International Journal of Theoretical & Applied Sciences, 9(2): 192-200(2017)

ISSN No. (Print): 0975-1718
ISSN No. (Online): 2249-3247

Problem of Water Logging through Soil Quarrying in Brick Kiln Industry: A Study of Tufanganj Block-I, Koch Bihar, West Bengal

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(Received 14 September, 2017 accepted 28 October, 2017)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The manufacturing of brick is an unorganized and traditional industry. It is generally concentrated in the rural areas in the vicinity of urban centres. The preparation of brick follows traditional to modern technology around the world. It requires a huge amount of good quality loamy soil to prepare clay bricks. The rapid urbanization process makes this sector more vulnerable to waterlogging. NBSS & LUP (2016) estimated 4.16×10^{18} ton topsoil has been removed every year. It causes of about 93×10^{3} hectares of land degradation in every year. The present study was carried out 24 brick kilns in Tufanganj Block-I of Koch Bihar district, West Bengal. The main objective of the study is to determine the permanent and temporary water logging in the study area. To establish the fact, an intensive field survey with a handheld GPS was carried out. Moreover, Modified Normalized Difference Water Index (MNDWI) method has been followed for extracting the surface water from IRS-P6, Resourcesat-2 LISS-III data. It is evident from the study that the problem of waterlogging persisted in the study area. Permanent and temporary water logging area was 323.94 acres and 209.0 acres in the study area. It would be recommended to encourage the kiln owners to reduce the consumption of topsoil and looking for the alternatives of clay for preparing the bricks.

Keywords: Topsoil, Land degradation, Water logging, MNDWI

I. INTRODUCTION

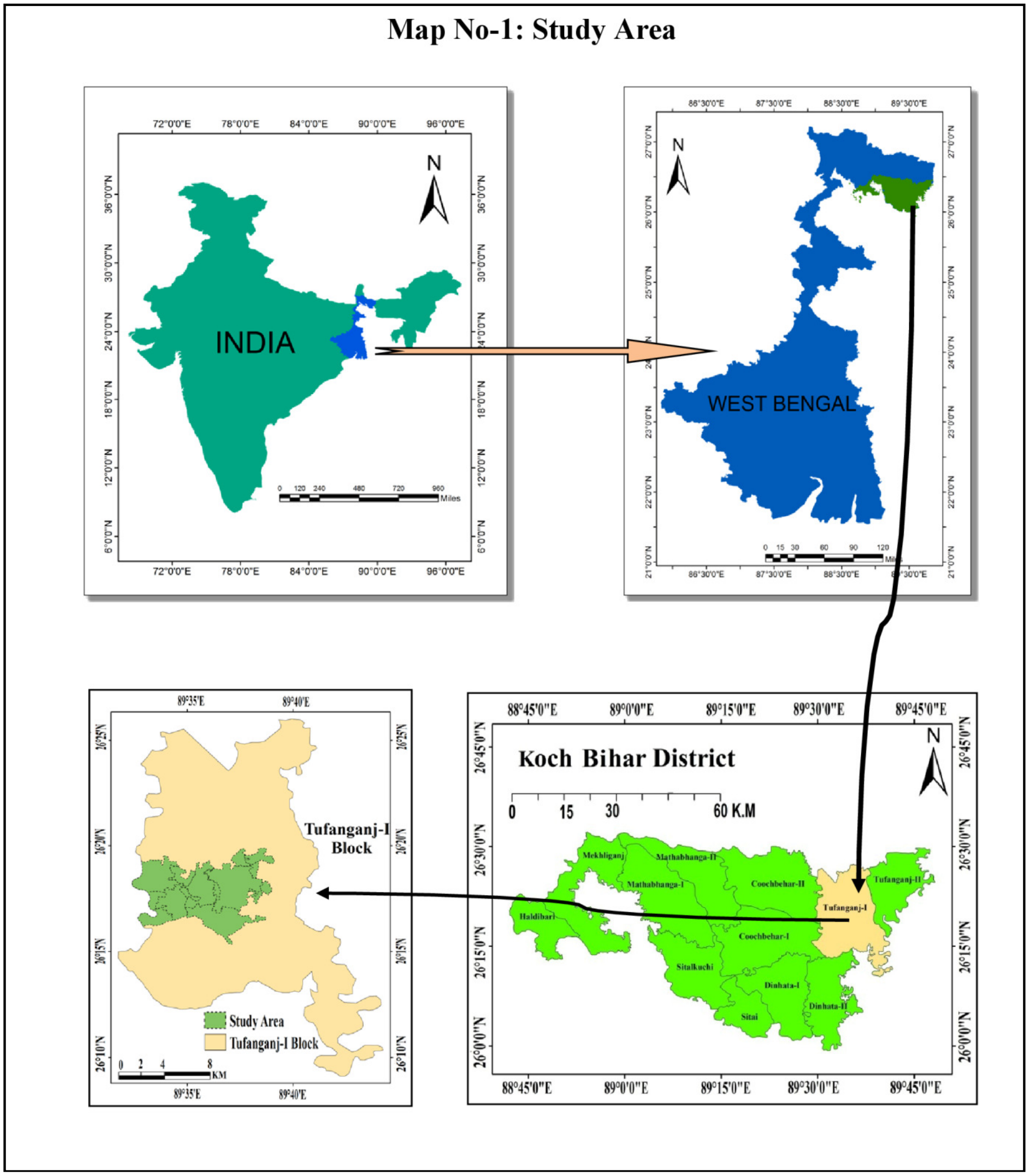
The bricks are the cheaper materials in the construction industry. Manufacturing of bricks is considered as one of the fastest growing sectors (9% annual) in developing countries like India though it has been yet followed both traditional and modern methods of firing. Being an unorganized sector, the brick kiln industry has the capability of creating seasonal job opportunity (3.11% of India) to the local as well as to the migrant people. The current production of bricks in the world is about 1391 billion units (Freedonia, 2012). India produces 250 billion bricks annually from 1, 40,000 brick kilns, employing about 15 million workers and consuming about 35 million tons of coal annually (Wanjule *et.al.* 2015). India's share on brick production is second (17.97%) succeeded by China (54%). The sector contributes 10% of the country's GDP. The use of fertile topsoil is crucial for brick production.

The clay loam (Sand=20-45%, Clay=15-53% and Silt-27.40 %) is suitable for brick making. It consumes about 4.16×10^{18} tons of fertile topsoil which causes a loss of 93×10^{3} hectares of land every year in India. About 70% of the kilns in India and all the kilns in the present study area follow Fixed Chimney Bull's Trench Kiln (FCBTK). The excessive and rampant quarrying of agricultural land causes temporary and permanent waterlogging problem in the study area. The topsoil quarrying engulfs agricultural land, reduces soil productivity, diminishes production of crops as well as contaminates the soil and water in the study area. The prime objective of the present study is to discuss the problem of waterlogging by the quarrying of land in the study area and to incorporate some recommendations.

II. MATERIAL AND METHODS

A. Study Area

The study area lies between Ghargharia-Kaljani-Gadadhar interfluves in Tufanganj-I block of Koch Bihar district of West Bengal with the latitudinal and longitudinal extension of 26°15′19″ N to 26°20′ N and 89°32′20″ E to 89°39′8″ E respectively. The study area is located in Maruganj which is 12 km away from Koch Bihar Sadar and Tufanganj Town along the NH-31. The authors concentrate on their in-depth study in 6 mouzas with brick kilns namely Maradanga, Soladanga-II, Velakopa-II, Ghogarkuthi-I, Chilakhana and Shikarpur and 8 mouzas adjacent to the kiln sites namely Velakopa-I, Soladanga, Deocharai, Gobindapur, Ghogarkuthi-II, Noakhuli, Khorapara, and Gobindapur.



Map No. 1. Study area.

B. Database and Methodology

Different procedures such as visual interpretation of Google Earth images, Topographical map and satellite imageries, GPS survey and field verification have been adopted to identify the water logging in the study area.

A cloud-free IRS-P6 (RESOURCESAT-2) (LISS-III) satellite imagery acquired on 25.11.2011 has been used to identify the permanent water logging area in the study area. The details of the imagery are tabulated:

Table 1: Metadata of the Satellite data.

Name	**Sensor**	**Latitude**	**Longitude**	**Tile No**	**Row**	**Path**	**Resolution**	**Spheroid/Datum**	**Band & Wave length(µm)**	**Date of acquisition**
IRS-P6 RESOURCESAT-2	LISS-III	26° 15″N to 26°30″N	89° 30″E to 89° 45″E	G45L11	053	108	23.5m	GCS, WGS-84	4(B2-Green- .52-.59 ; B3-Red; (.62-.68) B4-NIR; (.77-.86)and B5-MIR/SWIR (1.55-1.70)	25.11.2011

Source: NRSC, Hyderabad

For detecting changing pattern of permanent waterlogged areas, MNDWI and digitization of Google Earth images of two different periods i.e. 2011 and 2016 has been extracted by ERDAS imagine v9.2 and a union operation was used in raster calculator in Arc GIS v10.2. Normalised Difference Water Index (NDWI) proposed by Mc Feeters (1996) is defined as

$$\text{NDWI}=\frac{\text{Green}-\text{NIR}}{\text{Green}+\text{NIR}}$$

where in Resourcesat-2 Green band is defined by B-2 and NIR is defined by B-4. The value of NDWI ranges between +1 to -1 where positive and negative values represent water bodies and vegetation. But sometimes built up areas may have positive value due to spectral confusion. To eliminate the problem of NDWI, Xu (2006) proposed Modified Normalised Difference Water Index (MNDWI) to extract the waterlogged areas.

$$\text{MNDWI}=\frac{\text{Green}-\text{SWIR}}{\text{Green}+\text{SWIR}}$$

where in Resourcesat-2 Green band is defined by B-2 and SWIR is defined by B-5. Like NDWI its value also ranges between +1 to -1 where negative values show built up area and positive value show water bodies. The authors used MNDWI method for extracting water features in their present study.

For determining the temporary water logging area, a GPS survey was done by Oregon eTrex-550 in the study area. The researcher have identified 90 points as temporary water logging areas from where the soil has been quarried in the previous year i.e. during pre-monsoon in 2016. The points are located in and adjacent mouzas of kiln area. Finally, maps have been prepared by Arc GIS v-10.2.

III. RESULTS AND DISCUSSION

Water logging is one of the most important issues of the study area. Water logging arises due to inundation by water in the low-lying agricultural land. The quarrying of land for topsoil has destroyed the soil and it is no more suitable for agriculture as well as for brick making. As paddy cultivation is not lucrative, the farmers lease their land to the brick kiln owners for a period of 2-3 years. In most of the cases, the farmers sell their topsoil to the owner through the land vendors. After the end of the lease, the land becomes fallow land and lowered to the adjacent land. These lands become unfertile. The land is inundated during the rainy season. The authors have identified such land during the course of their field visit and mapped with the help of a handheld GPS. These types are designated as temporary waterlogged area. The temporary water logging is vulnerable to soil erosion.

A vicious circle of temporary water logging is observed in and adjacent to the kiln area. The lands which are lowered drain the water and nutrient of the adjacent land by leaching to the lowered ground. So, the adjacent unquarried lands become unfertile due to its higher position. Thus, the farmers of adjacent unquarried land are compelled to sell the topsoil for levelling the land to adjacent quarried land. The process of quarrying continues and ultimately the land becomes permanently waterlogged. On the other hand, the permanent waterlogged area is identified in the vicinity of kilns in those mouzas where brick kilns are located.

The more the presence of kilns the more is the permanent water logging. The owners of the kilns have carried out open cast clay mining for a long period of time and the pit area became permanently waterlogged. The area with high concentration of brick kilns is more waterlogged and where the permanent waterlogged area is high, the temporary water logging is less due to the unavailability of the fresh land for clay mining for brick making.

Table 2 and Fig. 1 shows that total permanent water logging area is 323.94 acre whereas the temporary waterlogged area is 209 acres. Maradanga (107.31 acres) has the highest permanent waterlogged area and Ghogarkuthi-1(89.44 acres) has the lowest waterlogged area. Ghogarkuthi and Chilakhana have more or less similar permanent waterlogged area (69.67 acres and 70.98 acres) followed by Velakopa-II (48.86 acres). Maradanga and Chilakhana have 41.15-acre & 33.57 acre area covered by temporary water logging. Another striking feature is that Deocharai and Khorapara mouza have no kilns at all but the authors noticed during their field survey that these two Mauzas have 12.24 acre and 8.48 acre land have been converted to temporary water logged. 10.24 acre land of Khorapara has been turned into permanent waterlogged due to cumulative excavating of topsoil for brick making.

Table 2: Permanent and Temporary Water Logging Area.

Name of the Mouza	Geographical Area (Acre)	Total No of Kilns	Permanent Water logged area (Acre)	Temporary Water logged area (Acre)
Maradanga	1810.00	12	107.31	41.15
Soladanga-II	285.54	2	6.65	11.76
Velakopa-II	1108.57	2	48.86	5.41
Ghogarkuthi-I	2757.20	5	69.67	89.44
Chilakhana	1475.07	2	70.98	33.57
Shikarpur	290.02	1	8.51	6.95
Deocharai	2085.81	0	1.72	12.24
Khorapara	155.42	0	10.24	8.48
Total	9967.63	24	323.94	209.00
Source: Field Survey, 2015-16				

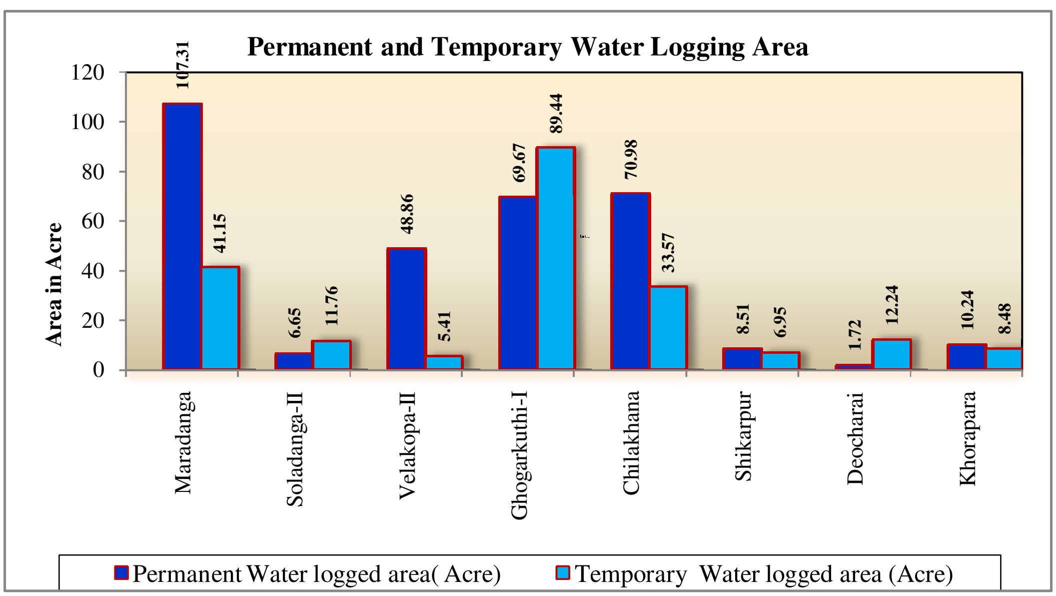


Fig. 1. Permanent and Temporary Water Logging Area.

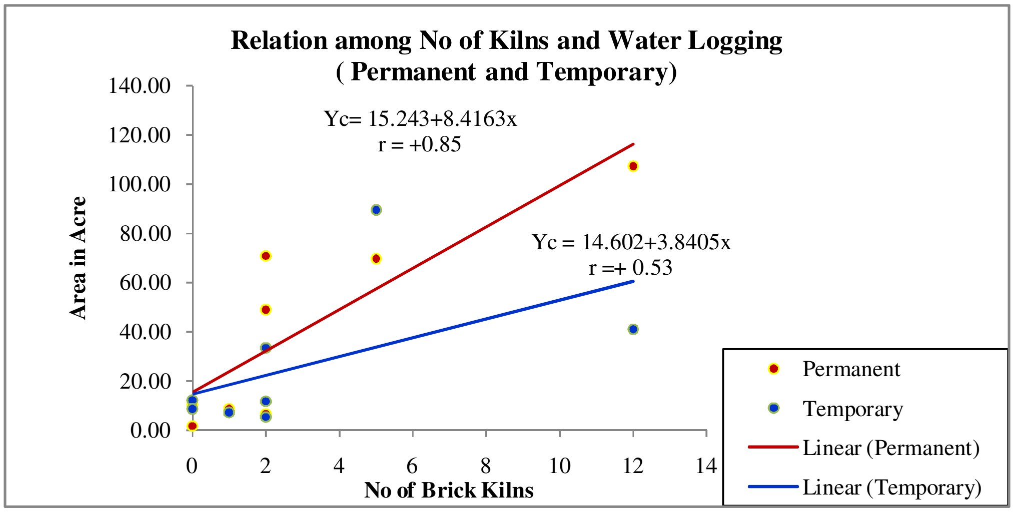
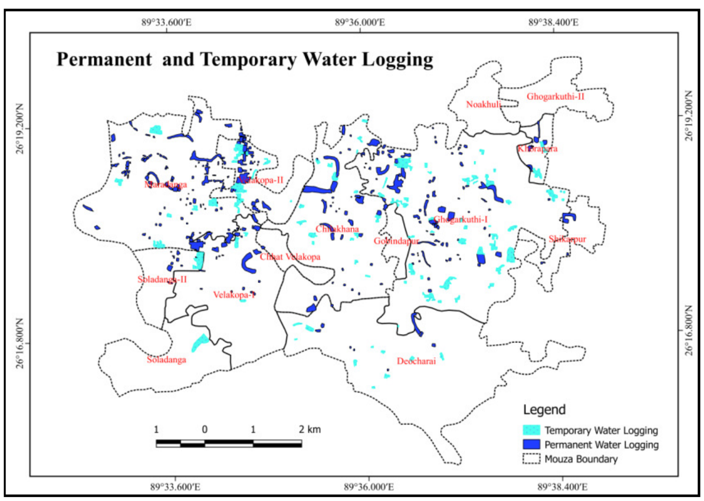


Fig. 2. Relation among No of Kilns and Water Logging (Permanent and Temporary).

Table 2 and Fig. 2 also depict the relationship between the number of brick kilns and permanent waterlogging. The value of the coefficient correlation (r) between these two variables is very high 0.85 which indicates the very strong positive relationship between number of brick kilns and permanent waterlogging. On the other hand, the relation between a number of brick kilns and temporary waterlogging is moderate positive i.e., the value of the coefficient correlation (r) is 0.53. Thus, temporary waterlogging is not very much associated with the location of kilns as in case of permanent waterlogging. The permanent and temporary water logging area is shown in Map No.1.



Map No. 2. Permanent and Temporary Water Logging Map.

C. Change Detection

Change detection is defined as the process of detecting the differences of any object or phenomenon over time. In this study, a change detection of permanent waterlogged areas in the study area has been done during the period 2011 and 2016. MNDWI data reveals that in 2011 there were 282.27 acres of land under water logged but in 2016 it has been increased to 323.94 acres.

Table 2: Pearson's Product Moment Correlation Coefficient, t-Stat and P-Value.

Regression Coefficient	**Total No of Kilns**	**Permanent Water logged area (Acre)**	**Temporary Water logged area (Acre)**
Total No of Kilns	1		
Permanent Water logged area (Acre)	0.85*	1	
Temporary Water logged area (Acre)	0.53	0.64	1
t-stat	**Total No of Kilns**	**Permanent Water logged area (Acre)**	**Temporary Water logged area (Acre)**
Total No of Kilns	1		
Permanent Water logged area (Acre)	3.876	1	
Temporary Water logged area (Acre)	1.527	2.032	1
P-Value	**Total No of Kilns**	**Permanent Water logged area (Acre)**	**Temporary Water logged area (Acre)**
Total No of Kilns	1		
Permanent Water logged area (Acre)	0.008	1	
Temporary Water logged area (Acre)	0.178	0.088	1

Source: Calculated by the Authors
*Significant at 5% level.

Table 3: Change Detection of Waterlogged Area.

Permanent Water logged area	**Area in Acre**
Total Water bodies	938.58
River and Water Bodies	656.31
Permanent Water Logged (2011)	282.27
Permanent Water Logged (2016)	323.94
Total Change	41.67
Change per Year	8.33 (2.95%)

Source: Resourcesat-2 LISS-III

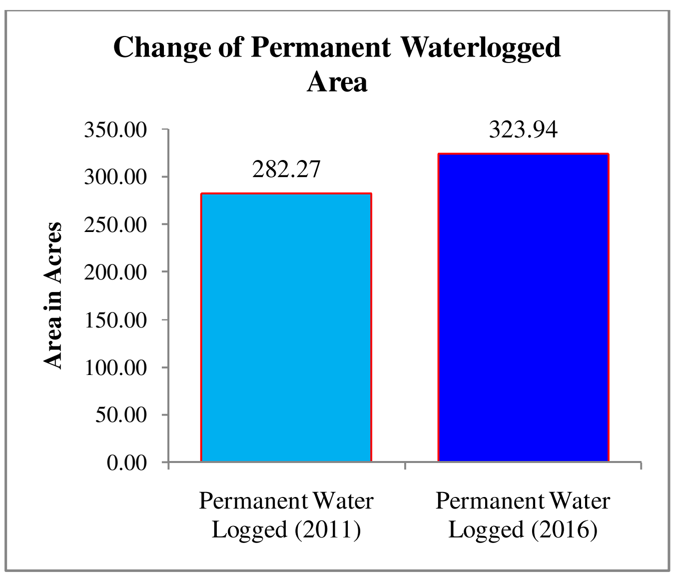
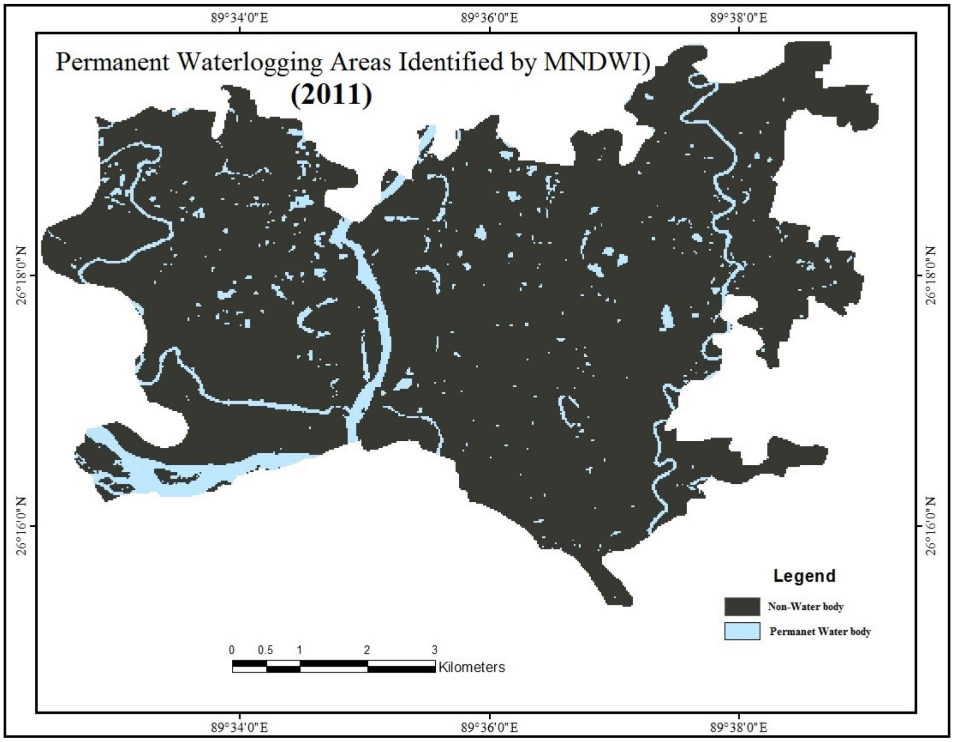
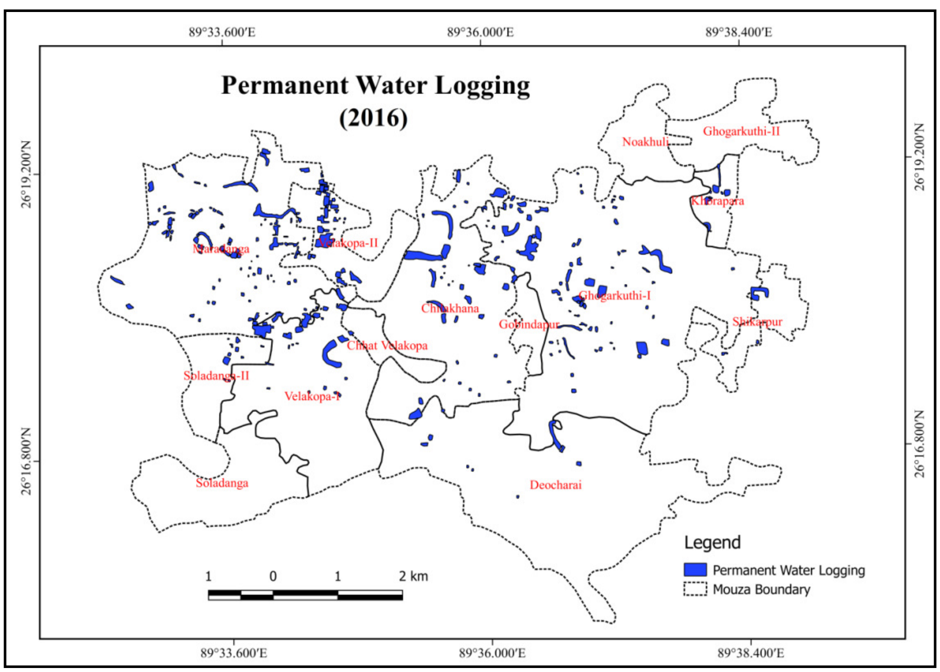


Fig. 3. Change of Permanent Waterlogged Area.

Thus, a 2.95% area has included as new permanent waterlogged area per year in the study area. About 8.33 acres of agricultural land has been converted to permanent water bodies. The huge amount of topsoil quarrying makes the area more susceptible to waterlogging.



Map No. 3. Permanent Waterlogging Area in 2011.



Map No. 4. Permanent Waterlogging Area, 2016.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

Waterlogging whether it is permanent or temporary adversely affect the underground water and fertility of the soil. It also changes the land use pattern. The quarried land causes the soil erosion. Further, permanent water logging in or around the kiln sites may contaminate water by the coal wastes. The workers, who use to bathe or wash their clothes and dishes in this water, suffer from skin diseases. The inundation of water is the breeding places of mosquitoes. Sometimes the permanent burrow pits are used as a dumping ground which may cause the pollution water. The temporary waterlogged areas are inundated by rainwater and the crops which are sowed may be spoiled most of the year.

Waterlogging creates problems throughout the years. It is not only the problems in summer or rainy season but also affects agricultural land in other seasons. Sometimes, it is difficult to cultivate the crops because of waterlogging. After studying the area, it is found that paddy cultivation is not possible in the area where the depth of quarried land > 4-5 feet. The un-quarried land becomes higher in elevation and hence difficult to irrigate. During the time of cultivation, the major portion of that irrigated water is leached or drained away towards the lower land. It usually requires much water to the upper land comparatively than lower land because of being rapid dry out of the water.

a) Thus, encouragement should be given to the kiln owners to manufacture Fly-Ash-Lime-Gypsum (FAL-G) bricks and concrete bricks.

b) Clay solid bricks should be diversified like the production of hollow bricks, perforated bricks etc. This will reduce the amount of clay in making bricks.

c) Proper irrigation facilities should be provided to the farmers to make the agricultural sector more lucrative.

d) The government should initiate proper land management policies for encouraging the use of coal ash for brick making.

Plate 1. Soil Quarrying in Different Year and Permanent Water Logged Area.

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