health and create extra burden on women.

Keywords: *climatechange, gender, livelihoods, health, coastal area.*

GJHSS-B Classification : *FOR Code: 960799, 760101*



Strictly as per the compliance and regulations of:



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Keywords: climate change, gender, livelihoods, health, coastal area.

I. INTRODUCTION

Bangladesh is recognized as one of the worst affected countries of the world due to climate induced disasters. The disadvantageous geographical setting along with low and flat topography makes this country physically vulnerable to climate change. Moreover, various socio-economic factors like high population density; high levels of poverty; gender inequality; dependency on climate sensitive livelihoods sectors, especially agriculture, fishing, and hunting and gathering forest resources; lack of adaptation fund and other institutional insufficiency are triggering the vulnerabilities of people. The impacts of climate change are multifaceted, it is not static rather it is disproportionately distributed regardless of race, caste, ethnicity, sex and level of income, its impacts are more heavily felt by poor nations and communities. Climate change magnifies existing inequalities. The IPCC concluded: "Poor communities can be especially vulnerable, in particular, those concentrated in high-risk areas. They tend to have more limited adaptive capacities, and are more dependent on climate-sensitive resources such as local water and food supplies" (IPCC 2007:9).

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Now-a-days, women and climatic risk is a much talked matter. The perception and impact of climate change is completely gender differentiated. Women are ever more vulnerable to the impact of climate change than men, because they have very limited access to financial resources, land, education, health services and in decision making process. All these insufficiencies make women vulnerable to climate induced disaster than men. Besides, a significant number of female headed households are found in coastal areas who are mostly depends on primary economic activities. Considering the vulnerability and inequality of women, it is a proposition that climate change adversely impacted on women's livelihoods and health.

a) Women and climate change

Climate change affects everyone. But, women are the most vulnerable to the impact of climate change, because they have limited access to resources that are required for preparedness and adaptation. UNFCCC (2005) reported that during natural disasters more women die than men because they are not warned, cannot swim or cannot leave the house alone.

Moreover, women are being affected in their multiple roles as food producers and providers, as guardians of health, care givers, and economic actors. As access to basic needs and natural resources, such as shelter, food, fertile land, water and fuel, becomes hampered, women's workload increases. Drought, deforestation and erratic rainfall cause women to work harder to secure resources and livelihoods. Depletion of natural resources and decreasing agricultural productivity may place additional burdens on women's health and reduce time for decision-making processes and income-generating activities.

b) Study area profile

Satkhira is a district in South-western Bangladesh. It lies along the border with West Bengal in India. It is located at 22.35° N 89.08° E. It is bordered to the north by Jessore district, on the south by the Bay of Bengal, to the east by Khulna district and to the west by Pargana district of West Bengal. It consists of seven upazila, two pourasavas (Municipality) and seventy eight unions. Sundarban is the largest single block of tidal halophytic mangrove forest in the world and is a World

Heritage Site, and covers an area of 5747 km². The main rivers are Morichap River, Kholpota River, Betna River, Rainmangal River, Hariabhanga River, Ichamoti River, Betrabiati River and Kalindi Jamuna River.

Gabura Union is under the constituency of Shyamnagar Upazila. The area of this Union is 33 km². According to BBS, 38825 people are living in this village among them 19307 male and 19518 female (BBS, 2011). Around 70% of the people depends on fishing and the rest 30% on agriculture (25%) and others (5%).

It is one of the most extreme southern Unions of Bangladesh has exposed to Bay of Bengal through two rivers- Kholpetua and Kapatakkha.

Chakbara village is one of the villages of Gabura Union. The study was conducted in Chakbara village. This village was severe affected by the cyclone Sidr (2007) and Aila (2009). The *Gher* system is also prominent in this village. To fulfill the requirement of the study, the samples were drawn from this village.

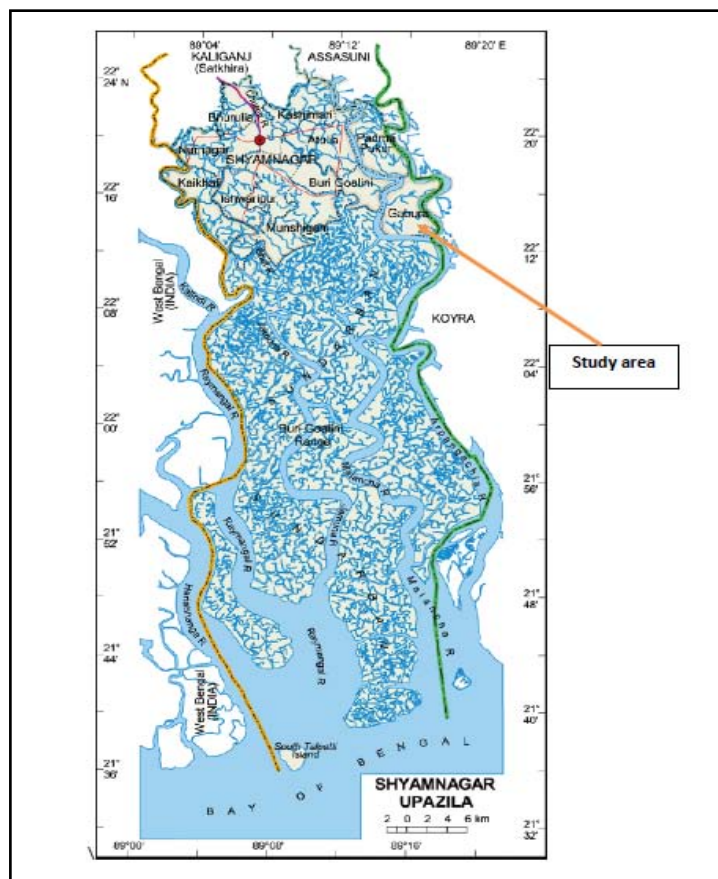


Fig. 1 : Map of Shyamnagar Upazila (Source: Banglapedia, 2001)

a) Objectives of the study

The objective of this study is to find out the devastating impact of climate change on women. The study focuses on coastal women residing at Gabura Union of Shyamanagor Upazila under Satkhira district. The specific objectives of this study are:

1. To identify the impact of climate change on women
2. To analysis reasons behind those impacts and vulnerabilities
3. To recommend some specific measure to address the impacts.

b) Methodology

The study involves multistage analytical process of analysis. Both primary and secondary data on the impact of climate change on women have comprehensively been used in this study. The primary

data was collected through focus group discussion and in-depth interviews with the women.

c) Sample size

This study was exclusively focused on female headed households, divorced, tiger widows, and widows (husband died from disasters or during fish collection). 6 FGD (10 women participated in each FGD) and 2 in-depth interviews were conducted in the study area. Purposive sampling was employed to select the respondents.

d) Source of data

Focus Group Discussion (FGD) and interviews were conducted to collect qualitative information. Besides, secondary information were collected from various reports focusing on disaster and women; BBS,

journals, books, newspaper, gender specific publications of GO, UN, INGO and NGO etc. The primary data was collected in the month of February.

collection, small trade and household maid. Livelihoods of women in coastal area are extremely nature depended.

II. DISCUSSION AND RESULTS

a) Occupation of the participants

The participants of FGD were women and they engaged in different livelihoods like day labor, shrimp fry

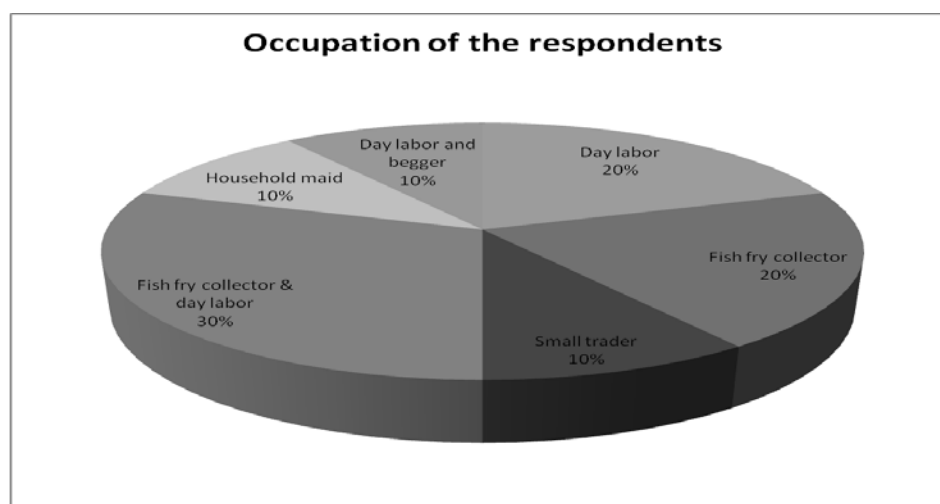


Fig. 2 : Occupation of the respondents

b) Data presentation: Evidence of climate change as identified in FGD

The women were asked to mention some noticeable indication of climate change. They mentioned the following interpretations:

- Frequency of cyclone has increased like Sidr, Ayla, Bizli, Laily etc.
- Paddy and vegetable were grown in 80% (approximately) of the land before 25 years ago, but now only 15% (approximately) of land is under cultivation, because salinity has increased
- No livestock in the village because there is no pasturage land, all trees and grasses are died due to the salinity ingressions.
- Salinity of water has increased a lot. All the sweet (drinking) water sources are now contaminated by ground water salinity.
- Salinity level of rivers/ ponds has become increased in *Choitra- Boishakh*. And river water is now hotter than previous.
- Recurrent interval of high tide flow in rivers.
- Doughtiness in the village, no tress, high daytime temperature, high wind in winter
- Decrease in agricultural productivity
- Increase vector-borne and skin diseases

c) Triple burden of women due to the impact of climate change

It was hypothesized that the burden of women increased in manifolds. Women were asked to identify

their burden on three broad categories like producers, caregivers and breadwinners. All the respondents were engaged in different income generating activities to feed their families.

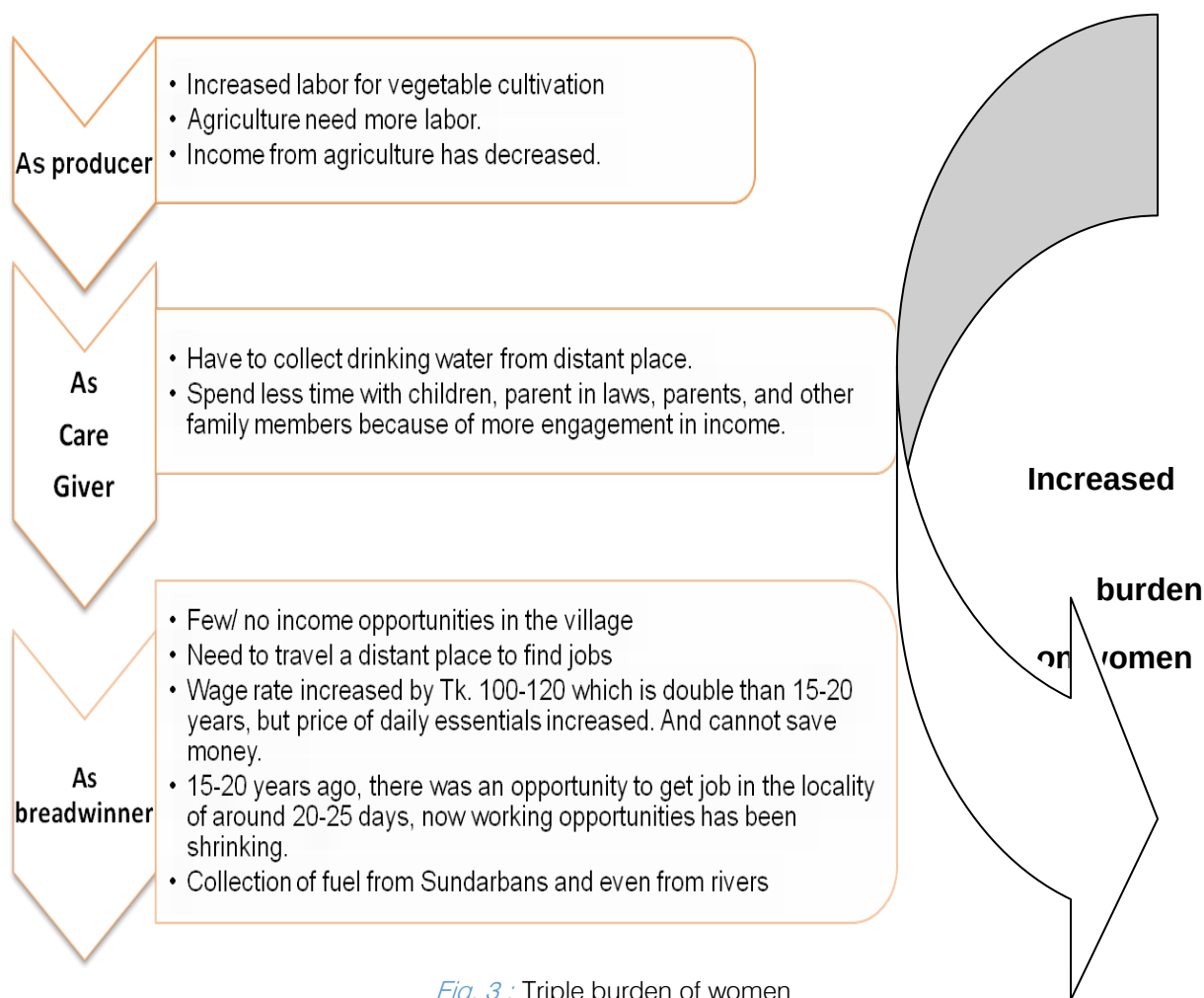


Fig. 3 : Triple burden of women

d) *The most vulnerable work for women*

Women in the discussions also asked to identify three most vulnerable works for women. All of them were agreed and prioritized the following works as most vulnerable for them. They ranked shrimp fry collection in

river as top. To collect the shrimp fry they need to stay in saline water. Saline water is detrimental for health especially for reproductive health and often they are facing skin diseases.

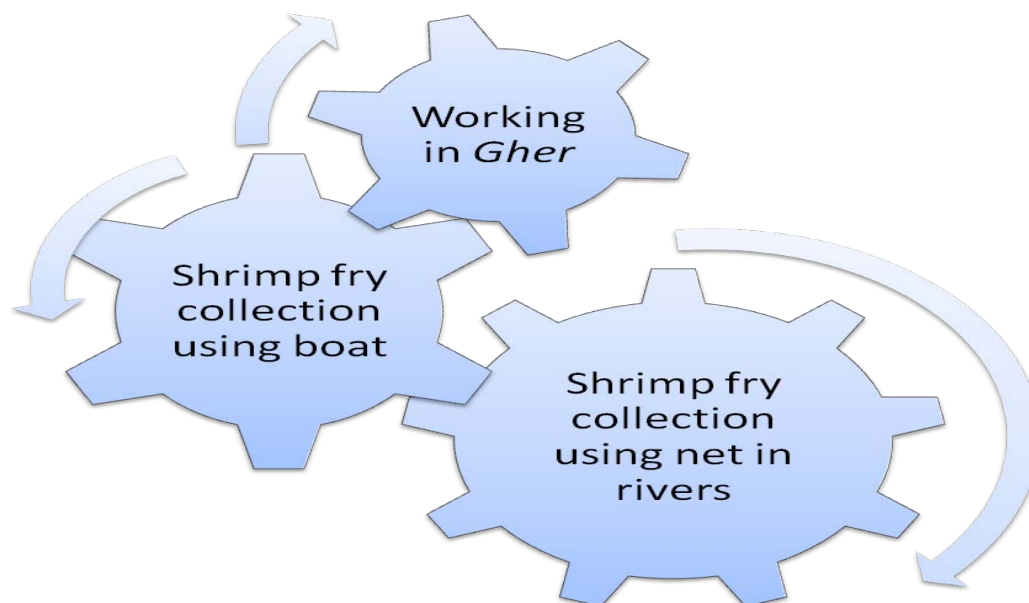


Fig. 4 : Most vulnerable work for women

e) *The impacts climate change on the livelihoods and health of women*

Women participated in the discussion identified their vulnerabilities that fragile their livelihoods and health. The key issues are discussed in the following table 1:

Table 1 : Impact on livelihoods and health

Fragile condition	Women's vulnerability
Housing and homestead	Disaster destroys houses. Homesteads are now unusable for vegetable production because of salinity ingression (case story of Ms. Moyna Khatun is described in box 1).
Crop production loss	Women, who control homestead-based livelihoods, lose income when crops are blown or washed away. Most of the homesteads are now fallow and unsuitable for cultivation. For this reason, they have to buy vegetable from the market with a high price. Thus expenditure increased in manifolds. And, finally women are facing chronic nutritional deficiency.
Limited access to market	Communication systems in Gabura union have collapsed after the cyclone Sidr and Ayla. Markets are located far away from their village, where women have very limited market access to buy or sell their goods. Women are forced to trade within the village or accept lower prices offered by male buyers from other areas.
Loss of income, savings and employment	Climate change affects every sector adversely. Sources of income especially for women have reduced. Less income opportunities leads to less earning which further hamper the food security of the family. The net loss in income leads to a loss in
Fragile condition	Women's vulnerability
	savings, thus making it even harder for households to cope with disasters (case story of Rizia Khatun is in box 2)
Increase disease and sickness	Frequency of sickness has increased. Women who are involved in fish fry collection, has to stay in saline water for long time. During menstruation period, fish fry collectors faced severe gynecologic diseases. Most of the cases these women needs to go to cities for having treatment, which is financial burden for them. There was very limited or no saline intrusion in agricultural land before 20-25 years and during that time women were engaged in agriculture and they had not experienced such health hazards. Now most of the agricultural land is employed for shrimp cultivation and as a result job market for women has been shrinking. Therefore, women are forced to involve in fish fry collection to maintain their families.
Social security	Women who engage in employment are facing social insecurity at their workplace and outside. They often fall prey to local miscreants (<i>mastans</i>). Besides, everybody neglects the social dignity of working women. Moreover, in cyclone shelter women have no separate facilities.

Box 1:

Moyna Khatun: Her homestead washed away by cyclone Ayla. After that she couldn't buy any land. She also lost her sewing machine at that time and it was her only earning source. Now she is living in her parents' house.

III. CONCLUSION AND RECOMMENDATIONS

a) Conclusion

Changes in climate variability directly affect agricultural production and female headed households. Although this study was conducted at a micro scale, the study found a significant relationship between climate change and women livelihoods who are dependent on natural resources. Women are playing different role in their families. In previous time women played only one role for their families as caregiver. Two other burdens have added with their role- producer and breadwinner. Many development interventions implemented in this area, but few of them can address women vulnerabilities, because the target oriented programs

mostly focus on outputs not the outcomes. However, access to service from different service providers is still far reaching for women. Therefore mainstreaming the gender in policies and development process is very urgent.

b) Recommendations

In this study, the relationship of women vulnerability and impact of climate change has been examined on a micro scale. The following recommendations are based on the outcomes of this study:

- Conduct in depth gender specific vulnerability analysis in relation to climate change impact to unearth women's situation.



- Create an enabling environment for women's participation in climate change process, and raise women's voices at from micro level to macro level.
 - Create gender-specific disaster reduction policies to address the effects of climate change in disaster-prone areas.
 - Promote women's empowerment through capacity-building before, during and after climate-related disasters, as well as their active involvement in disaster anticipation, early warning and prevention as part of their resilience building.
 - Ensure that government policies and programs on human rights, women's rights and climate change are coherent and reinforce each other.
 - Gender specific indicator need to be added in national policies on disaster and climate change to as a measure of gender gap.
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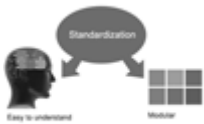
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- (c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.
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- (h) Brief Acknowledgements.
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- All figure and table must be adequately complete that it could situate on its own, divide from text

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The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
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- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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ISSN 975587

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