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CONTAMINATION SEVERITY INDEX: AN ANALYSIS OF BANGLADESH GROUNDWATER ARSENIC

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Abstract

This paper deals with measurement of ground water arsenic contamination. The focus is on using a proper index for the severity of contamination, rather than just using the proportion of observations above a threshold level. We specifically focus on the Contamination Severity Index (CSI) proposed in Sen (2016, *Sankhyā*). An alternative estimator in contrast to the one given in Sen (2016) is used here that is useful for small number of observations. The data used is that collected by British Geological Society(BGS) and the BD Department of Public Health Engineering (DPHE) during 1997-2001. Their analysis was based on the simple proportion of the observations above a threshold level, where as the CSI measure adequately takes into account the severity of the observations also. We have also segmented the data into three categories of wells according to the depth of the wells instead of just the two categories, namely 'deep' and 'shallow' wells. It is emphasized in this manuscript that the comparison of areas with average arsenic (As) level to determine As severity is not appropriate as the regression of CSI on AAs is highly nonlinear and seemingly non-heteroscedastic; where as the CSI index proposed in Sen (2016), shows a clear picture, especially when the values are adjusted according to average log depth of the wells sampled at the thana and district levels.

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1 Introduction and Background

The present investigation concentrates on the severe groundwater Arsenic contamination(GAC) in Bangladesh (BD). Basically BD is a riverine country of about 150,000 km^2 area with a population burden of more than 170 million. Although there are more than 230 rivers and their tributaries and adequate annual rainfall, especially with about a 4 month rainy season, it is the population influx and change in the urban-rural demographics that has resulted during the past 45 years in a pressing need for the use of groundwater through tube wells and other pumping devices. Even in agricultural and irrigation works, especially during the dry months (February though mid-June) the use of groundwater has become essential. On top of that the age old ponds and other surface water sources are mostly contaminated with chemical dumping, human waste and inadequate sanitary practice are mostly unsuitable for drinking. The major source of drinking water is the network of tube wells all over the country, with more concentration in cities and other urban areas. Again, a majority of these tube wells are not too deep to meet the international standard. As such, studies of abundant environmental contaminants with their severe impact on human health and ecological morphology are of prime importance. International teams such as World Health Organization (WHO) and British Geological Society (BGS) have been in collaboration with the BD Department of Public Health Engineering (DPHE) to collect data on various contaminants in groundwater, mostly through tube wells in a major part of the country.

Exposure to Arsenic contamination (AC) in drinking water has been reported by WHO in UNICEF (2013) Current Issues. No. 2, Arsenic Contamination in Groundwater. A national drinking water quality survey conducted in 2009 furnished data that were used to update the estimate of chronic exposure in BD (viz., Flanagan et al. 2013). These data collection involved costly hydrological observations, some of which were reported by BRGS where the time period referred to around 2000-2001. Arsenic in tube well water in BD has serious health economic impacts and implications for arsenic mitigation. As per UNICEF report in 2013-2014, a water point mapping (WPM) was conducted of 150,000 water points installed by DPHE between 2006 and 2012. Selected water points were tested for arsenic and other parameters (n=125,000) and functionality was also assessed. The findings suggested that 95 per cent of newly constructed water points are free of arsenic above the national standard of 50 ppb. (Unicef: Bangladesh MICS 2012-13, Water Quality Thematic Report). The article by Flanagan et al. (2013) suggested that arsenic "mitigation should follow a two-tiered approach: (i) prioritizing provision of safe water to an estimated 5 million people exposed to more than $200 \mu g/litre$ arsenic, and (ii) building local arsenic testing capacity" and concluded that "such an approach has been effective as demonstrated during the UNICEF 2006-1011 country program that provided safe water to arsenic-contaminated areas at a cost of US$11 per capita." A comprehensive review dealing with research 21 years of research for "groundwater arsenic contamination in Bangladesh" is provided in an article by Chakraborti et al. (2015) finds that through follow-up studies after 9-18 years (a) villagers are now more aware about the danger of drinking arsenic contaminated water (b) villagers are currently drinking less arsenic contaminated water (c) many villagers in affected village died of cancer (d) arsenic contaminated water is in use for agricultural irrigation and arsenic exposure from food chain could be future danger. And concludes that "since at present more information is coming about health effects from low arsenic exposure, Bangladesh Government should immediately focus on their huge surface water management and reduce their permissible limit of arsenic in drinking water."

We emphasize two aspects of importance in the present analysis over the comprehensive BGS reports. First, we have chosen two threshold values of L, namely $L = 10\mu g/lit$ and $L = 50\mu g/lit$. This is because as reported in Vol 2. of BGS report, "the WHO guideline value for As in drinking water was provisionally reduced in 1993 from $50\mu g/lit$ to $10\mu g/lit$ in 1993," however the original water screening of Bangladesh in 1997 was based on the present standard of Bangladesh, $L = 50\mu g/lit$.

Second, albeit BGS findings present useful descriptive information about Arsenic mapping in Bangladesh, from a statistical point of view there remains much more to be accomplished. With respect to Arsenic severity, the mere proportions of wells with As level beyond the threshold value for low, moderate and high GAC class intervals fail to incorporate the severity of GAC in a well defined manner along with statistical interpretation. This proportion ignores the values of the contamination at the well sites, that is where the contamination severity index (CSI) developed in Sen (2016) comes out as a useful measure to assess the GAC relative to the safe limits as set by WHO and other organization. This CSI is not necessarily confined to the GAC problem, but also being used for air pollution and other contamination problems.

Some preliminary notion on this CSI will be presented in Section 2. In Section 3, we shall deal with estimation of CSI essentially derived from the 2016 CSI measure. In Section 4, these CSI measures are to be incorporated in the study of GAC severity in BD, at the thana level and then at the district level. The last section deals with general observations and concluding remarks.

2 CSI in Data Analysis Perspective

The index called Contamination Severity Index (CSI) for a particular area or location developed in Sen (2016) depends on the distribution of the As level in that area, so that we can talk about the severity of contamination based on this index for the whole area of interest. This index may be defined by the so called *CSI score* (also called "propensity score") for an individual unit with As level y (for a given threshold level L) (see Eq 6.25 of Sen 2016),

$$S_L(y) = \{(1 - L/y)^+\}^{\theta(F_0,y)} \tag{2.1}$$

where

$$\theta(F_0, y) = 2\int_L^\infty \frac{\min(x,y)}{x+y} dF_0(x), y \in (L, \infty) \tag{2.2}$$

where, F denotes the distribution of As levels in the region concerned and F^0 denotes the truncated distribution at the threshold L, i.e.,

$$F_0(x) = \frac{F(x) - F(L)}{1 - F(L)}.$$

The individual *propensity Scores* $S_L(y)$ can be combined to produce the regional CSI index that is given by

$$C_F = \int_0^\infty S_L(y)dF(y) = \int_L^\infty \{(1 - L/y)^+\}^{\theta(F_0,y)} dF(y). \tag{2.3}$$

In this article we will focus on a variant of this index, where $\theta(F_0, y)$ will be replaced by $\theta(F, y)$, that is based on whole distribution, not just the truncated ones.

This is seen to highlight better the contamination scenario in the context of Bangladesh Arsenic contamination at thana level, as The present definition will be more meaningful, especially for small sample sizes.This alternative CSI index will be denoted by $C_F^{(a)}$, that is obtained by first computing the alternative CSI scores

$$S_L^{(a)}(y) = \{(1 - L/y)^+\}^{\theta(F,y)} \tag{2.4}$$

where

$$\theta(F, y) = 2\int_0^\infty \frac{\min(x,y)}{x+y} dF(x), y \in (L, \infty) \tag{2.5}$$

and then incorporating these scores in the alternative CSI as

$$C_F^{(a)} = \int_0^\infty S_L^{(a)}(y)dF(y) = \int_L^\infty \{(1 - L/y)^+\}^{\theta(F,y)} dF(y). \tag{2.6}$$

Sen (2016) proposed estimating the CSI index by a plug-in estimator by using the empirical distribution function based on a random sample of As contents measured at randomly selected points in the given region of interest. This estimator is explained in the next section along with the alternative estimator of $C_F^{(a)}$.

3 Estimates of CSI Based on Empirical Distribution

Let $Y_{(i)}, i = 1, 2, .., n$ be the order statistics based on a random sample of As contamination in a specific site. Let M denote the number of observations less than equal to L, we estimate above quantities by replacing $F(x)$ by $F_n(x) = \frac{1}{n}\sum_{i=1}^{n} I(Y_i \leq x), x \geq 0$. For the unit with As level $Y_{(i)}$, the corresponding propensity score, denoted by $C_{ni}, i = 1, 2, ..., n$ is given by the formula

$$C_{ni} = (1 - L/Y_i)^{+\hat{\theta}_n^{(0)}(Y_{(i)})}, \tag{3.1}$$

where

$$\hat{\theta}_n^{(0)}(y) = \frac{2}{n - M} \sum_{j=M+1}^{n} \frac{\min(y, Y_{(j)})}{y + Y_{(j)}}, i = 1, ..., n \tag{3.2}$$

and thus the estimate of the combined scores for the site is given by

$$\hat{C}_F = \frac{1}{n} \sum_{M<i\leq n} C_{ni} = \frac{1}{n} \sum_{i=M+1}^{n} (1 - L/Y_{(i)})^{+\hat{\theta}_n^{(0)}(Y_{(i)})}. \tag{3.3}$$

On the other hand, the empirical estimate of the alternative CSI measure is given by

$$\hat{C}_F^{(a)} = \int_L^{\infty} \{(1 - L/y)^+\}^{\hat{\theta}_n(y)} dF_n(y) \tag{3.4}$$

$$= \frac{1}{n} \sum_{i:Y_i>L} \{(1 - L/Y_i)^+\}^{\hat{\theta}_n(Y_i)} \tag{3.5}$$

where

$$\hat{\theta}_n(y) = \frac{2}{n} \sum_{i=1}^{n} \frac{\min(y, Y_i)}{y + Y_i}; y \geq 0. \tag{3.6}$$

4 Estimated Thana and District CSI Values

We use the data on Arsenic samples available on the `https://www.bgs.ac.uk/research/groundwater/health/arsenic/Bangladesh/data.html`, collected by the British Geological Society in collaboration with the Department of Public Health and Environment (DPHE), Bangladesh, during

1998-1999. Their report is published in 4 volumes (BGS and DPHE 2001a-2001d); volume 1 gives a summary of the main findings with respect to various chemicals in groundwater based on their survey entitled, the *DPHE/BGS National Hydrochemical Survey*. This survey consists of n=3534 well waters, excluding the Chittagong Hill tracts. This data is obtained from 61 of the 64 districts and 433 of the 496 upzilas. Their reports contain description of data collection and summary of various chemical concentration in water samples. The concentration of As is analysed based on the average arsenic level in a particular district and the proportion (p_{GL}) of samples with arsenic level greater than the threshold level L.

It may be remarked that our data set is relatively small (considering more than 400 Thanas and more than 60 districts). As such, the results may be less precise than what would have been the case of a much larger data set as for example more than 52K wells for some other studies. For example, the paper by Chakraborti *et al.* (2010) refers to a data set on As based on 52,202 hand tubewell water samples collected over 14 years; however, we have not been able to acquire this data. The available data through the supplementary material available online contains only summary not the raw data, that would be useful for our analysis. Efforts to acquire the raw data have not yielded any success. Therefore, we have chosen the BDS/DPHE data that is freely available. Based on this analysis, we have attempted to show the usefulness of CSI as opposed to the mere proportion of wells over a given threshold. The data presented at the BGS website contained the names of thanas for each observation, however, the same thana appeared with different spellings. Therefore some cleaning of the data was necessary, for computing CSI at thana levels. Each observation was matched with respect to the longitude and latitude coordinate of the observation that provided 424 thanas. Interpreting thanas as upzilas, the discrepancy of 9 thanas missing from the data cleaning process is basically due to misclassification of the same thana by giving it different names. 32 missing thanas are in the Chittagong division. We dropped the wells with zero depth from analysis (there were four such wells in the whole data), as it was not clear whether they represent correct observations or not.

Volume 2 contains the results of statistical analyses, using standard Excel or GenStat packages. Their analysis of Arsenic concentration was based on district level Arsenic levels concluding that there was larger *between district variation* as compared to *within district variation* both on the original scale as well as on the logarithmic scale. Volume 3 is concerned with maps with details of various chemicals and attributes such as the depth of wells, for the whole of Bangladesh as well as the districts and Volume 4 tabulates observations on concentration of various chemicals.

It can be shown that the CSI estimates $\hat{C}_F^{(a)}$ proposed here are less than (p_{GL}), a comparison of CSI estimates with this value may be important for further inspection. We have only displayed in the tables and maps, the alternate CSI with the exponent derived from all the observations in contrast to those observations above the threshold L as it gives mostly higher index compared to the empirical CSI and may be preferable in general. The exceptions to this observation are found for large values of CSI, where the difference is expected to be minor.

As observed in volume 2 of BGS/DPHE report, As concentration for the *deep wells* are much lower than those for the *shallow wells*. We found (as expected) a large variation in CSI for wells of different depths. Thus we have decided to create CSI based on depth adjustment that is described in the subsection below.

4.1 Depth Adjusted CSI

We have computed propensity scores for each value of As, (see Eq 3.5-3.6), that need to be adjusted for the corresponding depths of the wells. This is achieved by logistic regression of propensity scores on the well depth that is described in detail below.

Let S_{ij} = propensity score for tube-well j in thana $i; j = 1, , m_i$, m_i is the number of observations corresponding to $Y_{ij} > L$. Let the corresponding depth be d_{ij}; then we perform a logistic regression of m_i propensity scores, i.e. using the model

$$T_{ij} \equiv logit(S_{ij}) = \alpha_i + \beta_i Z_{ij} + error; j = 1, ..., m_i \tag{4.1}$$

where $Z_{ij} = \log d_{ij}$.

Note that S_{ij} is computed for the Arsenic level Y_{ij} by the formula

$$S_{ij} = \{(1 - L/Y_{ij})^+\}^{\hat{\theta}_n(Y_{ij})} \tag{4.2}$$

See formula (3.6) for definition of $\hat{\theta}_n(Y_{ij})$, and Logit is defined as

$$logit(p) = log\left(\frac{p}{1-p}\right) \tag{4.3}$$

The depth adjusted value of CSI for the i^{th} thana is obtained by substituting $Z_{ij} = \bar{Z}_i$

$$\hat{C}_i^{(adj)} = \frac{m_i}{n_i}\bar{\hat{S}}_i, \tag{4.4}$$

where

$$\bar{\hat{S}}_i = \frac{\exp(\bar{T}_i)}{1 + \exp(\bar{T}_i)}, \bar{T}_i = \frac{1}{m_i}\sum_{j=1}^{m_i} T_{ij} \tag{4.5}$$

A generic notation for this depth adjusted CSI corresponding to $\hat{C}_F^{(a)}$ will be denoted by $\hat{C}_F^{(d)}$.

Furthermore, it is seen that the intermediate logit model fitting of CSI scores is really not required and the logit modeling approach allows a quick calculation of district level CSI based on

Figure 1: Bangladesh Map with 9 Divisions

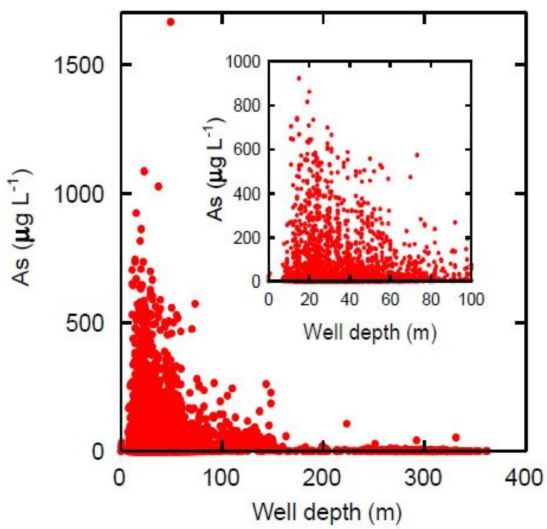


Figure 2: Arsenic level in groundwater in wells from BGS/DPHE survey as a function of well depth

the average log-depth of a district $\bar{Z}_k$ for a given district k, based on the average logit values of thana CSI's

$$\bar{W}_k = \frac{\sum_{i=1}^{n_{.k}} n_{ik} W_{ik}}{n_{.k}}, \tag{4.6}$$

where $W_{ik} = logit(\hat{C}_{Fik}^{(a)}), n_{ik}$ = number of wells in thana i in district k and $n_{.k}$ = number of wells in district k.

Depth adjusted CSI for district k is thus given by

$$\hat{C}_{d.k}^{adj} = \exp(\bar{W}_k)/(1 + \exp(\bar{W}_k))$$

The values of *logit* for large and small values of CSI-scores may be modified as

$$logit_m(p) = \begin{cases} \log\left(\frac{p_0}{1-p_0}\right) & \text{for} \quad p \le p_0 \\ \log\left(\frac{p}{1-p}\right) & \text{for} \quad p_0 < p < 1 - p_0 \\ \log\left(\frac{1-p_0}{p_0}\right) & \text{for} \quad p \ge 1 - p_0 \end{cases}$$

for some small value p_0. For $L = 10$, and a difference in arsenic level of 0.1, the difference in the propensity score is 0.0099, hence for $L = 10$, we choose $p_0 = .01$. On the other hand, for $L = 50$, this difference is 0.0019, thus for $L = 50$, we chose $p_0 = .002$. We will denote the district adjusted CSI using the logit modelling of $\hat{C}_F^{(a)}$ by $d\hat{C}_F^{(a)}$. It might be more appropriate, however, to use $\hat{C}_F^{(d)}$ in order to better take into account the within thana variation; thus we will focus more on the district adjusted CSI using the logit modelling of $\hat{C}_F^{(d)}$ that is denoted by $d\hat{C}_F^{(d)}$. As we will see, at least in the context of the present investigation, these values are generally not much different.

Table 1 gives summary of alternative CSI estimators $\hat{C}_F^{(a)}$ for all the Thanas and districts as well as the values of p_{GL} along with average arsenic level (AAs). The original CSI proposed in Sen (2016) as given in Eqs. (3.2)-(3.3) was also considered. But that has the minor problem that for observations close to L but greater than L, it does not capture the entire relative dispersion around $y(> L)$, and hence, we consider the adjusted CSI given by Eqs. (3.4)-(3.6). This is consistent with the definition of $\theta(F, y)$ being the expected value of $g(X, Y) = \frac{2\min(X,Y)}{X+Y}$, for a given value of $Y = y$.

To understand the extent of severity implied by the CSI estimates as a function of the topography of Bangladesh, we have summarised the CSI estimates for the 9 divisions of Bangladesh, namely, (i) Rangpur, (ii) Rajshahi, (iii) Mymensingh, (iv) Sylhet, (v) Khulna, (vi) Barisal, (vii) Dhaka, (viii) Comilla, and (ix) Chittagong (see the map of different division in Figure 1).

The value of $\hat{C}_F^{(a)}$ and the depth adjusted CSI $\hat{C}_F^{(d)}$ are summarized for each thana in different divisions in Table 1, along with p_{GL} : proportion of wells with As level greater than L, $\hat{C}_min$, that is computed from the raw propensity scores using $\hat{\theta}_n(y) \equiv 1$, ALd = average log depth of wells, and AAs =average arsenic level based on all the thanas. It may be noted that only two districts, Chittagong and Cox's Bazar, in the Chittagong division were sampled.

In Table 2, we summarise depth adjusted CSI values for districts $dC_F^{(a)}$, and $dC_F^{(a)}$ along with other indicators described above. A natural question may arise as why we use the logit model for depth adjusted CSI ? This is a convenient device, since the CSI value lies in the interval (0,1) and its variability depends on the mean values. Also, we consider the log-depth for modeling instead of depth, as it will be seen in the next section, because it provided a better fit. Furthermore, depth on the log-scale may be more useful for the segmentation of wells in categorising 'shallow' and 'deep' wells, as there is a large variation in raw depth measures. (We have not pursued this in the present manuscript and leave it for a future study).

5 Discussion and Remarks

The tables for CSI values presented here are for a detailed exploration of the extent of contamination in a given district and corresponding Thanas. We provide below some general remarks based on these values.

(i) DPHS/BGE Summary vol.1 (§2) states:

“The wells included in this network are not representative subset of all wells in Bangladesh and so many statistics derived from them have to be treated with caution - the network contained a greater proportion of deep wells than found in Bangladesh as whole.” The majority of wells were less than 150 meter deep; only 9% of the wells in the DPHE/BGS National Hydrochemical Survey, were ’deep’ where ‘deep’ means depth of more than 150 meters (see Figure 2, that is a reproduction of Figure 3 of BGS and DPHE 2001a). The deep wells are comparatively better with lower CSI values. In some districts along the southern/eastern coast line with high level of salinity in ground/surface water, DPHE installed some deep tube wells only for drinking water and they are generally good.

(ii) If we compare the CSI values for $L = 10$ and $L = 50$, we notice that for $L = 10$, those CSI values less than 0.25 are even much smaller for $L = 50$. The basic reason for this is that the p_{GL} values for $L = 50$, are then much smaller than the ones for $L = 10$. On the other hand when the p_{GL} values for $L = 10$ and $L = 50$ are not so different, the CSI values are not so much different for $L = 10$ and $L = 50$. If we look into the score function $(1 - L/y)^{\theta(y)}$, then for $L = 10$ a value of $y = 200$ gives the value $(0.95)^a$ where typically a is around 0.5. On the other hand, for $L = 50$, and $y = 200$, it is $(0.75)^a$. If we take $a = 0.5$, in the first case, it will be around 0.975 while in the second case, it is around 0.85. If we take $y = 250$, the corresponding score value is around $(0.96)^{1/2} = 0.98$ for $L = 10$ and for $L = 50$, it is about $(0.80)^{1/2} = 0.90$. The other point is that if $F^0(.)$ is more tilted to the right, $\theta(F, y)$ will be larger for larger y, and hence the score value will not be much different from the ones without the power a. That tends to bring closer the CSI values for $L = 10$ and $L = 50$ when the distribution function $F^0(.)$ is tilted to the right.

(iii) This study was mainly confined to the Southern divisions covering the Ganga-Jamuna-Padma-Meghna delta area; in particular the focus was on Comilla, Khulna, Barisal and Dhaka Divisions. In the north, Shylet Division has also in some areas large CSI values due to the fact that sedimentation from the rain-rich hills in the Indian State of Meghalaya through a large number of streams and rivers account for these CSI values. In the Rangpur

Table 1: Depth Adjusted Thana Level CSI Values by Division

Rangpur Division

			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Dinajpur	Biral	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.467	2.062
	Birampur	5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.153	2.020
	Birganj	10	0.20000	0.18971	0.18972	0.16190	0.20000	0.08924	0.08893	0.00952	3.093	12.030
	Bochaganj	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.078	0.933
	Chirirbandar	8	0.12500	0.09063	0.09063	0.03172	0.00000	0.00000	0.00000	0.00000	3.207	2.487
	Dinajpur S.	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.408	1.840
	Ghoraghat	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.305	0.500
	Hakimpur	4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.094	0.825
	Kaharole	6	0.16667	0.05944	0.05944	0.01515	0.00000	0.00000	0.00000	0.00000	3.148	3.750
	Khansama	5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.950	2.160
	Nawabganj	8	0.12500	0.11796	0.11796	0.08544	0.00000	0.00000	0.00000	0.00000	3.221	4.388
	Parbatipur	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.246	0.644
	Phulbari	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.263	1.238
Gaibandha	Gaibandha S.	14	0.42857	0.26223	0.29348	0.17273	0.07143	0.05882	0.05882	0.02891	3.282	13.079
	Gobindaganj	15	0.40000	0.30511	0.32305	0.21847	0.06667	0.03097	0.03097	0.00539	3.086	13.067
	Palashbari	9	0.44444	0.25340	0.25938	0.18917	0.00000	0.00000	0.00000	0.00000	3.340	11.767
	Phulchhari	8	0.12500	0.11266	0.11266	0.07801	0.00000	0.00000	0.00000	0.00000	2.913	4.713
	Sadullapur	9	0.33333	0.30195	0.30980	0.24922	0.22222	0.16331	0.16361	0.07943	2.692	21.189
	Sughatta	6	0.16667	0.08689	0.08689	0.04135	0.00000	0.00000	0.00000	0.00000	2.902	4.933
	Sundarganj	10	0.20000	0.15959	0.16304	0.11468	0.00000	0.00000	0.00000	0.00000	2.941	8.370
Kurigram	Bhurungamari	8	0.25000	0.12377	0.12287	0.07567	0.00000	0.00000	0.00000	0.00000	2.914	6.562
	Charrajibpur	5	0.20000	0.18508	0.18508	0.14652	0.00000	0.00000	0.00000	0.00000	3.085	8.440
	Chilmari	5	0.60000	0.32935	0.34830	0.22497	0.00000	0.00000	0.00000	0.00000	3.169	13.100
	Kurigram S.	10	0.20000	0.14183	0.16370	0.08822	0.00000	0.00000	0.00000	0.00000	2.906	7.310
	Nageshwari	11	0.27273	0.21314	0.23648	0.15478	0.09091	0.06311	0.06311	0.01864	3.194	11.845
	Phulbari	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.627	0.833
	Rajarhat	9	0.77778	0.62552	0.68982	0.53018	0.33333	0.26824	0.29040	0.20720	2.752	84.900
	Raomari	13	0.53846	0.42504	0.44250	0.34256	0.15385	0.09567	0.09567	0.04441	3.241	21.292
	Ulipur	9	0.44444	0.33439	0.37644	0.25213	0.11111	0.10474	0.10474	0.08140	2.857	28.778
Lalmonirhat	Aditmari	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.890	0.567
	Hatibandha	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.685	1.038
	Kaliganj	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.980	1.933
	Lalhonirhat S.	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.045	1.356
	Patgram	7	0.14286	0.11452	0.11452	0.05187	0.00000	0.00000	0.00000	0.00000	2.747	2.871

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Rangpur Division

			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Nilphamari	Dimla	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.070	0.811
	Domar	9	0.11111	0.08189	0.08189	0.04458	0.00000	0.00000	0.00000	0.00000	3.045	4.267
	Jaldhaka	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.086	0.875
	Kishoreganj	11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.860	1.682
	Nilphahari S.	9	0.22222	0.17180	0.17415	0.09686	0.00000	0.00000	0.00000	0.00000	3.316	5.100
	Saidpur	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.145	1.044
Panchagarh	Atwari	5	0.20000	0.12912	0.12912	0.04375	0.00000	0.00000	0.00000	0.00000	2.957	3.160
	Boda	13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.004	2.208
	Debiganj	9	0.11111	0.10578	0.10578	0.07824	0.00000	0.00000	0.00000	0.00000	3.071	4.256
	Panchagarh S.	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.128	1.271
	Tentulia	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.920	2.017
Rangpur	Badarganj	9	0.11111	0.10605	0.10605	0.07927	0.00000	0.00000	0.00000	0.00000	3.165	4.356
	Gangachhara	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.790	1.333
	Kaunia	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.878	3.467
	Mithapukur	15	0.40000	0.26799	0.28223	0.16658	0.00000	0.00000	0.00000	0.00000	3.329	9.327
	Pirgachha	14	0.35714	0.29729	0.32880	0.22849	0.14286	0.14026	0.14058	0.12583	3.002	77.357
	Pirganj	12	0.08333	0.07947	0.07947	0.06019	0.00000	0.00000	0.00000	0.00000	3.091	4.258
	Rangpur S.	14	0.07143	0.06272	0.06272	0.03836	0.00000	0.00000	0.00000	0.00000	3.175	3.250
	Taraganj	6	0.16667	0.12851	0.12851	0.05172	0.00000	0.00000	0.00000	0.00000	3.145	2.833
Thakurgaon	Baliadangi	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.912	0.650
	Haripur	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.912	0.983
	Pirganj	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.002	1.033
	Ranisankail	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.970	0.500
	Thakurgaon S.	13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.130	1.915

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Rajashahi Division

			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Bogra	Adamdighi	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.182	0.850
	Bogra S.	15	0.13333	0.11979	0.12201	0.07525	0.00000	0.00000	0.00000	0.00000	3.135	4.320
	Dhunat	8	0.62500	0.54867	0.55462	0.49751	0.50000	0.20598	0.20057	0.11659	3.157	38.212
	Dupchanchia	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.963	1.167
	Gabtali	9	0.55556	0.39829	0.45338	0.30680	0.11111	0.10980	0.10980	0.10232	2.987	81.000
	Kahaloo	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.981	0.770
	Nandigram	5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.968	0.560
	Sariakandi	12	0.33333	0.28365	0.30364	0.20517	0.08333	0.07804	0.07804	0.05556	2.913	19.367
	Sherpur	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.153	0.775
	Shibganj	9	0.33333	0.31557	0.31685	0.28182	0.22222	0.17072	0.17074	0.09851	3.218	26.156
	Sonatala	6	0.50000	0.34313	0.34943	0.25097	0.00000	0.00000	0.00000	0.00000	2.850	12.133
Jaipurhat	Akkelpur	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.185	0.529
	Jaypurhat S.	11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.214	0.782
	Kalai	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.231	2.371
	Khetlal	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.322	0.750
	Panchbibi	9	0.11111	0.06949	0.06949	0.02293	0.00000	0.00000	0.00000	0.00000	3.013	2.933
Naogaon	Atrai	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.457	1.333
	Badalgachhi	9	0.22222	0.16711	0.16724	0.07990	0.00000	0.00000	0.00000	0.00000	3.324	3.978
	Dhamoirhat	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.403	1.056
	Mahadevpur	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.296	1.344
	Manda	9	0.33333	0.29062	0.31934	0.24376	0.22222	0.20707	0.20750	0.16558	3.555	49.111
	Naogaon S.	11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.464	1.227
	Niamatpur	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.551	0.500
	Patnitala	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.509	1.567
	Porsha	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.919	0.529
	Raninagar	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.275	0.614
	Sapahar	5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.901	0.500
Natore	Bagatipara	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.572	1.550
	Baraigram	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.604	1.050
	Gurudaspur	9	0.11111	0.09346	0.09346	0.04869	0.00000	0.00000	0.00000	0.00000	3.506	3.033
	Lalpur	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.647	1.417
	Natore S.	13	0.07692	0.04817	0.04817	0.01061	0.00000	0.00000	0.00000	0.00000	3.540	2.031
	Singra	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.348	0.843

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Rajashahi Division–Continued

			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Nawabganj	Bholahat	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.634	1.417
	Gomastapur	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.779	2.400
	Nachole	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.715	1.289
	Nawabganj S.	9	0.22222	0.14564	0.15491	0.11111	0.00000	0.00000	0.00000	0.00000	3.402	10.333
	Shibganj	11	0.27273	0.25308	0.25364	0.22054	0.18182	0.10144	0.10152	0.03312	3.493	17.855
Pabna	Atgharia	5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.362	1.600
	Bera	8	0.87500	0.77332	0.80437	0.71385	0.50000	0.34501	0.37590	0.27529	3.185	98.475
	Bhangura	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.660	1.188
	Chatmohar	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.601	1.188
	Faridpur	6	0.16667	0.03257	0.03257	0.00165	0.00000	0.00000	0.00000	0.00000	3.516	3.017
	Ishwardi	10	0.40000	0.39317	0.39417	0.37451	0.40000	0.34742	0.36892	0.27257	3.413	128.270
	Pabna S.	12	0.16667	0.14100	0.14303	0.08227	0.00000	0.00000	0.00000	0.00000	3.604	4.450
	Santhia	11	0.45455	0.41870	0.42799	0.35968	0.36364	0.20661	0.22640	0.10576	3.549	37.764
	Sujanagar	11	0.18182	0.17662	0.17671	0.15482	0.18182	0.13969	0.14125	0.04685	3.693	13.036
Rajshahi	Bagha	8	0.12500	0.10351	0.10351	0.04383	0.00000	0.00000	0.00000	0.00000	3.503	2.362
	Bagmara	6	0.16667	0.12403	0.12403	0.05012	0.00000	0.00000	0.00000	0.00000	3.313	2.983
	Charghat	9	0.22222	0.19423	0.19897	0.12448	0.00000	0.00000	0.00000	0.00000	3.483	6.711
	Durgapur	8	0.12500	0.11949	0.11949	0.09421	0.00000	0.00000	0.00000	0.00000	3.601	5.800
	Godagari	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.634	1.188
	Mohanpur	8	0.25000	0.19735	0.21440	0.13987	0.12500	0.07877	0.07877	0.01761	3.684	10.975
	Paba	10	0.30000	0.28728	0.28748	0.25958	0.30000	0.21231	0.21396	0.09789	3.608	23.720
	Puthia	9	0.44444	0.32608	0.34812	0.22577	0.11111	0.07251	0.07251	0.02403	3.587	13.789
	Tanore	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.614	1.050
Sirajganj	Belkuchi	8	0.75000	0.51000	0.53198	0.40864	0.12500	0.03172	0.03172	0.00840	3.180	22.150
	Chauhali	8	0.12500	0.07937	0.07937	0.02579	0.00000	0.00000	0.00000	0.00000	2.941	2.775
	Kamarkhanda	8	0.62500	0.51796	0.54311	0.44725	0.50000	0.19523	0.18718	0.09952	3.230	35.737
	Kazipur	9	0.44444	0.38880	0.41623	0.30959	0.33333	0.22461	0.26147	0.12590	2.859	57.367
	Raiganj	8	0.50000	0.35762	0.37710	0.24629	0.00000	0.00000	0.00000	0.00000	3.093	13.350
	Shahjadpur	9	1.00000	0.85039	0.86958	0.80500	0.66667	0.24150	0.15788	0.19253	3.228	69.267
	Sirajganj S.	15	0.73333	0.56331	0.60443	0.47097	0.33333	0.16049	0.15919	0.09217	3.063	36.080
	Tarash	9	0.11111	0.06684	0.06684	0.00823	0.00000	0.00000	0.00000	0.00000	3.204	1.678
	Ullahpara	13	0.76923	0.51723	0.53035	0.42260	0.07692	0.00306	0.00306	0.00015	3.235	20.208

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Mymensingh Division

			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Jamalpur	Baksiganj	12	0.50000	0.40299	0.43680	0.30941	0.16667	0.13765	0.13778	0.08758	2.956	26.600
	Dewanganj	3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.880	2.867
	Islampur	9	0.22222	0.12334	0.12351	0.07412	0.00000	0.00000	0.00000	0.00000	3.137	6.778
	Jamalpur S.	12	0.25000	0.22345	0.22573	0.16901	0.08333	0.02863	0.02863	0.00099	3.461	9.842
	Madarganj	9	0.33333	0.17728	0.17758	0.08581	0.00000	0.00000	0.00000	0.00000	2.867	5.856
	Melandaha	11	0.36364	0.19101	0.19655	0.10975	0.00000	0.00000	0.00000	0.00000	3.154	7.545
	Sarishabari	7	0.28571	0.23104	0.26509	0.18232	0.14286	0.13664	0.13664	0.11180	3.210	37.471
Kishoreganj	Astagram	5	0.40000	0.26332	0.31341	0.19720	0.20000	0.14644	0.14644	0.07097	4.143	19.900
	Bajitpur	12	0.66667	0.58511	0.62287	0.49843	0.41667	0.32439	0.35472	0.23872	3.935	97.008
	Bhairab	9	0.77778	0.66359	0.72143	0.56838	0.33333	0.30822	0.31196	0.26909	4.082	120.700
	Hossainpur	8	0.25000	0.22582	0.23858	0.17849	0.12500	0.11915	0.11915	0.09295	3.833	28.200
	Itna	7	0.71429	0.55820	0.58297	0.48873	0.28571	0.15285	0.15310	0.09023	4.243	33.729
	Karimganj	9	1.00000	0.78889	0.83142	0.71076	0.44444	0.24141	0.24388	0.17780	4.118	57.278
	Katiadi	7	0.28571	0.24434	0.24653	0.16710	0.00000	0.00000	0.00000	0.00000	4.006	7.843
	Kishoreganj S.	15	0.33333	0.28356	0.31817	0.25122	0.26667	0.23901	0.23936	0.17970	3.971	44.187
	Kuliarchar	8	0.87500	0.75554	0.78790	0.68530	0.37500	0.29371	0.30107	0.23786	4.326	76.138
	Mithamain	4	0.75000	0.57479	0.63032	0.47167	0.50000	0.30401	0.30405	0.20484	4.298	45.400
	Nikli	5	1.00000	0.74371	0.80114	0.64537	0.40000	0.25089	0.25091	0.19279	4.331	54.120
	Pakundia	10	0.20000	0.19113	0.19408	0.15378	0.10000	0.09761	0.09761	0.08168	3.939	30.170
	Tarail	7	0.71429	0.47430	0.49681	0.39121	0.14286	0.03030	0.03030	0.00758	4.152	22.114
Nasirabad	Bhaluka	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.177	0.500
	Dhobaura	9	1.00000	0.86605	0.89839	0.78252	0.77778	0.43415	0.44390	0.34634	4.100	88.878
	Gaffargaon	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.206	1.289
	Gauripur	7	0.14286	0.14070	0.14070	0.12975	0.14286	0.12963	0.12963	0.07733	3.790	16.429
	Haluaghat	9	0.66667	0.52795	0.55053	0.43623	0.22222	0.10539	0.10470	0.05162	3.676	27.833
	Ishwarganj	9	0.11111	0.10262	0.10262	0.06965	0.00000	0.00000	0.00000	0.00000	3.911	3.844
	Muktagachha	8	0.12500	0.12149	0.12149	0.10595	0.12500	0.09763	0.09763	0.02973	3.941	9.862
	Mymensingh S.	10	0.30000	0.27907	0.27960	0.23358	0.10000	0.05995	0.05995	0.01582	4.086	14.570
	Nandail	8	0.37500	0.32050	0.32617	0.26047	0.12500	0.06948	0.06948	0.02220	4.085	16.400
	Phulbari	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.994	0.800
	Phulpur	10	0.30000	0.27407	0.27851	0.21682	0.10000	0.07801	0.07801	0.03464	3.960	14.840
	Trishal	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.132	0.525

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Mymensingh Division–Continued

			$L=10$				$L=50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Netrakona	Atpara	7	0.14286	0.14180	0.14143	0.13624	0.14286	0.13710	0.13710	0.10979	4.247	32.343
	Barhatta	8	0.62500	0.36977	0.37820	0.26534	0.00000	0.00000	0.00000	0.00000	4.169	13.338
	Durgapur	7	0.85714	0.65120	0.69790	0.56285	0.14286	0.12745	0.12745	0.10227	3.590	45.743
	Kalmakanda	9	0.88889	0.78677	0.81061	0.71727	0.66667	0.36922	0.38513	0.28216	4.365	83.344
	Kendua	10	0.20000	0.19149	0.19245	0.15766	0.10000	0.08454	0.08454	0.03711	3.965	11.710
	Khaliajuri	6	1.00000	0.83045	0.85959	0.77657	0.33333	0.24809	0.24817	0.20494	3.663	66.483
	Madan	8	0.87500	0.78031	0.79722	0.71177	0.75000	0.42300	0.42610	0.32695	4.390	77.325
	Mohanganj	9	0.66667	0.60319	0.61191	0.55170	0.44444	0.25945	0.26153	0.18006	4.385	52.044
	Netrokona S.	8	0.25000	0.20404	0.20409	0.12193	0.00000	0.00000	0.00000	0.00000	4.276	5.263
	Purbadhala	7	0.14286	0.13470	0.13470	0.10435	0.00000	0.00000	0.00000	0.00000	4.229	6.171
Sherpur	Jhenaigati	9	0.44444	0.35040	0.35865	0.27516	0.00000	0.00000	0.00000	0.00000	3.465	15.222
	Nakla	8	0.25000	0.21573	0.22359	0.15435	0.12500	0.07092	0.07092	0.01011	3.156	10.112
	Nalitabari	10	0.80000	0.58537	0.62917	0.50164	0.20000	0.11190	0.11776	0.07438	3.264	37.420
	Sherpur S.	13	0.23077	0.20737	0.21543	0.16521	0.07692	0.06959	0.06959	0.04348	3.392	15.577
	Sreebardi	11	0.54545	0.37931	0.44127	0.28283	0.18182	0.15865	0.16016	0.10908	3.042	31.027
Tangail	Basail	7	0.71429	0.51431	0.54667	0.40838	0.14286	0.10866	0.10866	0.06572	3.444	25.114
	Bhuapur	6	0.16667	0.08899	0.08899	0.05702	0.00000	0.00000	0.00000	0.00000	3.264	7.233
	Delduar	5	0.80000	0.66825	0.70516	0.58492	0.40000	0.27214	0.28101	0.19896	3.534	57.280
	Ghatail	10	0.20000	0.18721	0.18724	0.15363	0.00000	0.00000	0.00000	0.00000	3.718	9.990
	Gopalpur	9	0.44444	0.32596	0.34142	0.25639	0.00000	0.00000	0.00000	0.00000	3.538	15.211
	Kalihati	10	0.70000	0.42002	0.43717	0.34943	0.00000	0.00000	0.00000	0.00000	3.694	18.980
	Madhupur	8	0.12500	0.10501	0.10501	0.06604	0.00000	0.00000	0.00000	0.00000	3.523	4.662
	Mirzapur	13	0.46154	0.32544	0.37487	0.22620	0.15385	0.12809	0.13008	0.07421	3.508	21.592
	Nagarpur	6	0.50000	0.41664	0.44464	0.35130	0.16667	0.14782	0.14782	0.11074	3.406	35.617
	Sakhipur	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.951	0.514
	Tangail S.	10	0.70000	0.55677	0.59297	0.45229	0.20000	0.15623	0.15910	0.10547	3.352	35.570

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Sylhet Division

			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Habiganj	Ajmiriganj	7	0.85714	0.62696	0.68528	0.53013	0.28571	0.19569	0.20129	0.13481	3.890	43.657
	Bahubal	6	0.50000	0.34398	0.35505	0.26528	0.00000	0.00000	0.00000	0.00000	3.910	14.317
	Baniachong	9	1.00000	0.64442	0.73303	0.54400	0.44444	0.22557	0.24852	0.15768	3.880	66.478
	Chunarughat	8	0.37500	0.31230	0.31438	0.23934	0.00000	0.00000	0.00000	0.00000	3.923	12.075
	Habiganj S.	8	0.37500	0.24496	0.24507	0.16237	0.00000	0.00000	0.00000	0.00000	3.972	8.238
	Lakhai	5	0.40000	0.22788	0.25122	0.16082	0.00000	0.00000	0.00000	0.00000	4.038	11.660
	Madhabpur	7	0.14286	0.06862	0.06862	0.01299	0.00000	0.00000	0.00000	0.00000	3.845	2.786
	Nabiganj	8	0.50000	0.29062	0.31480	0.20604	0.00000	0.00000	0.00000	0.00000	4.052	13.812
Moulvibazar	Barlekha	8	0.12500	0.09943	0.09943	0.05707	0.00000	0.00000	0.00000	0.00000	4.035	4.112
	Kamalganj	10	0.40000	0.32316	0.35730	0.24802	0.10000	0.09636	0.09636	0.08031	3.819	35.190
	Kulaura	10	0.30000	0.24686	0.25149	0.18648	0.00000	0.00000	0.00000	0.00000	3.727	11.130
	Maulvibazar S.	9	0.77778	0.61682	0.65650	0.53223	0.44444	0.21879	0.22267	0.13550	4.280	43.778
	Rajnagar	8	0.25000	0.23091	0.23583	0.18626	0.12500	0.10596	0.10596	0.05632	3.910	15.863
	Sreemangal	9	0.33333	0.20297	0.20485	0.13123	0.00000	0.00000	0.00000	0.00000	3.833	8.056
Sunamganj	Bishwamvarpur	10	0.80000	0.59757	0.61466	0.51980	0.10000	0.02823	0.02823	0.01289	4.249	29.470
	Chhatak	7	0.85714	0.68637	0.74627	0.60361	0.28571	0.25010	0.25213	0.20742	4.753	72.100
	Derai	6	1.00000	0.85734	0.86061	0.84340	1.00000	0.25055	0.22056	0.21700	4.871	66.550
	Dharampasha	5	1.00000	0.90194	0.90947	0.86732	0.80000	0.47435	0.47747	0.41987	4.791	95.340
	Dowarabazar	5	0.60000	0.50415	0.54646	0.42535	0.40000	0.24354	0.27244	0.16371	3.892	56.340
	Jagannathpur	8	0.87500	0.47663	0.47970	0.38836	0.00000	0.00000	0.00000	0.00000	4.766	18.988
	Jamalganj	7	1.00000	0.83586	0.84103	0.80367	0.71429	0.18417	0.17112	0.15112	4.815	56.471
	Sullah	6	1.00000	0.82642	0.82880	0.80961	0.50000	0.11755	0.11272	0.09966	4.782	54.200
	Sunamganj S.	10	0.90000	0.72836	0.73267	0.69171	0.40000	0.06812	0.06109	0.04629	4.810	42.740
	Tahirpur	7	0.42857	0.36759	0.37689	0.30613	0.14286	0.08612	0.08612	0.03782	4.204	21.214
Sylhet	Balaganj	10	0.90000	0.64663	0.70941	0.55113	0.30000	0.22387	0.23031	0.16264	4.439	49.570
	Beanibazar	8	0.12500	0.11945	0.11945	0.10092	0.12500	0.06195	0.06195	0.00458	3.598	8.963
	Bishwanath	7	0.42857	0.35572	0.36138	0.29173	0.14286	0.04463	0.04463	0.00809	4.340	17.314
	Companiganj	5	0.80000	0.64030	0.65993	0.58254	0.40000	0.18481	0.18479	0.12077	3.844	40.280
	Fenchuganj	5	0.20000	0.10769	0.10769	0.03871	0.00000	0.00000	0.00000	0.00000	3.858	3.980
	Golabganj	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.036	3.188
	Gowainghat	9	0.55556	0.43345	0.45115	0.35265	0.22222	0.10083	0.10078	0.03596	3.593	21.456
	Jaintiapur	4	0.25000	0.12087	0.12087	0.07517	0.00000	0.00000	0.00000	0.00000	3.079	7.125
	Kanaighat	5	0.80000	0.59313	0.65948	0.50915	0.40000	0.17479	0.11392	0.13417	4.000	50.580
	Sylhet S.	8	0.12500	0.11093	0.11093	0.08291	0.00000	0.00000	0.00000	0.00000	4.174	6.750
	Zakiganj	8	0.62500	0.55248	0.55848	0.49209	0.37500	0.16959	0.15405	0.09881	3.767	35.425

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Khulna Division													
			$L=10$				$L=50$						
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Bagerhat	Bagerhat S.	12	0.75000	0.68602	0.71962	0.60533	0.58333	0.49010	0.51304	0.40484	3.767	156.092
	Chitalmari	5	1.00000	0.95858	0.96283	0.94917	1.00000	0.78785	0.80563	0.74587	3.231	237.400
	Fakirhat	7	0.85714	0.80631	0.83057	0.72917	0.71429	0.62310	0.63964	0.55061	3.569	234.686
	Kachua	6	1.00000	0.67799	0.75958	0.58256	0.33333	0.26230	0.26602	0.20535	2.855	61.817
	Mollahat	8	0.87500	0.82479	0.83197	0.79456	0.75000	0.55607	0.57377	0.48107	3.445	133.537
	Mongla	4	0.25000	0.12862	0.12862	0.07143	0.00000	0.00000	0.00000	0.00000	2.698	6.150
	Morrelganj	6	0.83333	0.74038	0.77079	0.67472	0.50000	0.36704	0.40395	0.28926	3.023	117.717
	Rampal	8	0.87500	0.84558	0.85287	0.81186	0.75000	0.65910	0.67044	0.60053	3.351	257.225
Chuadanga	Alamdanga	9	0.66667	0.59551	0.60747	0.53740	0.33333	0.23365	0.23937	0.16367	3.800	48.633
	Chuadanga S.	10	0.80000	0.68222	0.69148	0.62021	0.30000	0.15481	0.15563	0.10330	3.443	42.990
	Damurhula	9	1.00000	0.91169	0.94035	0.84967	0.66667	0.49590	0.53929	0.42345	3.753	175.122
	Jibannagar	6	0.83333	0.68244	0.70678	0.59119	0.33333	0.18794	0.18936	0.12489	3.878	42.750
Jessore	Abhaynagar	8	0.50000	0.48801	0.48984	0.46678	0.50000	0.42903	0.44124	0.33392	3.939	107.025
	Bagherpara	8	0.62500	0.53078	0.55218	0.45811	0.25000	0.16938	0.18008	0.10775	3.858	37.663
	Chaugachha	9	0.88889	0.74004	0.74980	0.68154	0.44444	0.14832	0.13503	0.09960	3.937	45.256
	Jessore S.	12	0.50000	0.43636	0.46892	0.38265	0.41667	0.32694	0.33111	0.22674	3.857	51.358
	Jhikargachha	8	0.87500	0.80545	0.81043	0.77674	0.75000	0.46010	0.46931	0.38469	3.921	91.513
	Keshabpur	8	0.62500	0.59826	0.60317	0.56171	0.50000	0.41641	0.42453	0.33823	3.941	97.612
	Manirampur	9	0.88889	0.81659	0.82887	0.76702	0.66667	0.46260	0.47663	0.38043	4.004	99.811
	Sharsha	8	0.75000	0.57275	0.58857	0.49455	0.25000	0.06267	0.06201	0.02518	3.835	28.375
Jhenaidah	Harinakunda	7	0.71429	0.51671	0.57908	0.39548	0.28571	0.21039	0.21608	0.13220	3.861	36.243
	Jhenaidaha S.	12	0.75000	0.58330	0.62165	0.49900	0.16667	0.14153	0.14165	0.10621	3.873	39.658
	Kaliganj	8	0.50000	0.42209	0.44017	0.33984	0.25000	0.14351	0.14668	0.06761	4.071	24.950
	Kotchandpur	7	0.42857	0.39228	0.39880	0.34752	0.14286	0.12301	0.12301	0.08833	3.886	32.671
	Maheshpur	10	0.70000	0.57442	0.62752	0.50234	0.50000	0.29791	0.34033	0.20082	3.736	89.210
	Shailkupa	10	0.60000	0.44812	0.50790	0.35327	0.20000	0.17052	0.17873	0.12254	3.832	45.650
Khulna	Batiaghata	9	0.11111	0.11087	0.11000	0.10905	0.11111	0.10987	0.10987	0.10078	4.837	60.833
	Dacope	3	0.66667	0.27968	0.27707	0.17792	0.00000	0.00000	0.00000	0.00000	3.633	9.433
	Dighalia	18	0.27778	0.26479	0.26703	0.22967	0.16667	0.13157	0.13720	0.06785	4.341	22.150
	Dumuria	9	0.44444	0.39128	0.39378	0.33591	0.11111	0.06393	0.06393	0.02655	4.346	20.767
	Kotwali	7	0.14286	0.13624	0.13624	0.11233	0.00000	0.00000	0.00000	0.00000	5.407	8.071
	Paikgachha	5	0.60000	0.56183	0.56327	0.53459	0.60000	0.37833	0.38334	0.27293	3.727	61.520
	Phultala	7	0.28571	0.28071	0.28109	0.26552	0.28571	0.25586	0.26012	0.18473	4.517	52.043
	Rupsa	10	0.60000	0.54106	0.55216	0.47334	0.40000	0.25435	0.26074	0.16067	4.634	43.330
	Terokhada	6	0.66667	0.58222	0.60247	0.50186	0.33333	0.25196	0.25198	0.18378	3.739	46.967

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Khulna Division–Continued

			$L=10$				$L=50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Kustia	Bheramara	6	0.66667	0.64033	0.64635	0.60924	0.66667	0.47988	0.56884	0.37952	3.846	339.833
	Daulatpur	9	0.33333	0.32732	0.32733	0.30875	0.33333	0.29494	0.30922	0.21044	3.745	98.244
	Khoksa	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.816	1.700
	Kumarkhali	8	0.25000	0.18157	0.22529	0.13985	0.12500	0.12246	0.12246	0.10842	3.796	50.788
	Kushtia S.	9	0.44444	0.38508	0.39135	0.30768	0.11111	0.06194	0.06194	0.02092	3.832	18.000
	Mirpur	9	0.66667	0.60456	0.62502	0.54647	0.44444	0.30243	0.36560	0.22248	3.737	155.500
Magura	Magura S.	11	0.45455	0.35875	0.38714	0.27880	0.09091	0.07715	0.07715	0.04803	3.989	20.782
	Mohammadpur	9	0.33333	0.31952	0.32146	0.29029	0.33333	0.23160	0.24557	0.11812	4.203	33.333
	Shalikha	7	0.57143	0.53603	0.54166	0.49556	0.42857	0.29072	0.30937	0.19353	4.040	58.529
	Sreepur	6	0.16667	0.11515	0.11515	0.05702	0.00000	0.00000	0.00000	0.00000	3.849	4.250
Meherpur	Gangni	7	0.85714	0.61490	0.64819	0.50930	0.28571	0.09972	0.09944	0.04912	3.703	31.229
	Meherpur S.	8	1.00000	0.93726	0.95384	0.90167	0.87500	0.61564	0.66592	0.52737	3.759	189.850
Narail	Kalia	10	0.70000	0.63374	0.66581	0.55300	0.50000	0.43841	0.43913	0.38300	4.088	113.710
	Lohagara	6	0.50000	0.47510	0.47914	0.43305	0.33333	0.28331	0.28332	0.22258	3.865	56.733
	Narail S.	8	0.62500	0.58059	0.59521	0.51230	0.37500	0.32944	0.32948	0.27868	4.035	80.987
Shatkhira	Assasuni	5	1.00000	0.95024	0.95855	0.91502	0.80000	0.66527	0.66951	0.62449	3.685	204.420
	Debhata	8	0.87500	0.82349	0.83257	0.79122	0.87500	0.56249	0.59769	0.45610	3.862	136.988
	Kalaroa	8	1.00000	0.94945	0.95678	0.93183	1.00000	0.73236	0.76241	0.65913	3.894	197.812
	Kaliganj	10	0.60000	0.47213	0.50272	0.37693	0.20000	0.15164	0.15188	0.09200	3.266	27.690
	Satkhira S.	14	0.78571	0.74921	0.75470	0.72417	0.78571	0.58074	0.60971	0.47801	3.987	142.514
	Shyamnagar	7	0.42857	0.38469	0.41178	0.33516	0.28571	0.26928	0.27224	0.22916	2.944	101.843
	Tala	10	1.00000	0.90424	0.93906	0.81747	0.80000	0.59879	0.62312	0.51111	3.848	152.320

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Dhaka Division												
			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Dhaka	Dhamrai	8	0.37500	0.32029	0.33513	0.26255	0.12500	0.10581	0.10581	0.06659	3.935	22.212
	Dohar	4	1.00000	0.91326	0.91972	0.89376	1.00000	0.53651	0.54537	0.46880	4.098	109.275
	Keraniganj	8	0.37500	0.31635	0.33811	0.23944	0.12500	0.10464	0.10464	0.06148	4.072	20.375
	Nawabganj	9	1.00000	0.88925	0.92160	0.81638	0.88889	0.53812	0.56382	0.44564	3.914	118.756
	Savar	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.012	1.100
	Tejgaon	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.298	0.500
Faridpur	Alfadanga	3	1.00000	0.94242	0.95867	0.89825	0.66667	0.58790	0.58841	0.55855	3.591	221.867
	Bhanga	7	1.00000	0.96474	0.96726	0.95380	1.00000	0.81720	0.82912	0.76899	3.454	260.714
	Boalmari	14	0.78571	0.71048	0.72936	0.63840	0.57143	0.39371	0.40613	0.30015	3.655	77.500
	Char Bhadrasan	4	0.50000	0.49245	0.49287	0.48278	0.50000	0.46042	0.46263	0.41391	3.115	163.575
	Faridpur S.	12	0.58333	0.54789	0.55459	0.51285	0.50000	0.34035	0.36070	0.24919	3.584	71.483
	Madhukhali	6	0.33333	0.32601	0.32665	0.31000	0.33333	0.29099	0.29501	0.21666	3.948	57.550
	Nagarkanda	9	1.00000	0.95568	0.96134	0.93864	1.00000	0.76566	0.80573	0.69318	3.388	258.800
	Sadarpur	7	0.85714	0.76302	0.80482	0.68563	0.57143	0.47142	0.48569	0.39908	3.944	132.614
Gazipur	Gazipur S.	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.255	0.722
	Kaliakair	5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.861	0.500
	Kaliganj	8	0.12500	0.12389	0.12375	0.11694	0.12500	0.11864	0.11864	0.08468	3.916	20.087
	Kapasia	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.813	0.533
	Sreepur	10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.906	1.300
Gopalganj	Gopalganj S.	12	0.91667	0.88453	0.88874	0.87038	0.91667	0.74874	0.77009	0.68523	3.674	241.400
	Kashiani	8	0.87500	0.80287	0.81628	0.77076	0.75000	0.44057	0.47433	0.35507	3.818	109.537
	Kotalipara	8	0.75000	0.72595	0.72837	0.70761	0.75000	0.61929	0.63503	0.53807	4.020	175.875
	Muksudpur	8	0.87500	0.84590	0.84949	0.83095	0.87500	0.72195	0.74117	0.65473	4.138	231.000
	Tungipara	8	0.75000	0.72085	0.72908	0.67109	0.62500	0.55817	0.55958	0.51455	3.778	186.537
Madaripur	Kalkini	9	0.44444	0.43920	0.43909	0.42931	0.44444	0.41645	0.41869	0.36879	4.080	161.700
	Madaripur S.	9	0.77778	0.76267	0.76384	0.75111	0.77778	0.69859	0.70500	0.64444	3.886	284.667
	Rajoir	10	0.70000	0.67636	0.68124	0.64917	0.70000	0.55901	0.59903	0.44585	4.246	186.450
	Shibchar	9	0.88889	0.82484	0.83763	0.79661	0.88889	0.52808	0.56988	0.42752	3.354	128.289
Manikganj	Daulatpur	6	0.66667	0.37045	0.39598	0.25418	0.00000	0.00000	0.00000	0.00000	3.451	14.567
	Ghior	7	1.00000	0.65605	0.69071	0.58508	0.14286	0.09507	0.09507	0.06260	3.903	32.700
	Harirampur	6	0.83333	0.69661	0.72182	0.61179	0.66667	0.30004	0.29797	0.20496	3.754	51.733
	Manikganj S.	9	0.66667	0.43074	0.46925	0.35457	0.22222	0.07106	0.06678	0.02671	3.252	24.289
	Saturia	8	0.37500	0.27852	0.28200	0.20375	0.00000	0.00000	0.00000	0.00000	3.311	10.637
	Shivalaya	6	0.66667	0.49180	0.50479	0.42000	0.00000	0.00000	0.00000	0.00000	3.992	23.333
	Singair	5	0.20000	0.18390	0.18390	0.15614	0.00000	0.00000	0.00000	0.00000	3.687	12.780

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Dhaka Division–Continued

			L = 10				L = 50					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Munshiganj	Gazaria	6	1.00000	0.95161	0.95780	0.92398	0.83333	0.67434	0.68173	0.62721	3.201	197.483
	Lohajang	7	1.00000	0.95514	0.95983	0.93882	1.00000	0.76297	0.78343	0.69409	4.031	208.943
	Munshiganj S.	8	0.50000	0.30721	0.34888	0.24242	0.25000	0.10551	0.10550	0.03048	4.262	19.512
	Sirajdikhan	8	1.00000	0.94851	0.96857	0.87795	0.87500	0.75658	0.76905	0.70182	4.151	286.163
	Sreenagar	8	1.00000	0.96104	0.96688	0.94669	1.00000	0.79644	0.82252	0.73347	4.034	256.000
	Tongibari	9	1.00000	0.94358	0.95047	0.92148	1.00000	0.69175	0.71858	0.60742	3.671	171.122
Narayanganj	Araihazar	6	0.50000	0.47500	0.47766	0.44544	0.50000	0.34584	0.35935	0.22721	3.194	55.833
	Bandar	3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.988	1.667
	Narayanganj S.	8	0.12500	0.10511	0.10511	0.07636	0.00000	0.00000	0.00000	0.00000	4.206	6.850
	Rupganj	9	0.11111	0.10416	0.10416	0.07628	0.00000	0.00000	0.00000	0.00000	3.691	4.622
	Sonargaon	6	0.66667	0.65070	0.65112	0.63920	0.66667	0.58341	0.58557	0.52933	3.490	172.500
Narshingdi	Belabo	8	0.37500	0.35949	0.36175	0.33114	0.25000	0.21549	0.21614	0.15957	3.602	43.688
	Manohardi	9	0.44444	0.39570	0.39972	0.33159	0.22222	0.10658	0.10618	0.03720	3.337	21.033
	Narsingdi S.	8	0.37500	0.36042	0.36289	0.32648	0.25000	0.21145	0.21622	0.14357	3.336	40.725
	Palash	6	0.33333	0.28903	0.29480	0.22260	0.16667	0.06106	0.06106	0.00610	3.761	13.283
	Raipur	11	0.63636	0.60024	0.60953	0.55448	0.45455	0.35077	0.37176	0.27900	3.027	88.882
	Shibpur	12	0.58333	0.48964	0.49989	0.40998	0.16667	0.06710	0.06429	0.02871	3.509	25.367
Rajbari	Baliakandi	7	0.14286	0.11020	0.11020	0.05128	0.00000	0.00000	0.00000	0.00000	4.105	3.257
	Goalandaghat	6	0.66667	0.46819	0.54681	0.39378	0.16667	0.15978	0.15978	0.14013	3.019	65.450
	Pangsha	11	0.36364	0.31269	0.33511	0.25434	0.18182	0.13926	0.14723	0.08044	3.670	27.073
	Rajbari S.	9	0.66667	0.61480	0.63543	0.55314	0.44444	0.37601	0.38740	0.30252	3.274	98.389
Shariatpur	Bhedarganj	8	0.87500	0.80394	0.81295	0.75748	0.62500	0.44143	0.44696	0.37331	3.806	92.588
	Damudya	8	0.50000	0.46624	0.47780	0.40797	0.37500	0.30281	0.32940	0.21107	4.431	97.700
	Gosairhat	8	0.75000	0.72452	0.73072	0.68822	0.62500	0.56107	0.56547	0.51641	3.927	206.475
	Shariatpur S.	10	0.80000	0.76608	0.77215	0.74255	0.80000	0.61200	0.64528	0.51276	3.526	169.460
	Zanjira	15	0.80000	0.76390	0.77306	0.72213	0.73333	0.56597	0.60290	0.46654	3.254	168.427

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Comilla Division												
			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Brahmanbaria	Akhaura	7	0.14286	0.14047	0.14047	0.12987	0.14286	0.12831	0.12831	0.07792	3.741	17.686
	Bancharampur	7	1.00000	0.94868	0.95847	0.91548	0.85714	0.67439	0.70748	0.60503	3.196	232.043
	Brahmanbaria S.	14	0.57143	0.54925	0.55603	0.50545	0.42857	0.37178	0.38545	0.29667	3.639	111.007
	Kasba	8	0.25000	0.22877	0.23561	0.18749	0.12500	0.10909	0.10909	0.06548	3.471	18.312
	Nabinagar	7	1.00000	0.94846	0.96199	0.91454	1.00000	0.67052	0.73070	0.57268	3.559	233.771
	Nasirnagar	6	0.16667	0.16584	0.16584	0.16200	0.16667	0.16233	0.16233	0.14332	3.964	60.933
	Sarail	5	0.20000	0.08749	0.08749	0.03193	0.00000	0.00000	0.00000	0.00000	3.829	4.580
Chandpur	Chandpur S.	10	0.90000	0.88430	0.88494	0.87783	0.90000	0.81987	0.82320	0.78914	3.445	421.380
	Faridganj	10	0.90000	0.88050	0.88291	0.86765	0.90000	0.79724	0.81015	0.73826	3.136	356.800
	Haimchar	4	0.75000	0.73480	0.73592	0.72519	0.75000	0.67148	0.67702	0.62597	3.570	265.000
	Haziganj	7	1.00000	0.97697	0.97829	0.97044	1.00000	0.88267	0.88908	0.85220	3.384	397.000
	Kachua	10	1.00000	0.96005	0.96818	0.92069	0.90000	0.72316	0.75226	0.67010	3.276	266.630
	Matlab	9	0.88889	0.87250	0.87322	0.86617	0.88889	0.80546	0.80899	0.77528	3.486	388.911
	Shahrasti	9	0.88889	0.87276	0.87315	0.86542	0.88889	0.80650	0.81524	0.77153	3.371	420.556
Comilla	Barura	11	0.81818	0.76484	0.78384	0.70519	0.72727	0.57124	0.59178	0.48243	3.511	147.718
	Brahmanpara	6	0.50000	0.47989	0.48060	0.45710	0.50000	0.38469	0.38879	0.28548	3.768	64.450
	Burichang	9	0.11111	0.10753	0.10753	0.09353	0.11111	0.08252	0.08252	0.02321	3.803	9.700
	Chandhina	7	1.00000	0.96636	0.96907	0.95337	1.00000	0.82370	0.83721	0.76684	3.332	271.200
	Chauddagram	9	0.66667	0.53836	0.59180	0.45957	0.44444	0.32992	0.33159	0.23868	3.429	53.378
	Comilla S.	11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.883	2.573
	Daudkandi	9	1.00000	0.96396	0.96827	0.94734	1.00000	0.80638	0.83294	0.73672	3.393	273.633
	Debidwar	13	0.92308	0.88109	0.88486	0.86708	0.92308	0.70419	0.71986	0.64310	3.555	180.700
	Homna	8	0.75000	0.70823	0.71160	0.68082	0.75000	0.51176	0.52609	0.40409	2.839	97.112
	Laksam	10	0.90000	0.84230	0.86385	0.77552	0.80000	0.64887	0.66893	0.56824	3.347	187.140
	Muradnagar	9	1.00000	0.96789	0.97059	0.95208	1.00000	0.82588	0.84222	0.76042	3.453	286.644
	Nangalkot	8	0.87500	0.74939	0.79467	0.67189	0.62500	0.37855	0.43544	0.28809	3.331	130.988
Feni	Chhagalnaiya	16	0.25000	0.13215	0.13307	0.08932	0.00000	0.00000	0.00000	0.00000	3.891	8.162
	Daganbhuiyan	8	0.87500	0.83235	0.84043	0.80136	0.75000	0.59005	0.61144	0.51310	3.087	164.100
	Feni S.	12	0.41667	0.37986	0.39527	0.33561	0.33333	0.27126	0.27347	0.18847	3.384	44.008
	Parshuram	6	0.33333	0.21875	0.22187	0.13937	0.00000	0.00000	0.00000	0.00000	3.646	7.817
	Sonagazi	11	0.90909	0.79769	0.81903	0.72643	0.63636	0.37709	0.38363	0.29573	2.986	74.755
Lakshmipur	Lakshmipur S.	10	0.60000	0.47390	0.53413	0.40376	0.30000	0.23412	0.24891	0.16833	3.275	55.500
	Raipur	7	0.85714	0.82762	0.83348	0.80272	0.85714	0.68610	0.72977	0.58502	2.949	255.829
	Ramganj	8	0.87500	0.85950	0.86102	0.84735	0.87500	0.79325	0.80546	0.73677	3.106	421.250
	Ramgati	9	0.77778	0.62669	0.65854	0.54080	0.33333	0.21899	0.21932	0.15000	2.601	42.256

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

Comilla Division – Continued

			L = 10				L = 50					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Noakhali	Begumganj	12	0.91667	0.88218	0.88808	0.85756	0.91667	0.71210	0.74777	0.62112	2.819	225.917
	Chatkhil	8	1.00000	0.89809	0.95245	0.82425	0.87500	0.69343	0.73487	0.60305	2.961	250.787
	Companiganj	8	0.75000	0.61689	0.63464	0.55413	0.25000	0.16286	0.16309	0.10968	2.662	38.650
	Noakhali S.	12	0.66667	0.62616	0.63700	0.58065	0.50000	0.41080	0.41818	0.33618	2.883	95.708
	Senbagh	9	0.88889	0.84887	0.85761	0.82374	0.88889	0.66440	0.70607	0.56315	2.977	196.756

Barisal Division

			L = 10				L = 50					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Barisal	Agailjhara	10	0.50000	0.48669	0.48834	0.46625	0.50000	0.42287	0.43326	0.33125	4.047	97.690
	Babuganj	10	0.50000	0.49273	0.49253	0.47841	0.50000	0.45914	0.47008	0.39206	4.190	209.780
	Bakerganj	8	0.25000	0.23565	0.24063	0.19280	0.12500	0.11540	0.11540	0.07938	5.070	21.137
	Banaripara	8	0.62500	0.44236	0.53638	0.33554	0.25000	0.23315	0.23574	0.19199	4.335	73.450
	Barisal S.	13	0.46154	0.44853	0.45169	0.41808	0.38462	0.32590	0.34488	0.25716	4.559	95.754
	Gaurnadi	10	0.60000	0.56292	0.57670	0.51297	0.40000	0.33531	0.35170	0.26611	4.168	96.780
	Hizla	7	0.14286	0.13569	0.13569	0.10843	0.00000	0.00000	0.00000	0.00000	4.389	6.871
	Mehendiganj	8	0.37500	0.37115	0.37025	0.35951	0.37500	0.35326	0.35952	0.29755	4.653	166.850
	Muladi	8	0.25000	0.24249	0.24392	0.21282	0.12500	0.12364	0.12364	0.11563	4.949	88.575
	Wazirpur	9	0.44444	0.39047	0.41108	0.32195	0.22222	0.16784	0.18694	0.10676	4.485	41.533
Bhola	Bhola S.	10	0.10000	0.09928	0.09900	0.09387	0.10000	0.09593	0.09593	0.06933	5.367	17.410
	Burhanuddin	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.629	0.700
	Charfasson	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.672	4.537
	Daulatkhan	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.717	1.386
	Lalmohan	8	0.12500	0.12426	0.12375	0.11977	0.12500	0.12099	0.12099	0.09885	5.498	31.550
	Tazumuddin	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.714	1.844
Barguna	Amtali	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.717	1.562
	Bamna	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.200	1.783
	Barguna S.	9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.708	1.544
	Betagi	5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.150	1.600
	Patharghata	5	0.20000	0.10479	0.10479	0.01818	0.00000	0.00000	0.00000	0.00000	5.094	2.600
Jhalakati	Jhalakati S.	10	0.30000	0.21749	0.24019	0.14908	0.10000	0.07444	0.07444	0.02722	4.590	11.910
	Kathalia	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.830	1.286
	Nalchity	8	0.37500	0.32424	0.34678	0.25209	0.12500	0.12323	0.12323	0.11364	4.255	75.750
	Rajapur	8	0.25000	0.19607	0.19639	0.11428	0.00000	0.00000	0.00000	0.00000	4.575	5.338

Table 1: Depth Adjusted Thana Level CSI Values by Division-Continued

			$L = 10$				$L = 50$					
District	Thana	n	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$\hat{C}_F^{(a)}$	$\hat{C}_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Barisal Division – Continued												
Patuakhali	Bauphal	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.639	2.263
	Dashina	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.600	1.483
	Galachipa	4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.685	3.325
	Kalapara	8	0.25000	0.12832	0.12850	0.08126	0.00000	0.00000	0.00000	0.00000	5.196	7.575
	Mirzaganj	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	5.742	1.533
	Patuakhali S.	10	0.10000	0.05498	0.05498	0.01525	0.00000	0.00000	0.00000	0.00000	5.140	2.800
Pirojpur	Bhandaria	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.687	3.143
	Kawkhali	6	0.33333	0.18849	0.19581	0.12652	0.00000	0.00000	0.00000	0.00000	3.707	9.000
	Mathbaria	12	0.25000	0.23384	0.23953	0.19729	0.16667	0.13230	0.13987	0.07113	2.786	22.333
	Nazirpur	8	0.62500	0.59602	0.60142	0.55983	0.62500	0.40571	0.43148	0.29916	3.852	90.475
	Nesarabad	9	0.33333	0.20689	0.21076	0.11041	0.00000	0.00000	0.00000	0.00000	4.436	6.233
	Pirojpur S.	10	0.50000	0.38401	0.43419	0.30172	0.20000	0.13186	0.15567	0.08569	3.210	38.470
Chittagong Division												
Chittagong	Anwara	6	0.16667	0.15066	0.15066	0.11765	0.00000	0.00000	0.00000	0.00000	4.301	8.067
	Banshkhali	11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.368	2.627
	Boalkhali	2	0.50000	0.46724	0.46724	0.43750	0.50000	0.30396	0.30396	0.18750	3.418	40.300
	Kotwali	8	0.25000	0.13809	0.13809	0.09326	0.00000	0.00000	0.00000	0.00000	3.712	7.737
	Mirsharai	8	0.75000	0.68949	0.71388	0.61527	0.50000	0.41430	0.42911	0.34009	2.945	113.750
	Patiya	2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	2.983	1.600
	Sitakunda	7	0.57143	0.39764	0.46392	0.33954	0.28571	0.20072	0.21097	0.12869	2.987	38.871
Cox's Bazar	Chakaria	8	0.12500	0.08365	0.08365	0.02810	0.00000	0.00000	0.00000	0.00000	4.397	2.800
	Cox Bazar S	7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.097	1.371
	Maheshkhali	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.581	2.250
	Ramu	8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	4.264	1.762
	Teknaf	6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	3.580	3.183
	Ukhia	8	0.12500	0.12165	0.12165	0.10717	0.12500	0.10026	0.10026	0.03584	3.135	10.688

Table 2: Depth Adjusted District Level CSI Values by Division

			$L = 10$				$L = 50$					
Division	District	n	p_{GL}	$dC_F^{(a)}$	$dC_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$dC_F^{(a)}$	$dC_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Rangpur	Dinajpur	93	0.05376	0.02367	0.02367	0.02846	0.02151	0.00304	0.00303	0.00102	3.221	3.024
	Gaibandha	71	0.32394	0.21647	0.22692	0.16422	0.05634	0.01251	0.01251	0.01691	3.051	11.644
	Kurigram	76	0.38158	0.22945	0.25025	0.21765	0.09211	0.01932	0.01957	0.04447	2.989	21.954
	Lalmonirhat	39	0.02564	0.01571	0.01571	0.00931	0.00000	0.00200	0.00200	0.00000	2.879	1.574
	Nilphamari	55	0.05455	0.02311	0.02317	0.02314	0.00000	0.00200	0.00200	0.00000	3.079	2.300
	Panchagarh	40	0.05000	0.02399	0.02399	0.02307	0.00000	0.00200	0.00200	0.00000	3.022	2.595
	Rangpur	85	0.17647	0.09263	0.09576	0.09389	0.02353	0.00412	0.00412	0.02072	3.100	16.646
	Thakurgaon	45	0.00000	0.01000	0.01000	0.00000	0.00000	0.00200	0.00200	0.00000	3.004	1.107
Rajshahi	Bogra	94	0.23404	0.09230	0.09584	0.15292	0.08511	0.01117	0.01114	0.03624	3.052	17.754
	Jaipurhat	40	0.02500	0.01560	0.01560	0.00516	0.00000	0.00200	0.00200	0.00000	3.183	1.495
	Naogaon	92	0.05435	0.01907	0.01932	0.03166	0.02174	0.00322	0.00322	0.01620	3.492	6.016
	Natore	53	0.03774	0.02177	0.02177	0.01087	0.00000	0.00200	0.00200	0.00000	3.538	1.717
	Nawabganj	45	0.11111	0.04026	0.04086	0.07613	0.04444	0.00534	0.00534	0.00810	3.601	7.411
	Pabna	79	0.26582	0.12518	0.12821	0.20396	0.17722	0.02528	0.02637	0.08363	3.525	34.529
	Rajshahi	76	0.18421	0.09959	0.10197	0.10884	0.06579	0.00867	0.00869	0.01758	3.567	8.062
	Sirajganj	87	0.58621	0.41229	0.43437	0.36423	0.22989	0.02593	0.02492	0.05878	3.117	29.320
Mymensingh	Jamalpur	63	0.31746	0.19529	0.20423	0.15339	0.06349	0.01236	0.01236	0.02929	3.125	14.363
	Kishoreganj	106	0.58491	0.47019	0.50968	0.40697	0.27358	0.14704	0.14969	0.14970	4.072	52.477
	Nasirabad	105	0.25714	0.11307	0.11703	0.18990	0.13333	0.02186	0.02192	0.04803	4.010	16.490
	Netrakona	79	0.55696	0.45073	0.46845	0.40599	0.26582	0.06066	0.06125	0.12482	4.146	39.135
	Sherpur	51	0.45098	0.33363	0.36019	0.27424	0.11765	0.05084	0.05151	0.05078	3.267	22.273
	Tangail	91	0.43956	0.26459	0.28225	0.25894	0.08791	0.01471	0.01482	0.04548	3.547	20.035
Sylhet	Habiganj	58	0.53448	0.32760	0.35663	0.27510	0.10345	0.00768	0.00787	0.04074	3.936	23.114
	Moulvibazar	54	0.37037	0.26957	0.28304	0.22709	0.11111	0.01714	0.01721	0.04580	3.927	20.176
	Sunamganj	71	0.84507	0.69192	0.70731	0.61405	0.39437	0.08281	0.08051	0.11527	4.598	47.963
	Sylhet	77	0.44156	0.25643	0.27092	0.28685	0.18182	0.03366	0.03239	0.05336	3.929	22.692
Khulna	Bagerhat	56	0.82143	0.75876	0.78370	0.67491	0.60714	0.42188	0.44019	0.42968	3.335	159.479
	Chuadanga	34	0.82353	0.74650	0.77525	0.65391	0.41176	0.25422	0.26534	0.20783	3.696	79.418
	Jessore	70	0.70000	0.63010	0.64490	0.56703	0.47143	0.27925	0.28275	0.23656	3.910	68.849
	Jhenaidah	54	0.62963	0.49927	0.54123	0.41600	0.25926	0.17610	0.18424	0.12209	3.869	46.417
	Khulna	74	0.37838	0.31185	0.31527	0.29371	0.21622	0.09556	0.09729	0.10452	4.440	35.201
	Kustia	47	0.40426	0.28587	0.30056	0.32426	0.27660	0.12069	0.13322	0.15381	3.791	104.281
	Magura	33	0.39394	0.32302	0.33355	0.28759	0.21212	0.07777	0.08067	0.08927	4.033	29.206
	Meherpur	15	0.93333	0.84031	0.86993	0.71857	0.60000	0.31528	0.34065	0.30419	3.733	115.827
	Narail	24	0.62500	0.57736	0.59745	0.50944	0.41667	0.36075	0.36105	0.30812	4.015	88.558
	Shatkhira	62	0.80645	0.79466	0.82000	0.69013	0.67742	0.49136	0.51296	0.42535	3.678	132.398

Table 2: Depth Adjusted District Level CSI Values by Division-Continued

			$L = 10$				$L = 50$					
Division	District	n	p_{GL}	$dC_F^{(a)}$	$dC_F^{(d)}$	$\hat{C}_{\min}$	p_{GL}	$dC_F^{(a)}$	$dC_F^{(d)}$	$\hat{C}_{\min}$	ALd	AAs
Dhaka	Dhaka	46	0.41304	0.20574	0.22444	0.32475	0.30435	0.04752	0.04859	0.15023	4.193	40.459
	Faridpur	62	0.75806	0.77805	0.79499	0.66938	0.64516	0.50580	0.52625	0.42321	3.603	140.169
	Gazipur	41	0.02439	0.01662	0.01662	0.02282	0.02439	0.00453	0.00453	0.01652	3.959	4.573
	Gopalganj	44	0.84091	0.81303	0.81934	0.77927	0.79545	0.63618	0.65622	0.56187	3.866	193.645
	Madaripur	37	0.70270	0.69011	0.69642	0.65635	0.70270	0.55326	0.57665	0.47095	3.901	190.173
	Manikganj	47	0.63830	0.43942	0.46226	0.37050	0.14894	0.01420	0.01400	0.04060	3.589	24.134
	Munshiganj	46	0.91304	0.91115	0.92708	0.80316	0.82609	0.62099	0.64166	0.56119	3.914	188.717
	Narayanganj	32	0.28125	0.18641	0.18677	0.24391	0.21875	0.01909	0.01933	0.14185	3.717	45.981
	Narshingdi	54	0.48148	0.43351	0.43990	0.38148	0.25926	0.14745	0.14902	0.11500	3.398	41.230
	Rajbari	33	0.45455	0.35406	0.38089	0.31811	0.21212	0.08589	0.08866	0.13480	3.536	48.448
	Shariatpur	49	0.75510	0.72467	0.73354	0.67524	0.65306	0.50994	0.53547	0.42718	3.702	150.920
Comilla	Brahmanbaria	54	0.50000	0.49887	0.51941	0.43383	0.40741	0.21985	0.23252	0.26531	3.613	101.363
	Chandpur	59	0.91525	0.91076	0.91505	0.88033	0.89831	0.79803	0.80824	0.75196	3.360	365.632
	Comilla	110	0.70909	0.68738	0.70690	0.62814	0.65455	0.40003	0.41913	0.43454	3.482	141.762
	Feni	53	0.52830	0.42637	0.44030	0.39046	0.32075	0.05459	0.05572	0.18150	3.439	53.598
	Lakshmipur	34	0.76471	0.70173	0.72607	0.62655	0.55882	0.44823	0.46952	0.38302	2.990	179.297
	Noakhali	49	0.83673	0.79729	0.82553	0.72855	0.69388	0.53118	0.56111	0.45424	2.862	162.159
Barisal	Barisal	91	0.42857	0.38520	0.39784	0.35685	0.30769	0.20158	0.20913	0.21620	4.466	93.509
	Bhola	48	0.04167	0.02516	0.02513	0.03952	0.04167	0.00919	0.00919	0.03092	5.589	10.277
	Barguna	33	0.03030	0.01443	0.01443	0.00275	0.00000	0.00200	0.00200	0.00000	5.440	1.761
	Jhalakati	33	0.24242	0.13207	0.13958	0.13399	0.06061	0.01690	0.01690	0.03580	4.556	23.539
	Patuakhali	42	0.07143	0.02489	0.02490	0.01911	0.00000	0.00200	0.00200	0.00000	5.449	3.288
	Pirojpur	52	0.34615	0.21007	0.22023	0.22339	0.17308	0.02978	0.03182	0.07892	3.545	29.012
Chittagong	Chittagong	44	0.31818	0.13547	0.14318	0.21877	0.15909	0.01579	0.01612	0.09083	3.655	31.934
	Cox's Bazar	43	0.04651	0.02416	0.02416	0.02517	0.02326	0.00421	0.00421	0.00667	3.861	3.819

Division, along the big valley of Brahmaputra and Jamuna, the same sedimentation may account for the associated CSI values.

(iv) From health hazard point, an Arsenic level greater than $10\mu g/lit$ is the right choice of L and hence, any CSI value greater than 0.25 may be marked as health hazardous. On the same count, for $L = 50$, any CSI value greater than 0.10 should be even more health hazardous. For L=10, CSI thana for the Commilla district values range from a minimum of 0.0875 to a maximum of 0.9782 for all wells, with a combined district level value of 0.7084, indeed a high value. In the whole division of Comilla, the range of district CSI values is 0.4403 to 0.9152, and that for Khulna, Barisal and Dhaka divsion is 0.3054-0.8699, 0.0144-0.3995 and 0.0166-0.9271, respectively.

(v) In the northern region, bounded in the south by Ganga/Padma, the AS level may be less but there are a large number of other mostly bacterial contaminants which needs to be appraised thoroughly; a conclusion shared with the original BGS/DPHE analysis.

(vi) We have also prepared heat-maps depicting the thana level CSI estimates for all of Bangladesh to get a visual picture of AC severity as a function of depth level of wells for the two threshold levels $L = 10$ and $L = 50$. The 'No Data' annotation in the maps signify absence of any observation in the corresponding region. Some thanas had 1 or two observations above the threshold values, while the samples were small. In these cases, the adjusted CSI will be the same as the original unadjusted CSI; there is a need to incorporate larger samples to improve the significance of the findings in such cases. The trajectory of high concentration of thana CSI's in Comilla, Khulna, Barisal and Dhaka Divisions features clearly, that is consistent with the observations in item (iv). Also is clear from the maps that the trajectory of serious arsenic contamination diminishes considering the threshold $L = 50$.

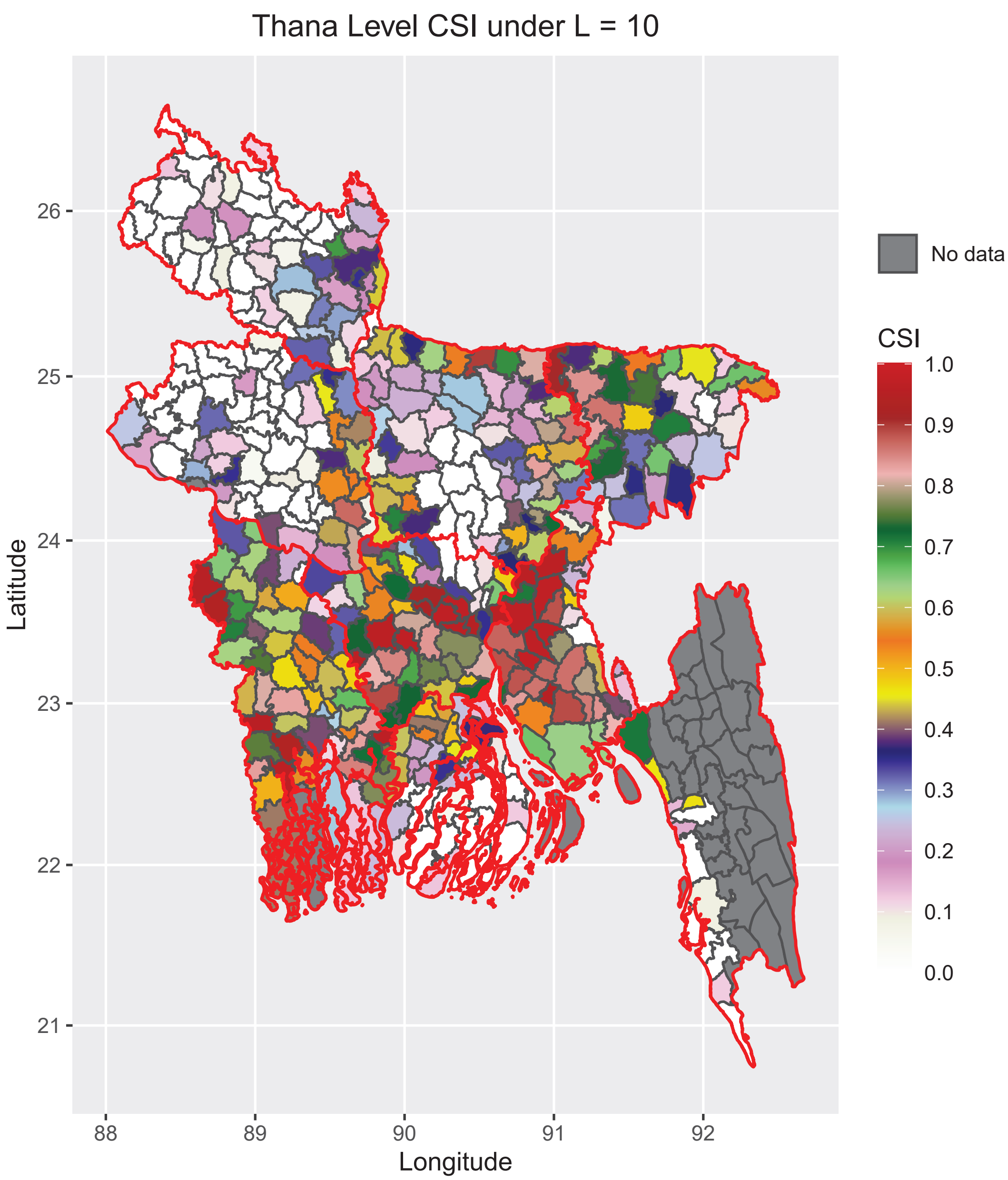


Figure 3: CSI of As in groundwater in All wells from BGS/DPHE survey for $L = 10$

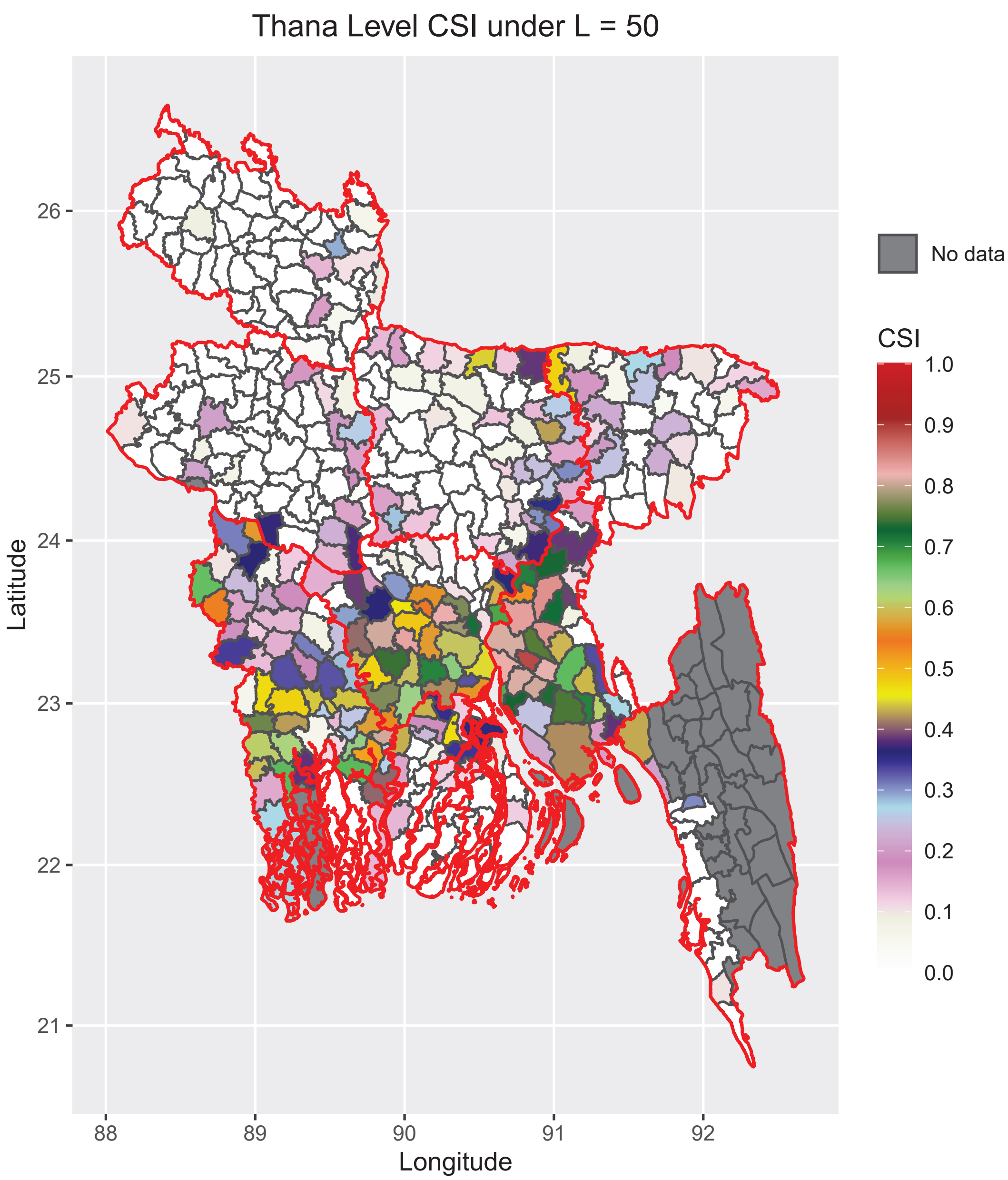
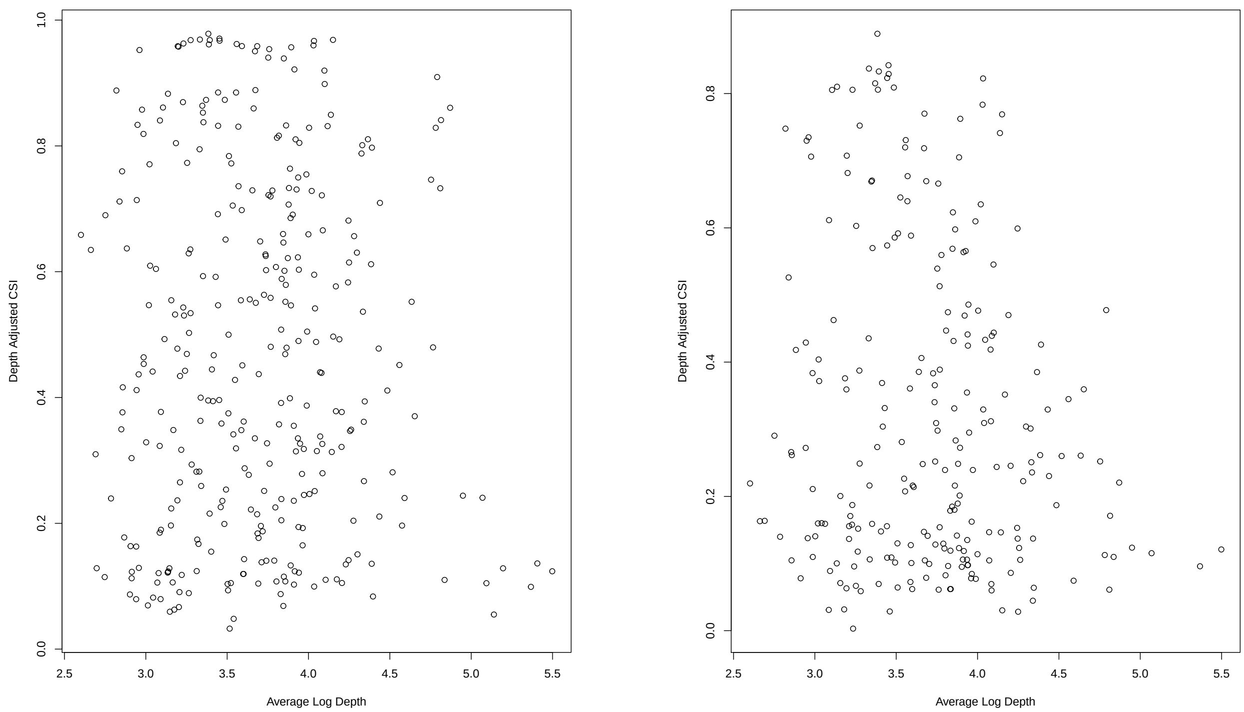


Figure 4: CSI of As in groundwater in All wells from BGS/DPHE survey for $L = 50$

(vii) The heat maps convey the information quite well. The high values of CSI are featured in the region of the delta formed by Ganga-Padma river in the North, Jamuna-Brahmaputra-Meghna and their tributaries to the East and India (West Bengal) border to the West. In this region, the number of deep tubeless are not large. Bangladesh and adjacent West Bengal region to the east of Bhaagirath (Hoogly) river, south of Ganga-Padma , both sides of Jamuna-Meghna rivers, all the way to the Bay of Bengal is the hot bed of arsenic contamination. Deeper analysis of the figures suggests that this contamination is most likely due to the sediments from the rivers over the centuries, while there was very little use of deep tube wells before 50 years. People were more relying on surface water for domestic as well as agricultural use. However, the influx of population and the need for industrial development had led to the reliance on tube wells. More geo-physical studies are needed to provide more satisfactory explanations on the CSI picture by segmenting the deep and shallow wells. In the north-east, the rivers are mostly from the Garo-Jayantia-Khashia Hills in the adjacent Indian State of Meghalaya. There has been some study of arsenic contamination but mostly for surface water.

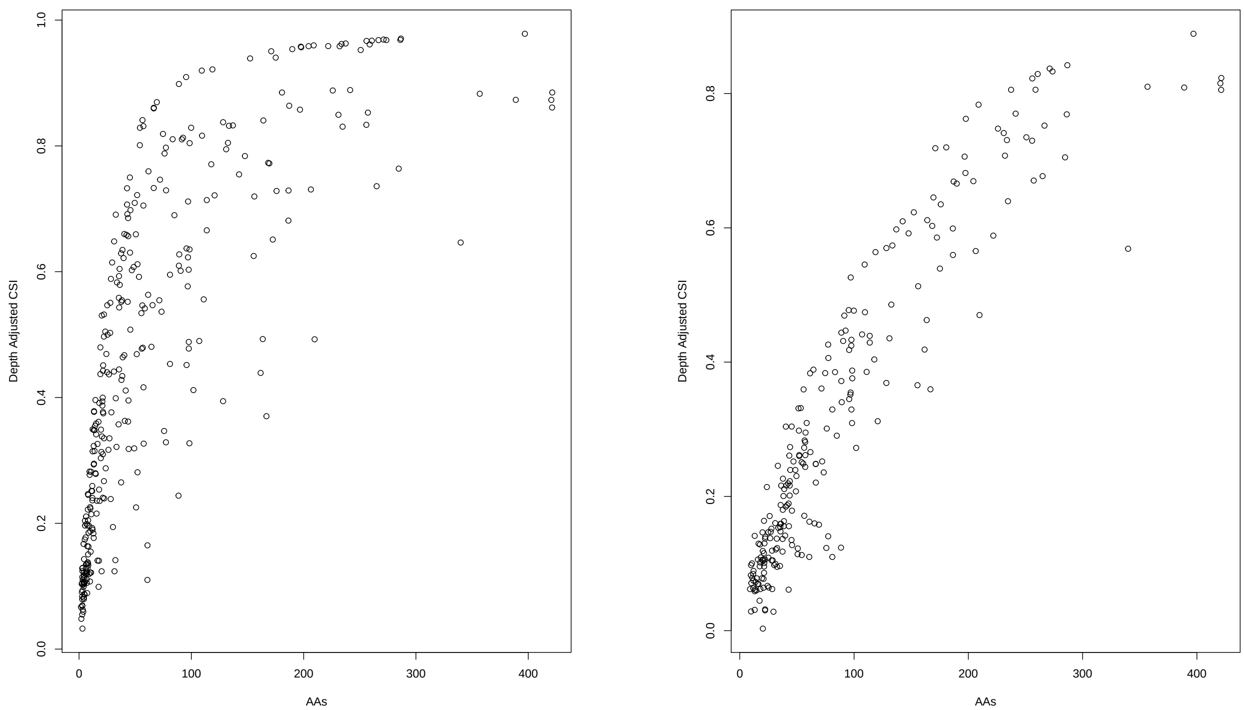
(viii) The scattered picture of CSI in this North-East part of Bangladesh may again be due to the sediments that the rivers carried from Meghalaya over centuries, but excessive rainfall in that area may still provide means of capturing the surface water for domestic as well as agricultural use. More intensive study is needed for the CSI picture in the pockets in this area by segmentation of 'shallow'and 'moderatly deep' tubewells. The BRGS/DPHE study was based on (i) Proportion of wells with As level greater than the threshold L (p_{GL}), and (ii) Average As (AAs) level. In our Tables, we may compare the CSI values $\hat{C}_F^{(a)}$ and $\hat{C}_F^{(d)}$ with the maximum possible value of $\hat{C}_F^{(a)}$ which is p_{GL} and CSI_{min}. We prefer the depth adjusted values $\hat{C}_F^{(d)}$, even though there seems a strong correlation between $\hat{C}_F^{(a)}$, and $\hat{C}_F^{(d)}$, ($R^2 = 99.88\%$) as these values permit us to analyse the severity of As without concern of the depth of wells on which the dependence of arsenic is quite high. This dependence is almost eliminated at thana level using $\hat{C}_F^{(d)}$ as can be seen from the following Figure 5.



(a) L = 10 (b) L=50

Figure 5: Plot of Depth Adjusted CSI $\hat{C}_F^{(d)}$ against Average Log Depth for Thanas

(ix) In Figure 6 we have plotted $\hat{C}_F^{(d)}$, depth adjusted CSI values for Thanas against AAs, that shows that neither there is a precise regression nor the heteroscdasticity of the AAs values can be ruled out. In general, a linear relation can not be prescribed, but possibly a curve with some smoothing will be a better picture. So, when we compare the CSI values with AAs and realize that the csi_{max} depends on the L values (10 or 50), Figures 6 shows the inadequacy of making conclusions based on average As values, more clearly. We have experimented with different regression models for logit(CSI) estimate against AAs level.



(a) L = 10 (b) L=50

Figure 6: Plot of Depth Adjusted CSI $\hat{C}_F^{(d)}$ against Average As for Thanas

(x) We find that the linear regression of $logit(CSI) = \log(CSI/(1-CSI))$ on AAs and $\log(AAs)$ provide comparable linear fits, the latter is some what better (see Figure 7). In order to deal with left truncation, we have considered only thanas with CSI values greater than zero. Further small and large values of CSI are modified as follows for computing the logit values. We find that inverse logistic regression provides prediction of AAs based on CSI provides a meaningful interpretation at the district level. The form of this smoothing is given by

$$\widehat{AAs} = \exp[a + b\text{logit(CSI)}]$$

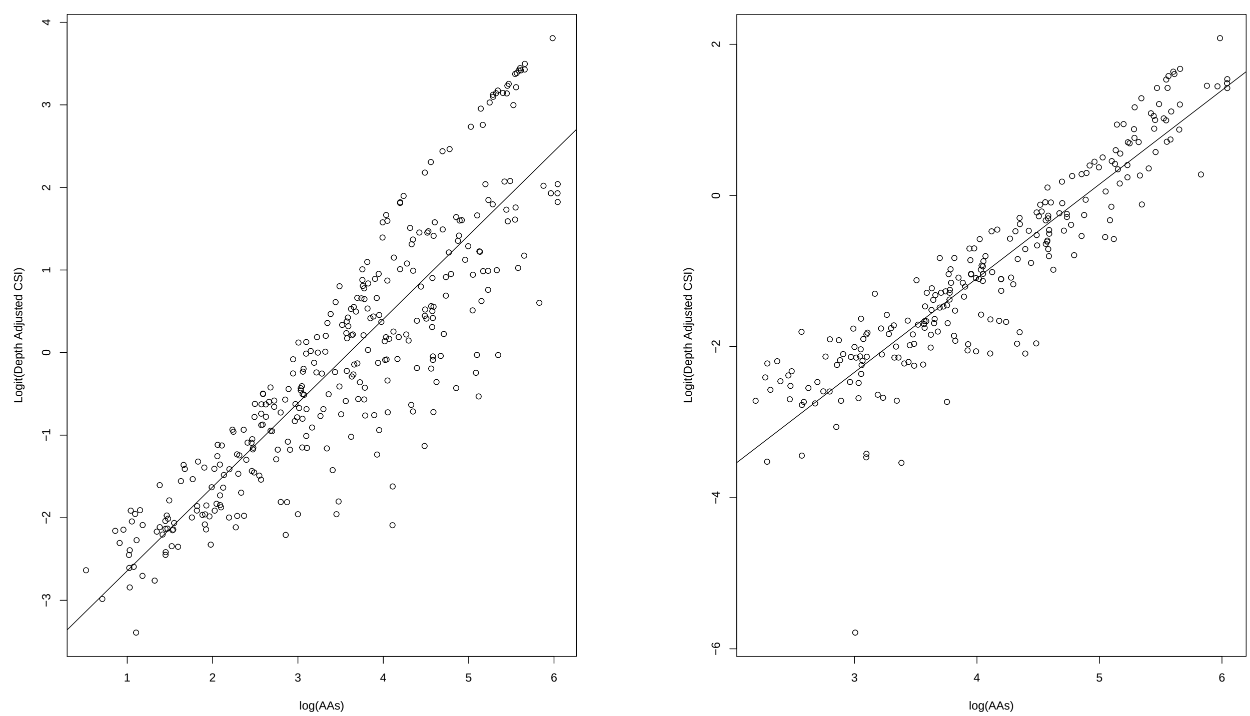
that is summarized below for thana and district level depth adjusted CSI-values.

Smooth Predictor of AAs based on Depth Adjusted CSI at Thana level

$$L = 10 : \widehat{AAs} = \exp[3.6022 + 0.9844 \text{ logit(CSI)}]$$
$$L = 50 : \widehat{AAs} = \exp[4.8812 + 0.8038 \text{ logit(CSI)}]$$

Smooth Predictor of AAs based on Depth Adjusted CSI at District level

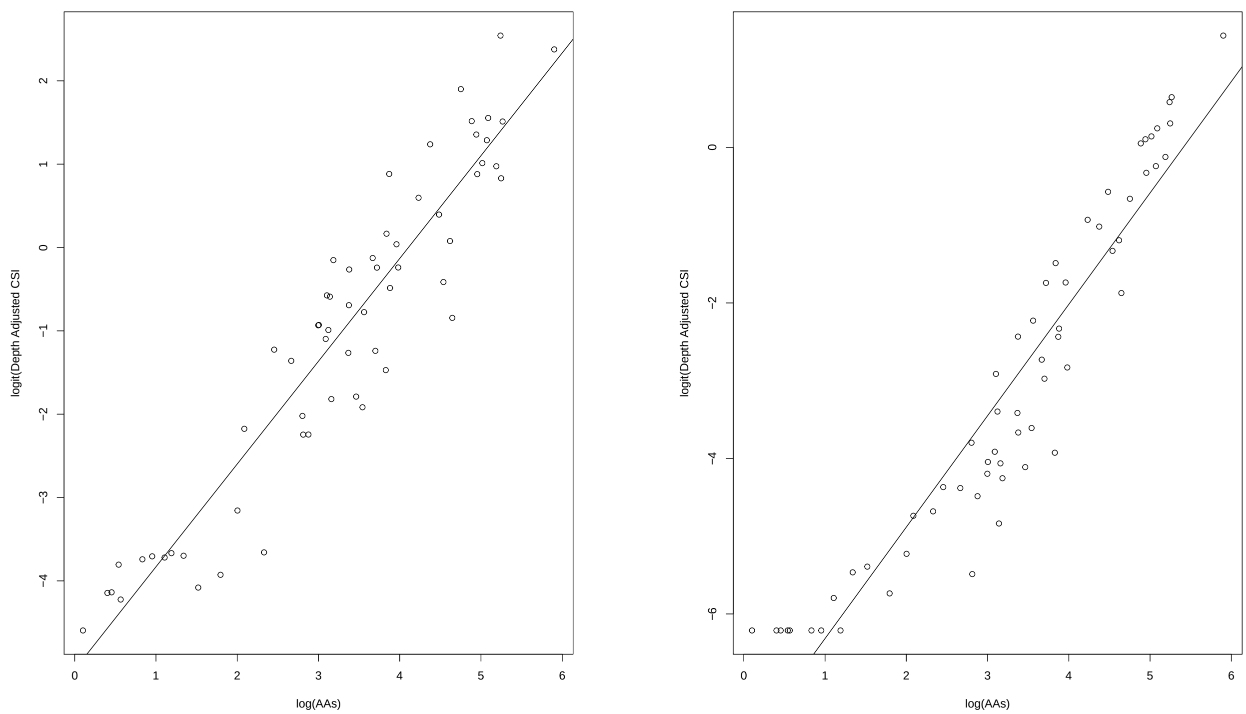
$$L = 10 : \widehat{AAs} = \exp[4.1066 + 0.8109 \text{ logit(CSI)}]$$
$$L = 50 : \widehat{AAs} = \exp[5.4086 + 0.6979 \text{ logit(CSI)}]$$



(a) L = 10 (b) L=50

Figure 7: Plot of logit($\hat{C}_F^{(d)}$) against log(AAs) for Thanas

(xi) It may be noted that at Thana level, in the prediction equation $\widehat{AAs} = \exp[a + b \text{ logit(CSI)}]$, a coefficient is characteristically larger for $L = 50$ than for $L = 10$, *i.e.* a much larger value of AAs will be needed for $L = 50$, in order to get a comparable CSI for $L = 10$. The quality of the prediction may be judged to be adequate (barring a few ouliers) as apparent from Figure 7; the multiple R^2 coefficients for $L = 10$ and $L = 50$ are 77% and 84%, respectively. Such a prediction equation works better for district level adjusted CSI's with R^2 coefficients being 89% for both $L = 10$ and $L = 50$. The ordering of the intercepts is still maintained and the slope is almost the same. This clearly shows that the intercept measure the differences due to the threshold and the slope takes into account the depth characteristic of the wells. The predictive power in this case can be favorably judged through Figure 8, that depicts a clear linear relation between $log(AAs)$ and $logit(d\hat{C}_F^{(d)})$. The above discussion clearly points out that the comparison of AAs does not give the full picture of the contamination, where it may be tuned better taking into smooth prediction equation using CSI values.



(a) L = 10 (b) L=50

Figure 8: Plot of logit($d\hat{C}_F^{(d)}$) against log(AAs) for Districts

(xii) The remarks attributed to Thanas in terms of the depth adjustment for CSI values hold at the district level also. Some general remarks studying the tabulated values and the maps are summarized for each of the nine divisions.

(a) For Rangpur division there are proportionately more shallow and medium depth wells; a few of these show very severe contamination that are well depicted on the map. This shows the importance of the analysis in contrast to the depth of the wells. The proportion of wells with As level greater than the threshold L is a poor measure of contamination can be seen from the Palashbari thana in the Gaibandha district; the average As (AAs) level is 11.767, that is very close to the threshold value $L = 10$; however p_{GL} for $L = 10$ is 0.44444, a high value. On the other hand, the CSI index of 0.25340 gives a better picture of the situation in the thana. Indeed higher concentrations will move the value of CSI up. For example, in the Birganj thana in Dinajpur district, the CSI index (0.18972) is close to p_{GL} value of 0.20.

(b) The situation of Rajshahi division is very similar to that of Rangpur division The thanas of Rajshahi with higher CSI values are on the border of Mymensingh division. The thanas in the central part show lower values of CSI, but as we move to the North-East, high arsenic levels are visualized. As we move to the Mymensingh division, high concentration of AAs is visualized in the East and North. Moving east to thanas in Sylhet divisions, the same pattern continues on the border thanas.

(c) Substantial areas of Khulna, Dhaka and Comilla divisions have serious AC at both the threshold levels. Major part of these divisions are filled with dark colors. Contrasting the maps, we see that certain dark colors are replaced by lighter colors as we move from $L = 10$ to $L = 50$, a phenomenon observed for other divisions earlier. The areas close to the border of these divisions with Barisal and Chittagong also fall in the category of serious AC.

Table 3: Depth Adjusted District Level CSI Values for Worst Affected Districts

	$L = 10$				$L = 50$			
District Name	p_{GL}	$\hat{C}_F^{(a)}$	$d\hat{C}_F^{(a)}$	$d\hat{C}_F^{(d)}$	p_{GL}	$\hat{C}_F^{(a)}$	$d\hat{C}_F^{(a)}$	$d\hat{C}_F^{(d)}$
Chandpur	0.91525	0.89568	0.91076	0.91505	0.89831	0.79831	0.79803	0.80824
Munshiganj	0.91304	0.85857	0.91115	0.92708	0.82609	0.64994	0.62099	0.64166
Gopalganj	0.84091	0.80907	0.81303	0.81934	0.79545	0.64743	0.63618	0.65622
Madaripur	0.70270	0.68204	0.69011	0.69642	0.70270	0.57907	0.55326	0.57665
Noakhali	0.83673	0.78006	0.79729	0.82553	0.69388	0.54549	0.53118	0.56111
Shatkhira	0.80645	0.75150	0.79466	0.82000	0.67742	0.52225	0.49136	0.51296
Comilla	0.70909	0.67172	0.68738	0.70690	0.65454	0.53177	0.40003	0.41913
Faridpur	0.75806	0.71633	0.77805	0.79499	0.64516	0.51320	0.50580	0.52625
Shariatpur	0.75510	0.71945	0.72467	0.73354	0.65306	0.52148	0.50994	0.53547
Meherpur	0.93333	0.81048	0.84031	0.86993	0.60000	0.38960	0.31528	0.34065
Bagerhat	0.82143	0.75089	0.75876	0.78370	0.60714	0.50953	0.42188	0.44019
Lakshmipur	0.76471	0.69713	0.70173	0.72607	0.55882	0.46739	0.44823	0.46952

(d) BGS/DPHE (2001a) reported the worst affected districts as Chandpur, Munshiganj, Gopalganj, Madaripur, Noakhali, Shatkhira, Comilla, Faridpur, Shariatpur, Meherpur, Bagerhat and Lakshmipur at $L = 50$. The CSI indices compare closely to the values of p_{GL}. These are summarized in Table 3, both for $L = 10$ and $L = 50$.

Table 4: Depth Adjusted District Level CSI Values for Least Affected Districts

	$L = 10$				$L = 50$			
District Name	p_{GL}	$\hat{C}_F^{(a)}$	$d\hat{C}_F^{(a)}$	$d\hat{C}_F^{(d)}$	p_{GL}	$\hat{C}_F^{(a)}$	$d\hat{C}_F^{(a)}$	$d\hat{C}_F^{(d)}$
Thakurgaon	0.00000	0.00000	0.01000	0.01000	0.00000	0.00000	0.00200	0.00200
Barguna	0.03030	0.01743	0.01443	0.01443	0.00000	0.00000	0.00200	0.00200
Jaipurhat	0.02500	0.01887	0.01560	0.01560	0.00000	0.00000	0.00200	0.00200
Lalmonirhat	0.02564	0.02201	0.01571	0.01571	0.00000	0.00000	0.00200	0.00200
Natore	0.03774	0.02965	0.02177	0.02177	0.00000	0.00000	0.00200	0.00200
Nilphamari	0.05455	0.04650	0.02311	0.02317	0.00000	0.00000	0.00200	0.00200
Panchagarh	0.05000	0.04207	0.02399	0.02399	0.00000	0.00000	0.00200	0.00200
Patuakhali	0.07143	0.04600	0.02489	0.02490	0.00000	0.00000	0.00200	0.00200
Rangpur	0.17647	0.14552	0.09263	0.09576	0.02353	0.02340	0.00412	0.00412
Dinajpur	0.05376	0.04610	0.02367	0.02367	0.02151	0.01635	0.00304	0.00303
Naogaon	0.05435	0.04921	0.01907	0.01932	0.02174	0.02151	0.00322	0.00322
Gazipur	0.02439	0.02433	0.01662	0.01662	0.02439	0.02407	0.00453	0.00453
Cox's Bazar	0.04651	0.03908	0.02416	0.02416	0.02326	0.02102	0.00421	0.00421
Bhola	0.04167	0.04154	0.02516	0.02513	0.04167	0.04095	0.00919	0.00919
Nawabganj	0.11111	0.09932	0.04026	0.04086	0.04444	0.03338	0.00534	0.00534
Jhalakati	0.24242	0.19942	0.13207	0.13958	0.06061	0.05502	0.02544	0.02544
Rajshahi	0.18421	0.16205	0.09959	0.10197	0.06579	0.05397	0.00867	0.00868
Gaibandha	0.32394	0.23663	0.21647	0.22692	0.05634	0.04185	0.01251	0.01251
Kurigram	0.38158	0.29650	0.22945	0.25025	0.09210	0.07584	0.01932	0.01957
Tangail	0.43956	0.34388	0.26459	0.28225	0.08791	0.07439	0.01471	0.01482

(e) The least affected districts were summarized as Thakurgaon, Barguna, Jaipurhat, Lalmonirhat, Natore, Nilphamari, Panchagarh, Patuakhali all with 0% p_{GL} and others with p_{GL} between 2% to 9%, based on threshold of $L = 50$; these are summarized in Table 4 for comparison purpose.It may be noted that the depth adjusted values CSI for p_{GL} values of 0% are scaled upward to 2% (due to logit modification), however, higher values may be scaled downwards. Also, looking at the depth adjusted CSI values, we see that these may be considerably higher for $L = 10$ than those for $L = 50$; for example, for the district of Tangail, the depth adjusted CSI is 1%, for $L = 50$, however, it is 28% for $L = 10$.

The analysis in this paper demonstrates that CSI is more robust in bringing out the contamination feature with respect to the threshold level as well as the combination of some high and some low contamination levels, while incorporating the depth of wells in the contamination index.

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