Decision Support Tool for Sanitation Interventions

Suitability Analysis for FSM Services with Zonification for Sewer and Non-Sewer Area

Khulna, Bangladesh

FINAL REPORT

December, 2019

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Chapter 1: Introduction

KHULNA CITY PROFILE

46km^2 Administrative area of Khulna City Corporation

657,798 Population *(Census 2011)*

14,413 Density *(BBS 2011)*

Climate

1,900mm Rainfall

tropical Climate

26.1^{0}C Average Annual Temperature

73%- **87**% Humidity
Mar — Jul- Sept

Slums

74 Number of Slums

8889 No: of households in the slums

Urban Poor

35% of the population is Urban Poor

84% toilets without soakpit or drainage pit *(SNV 2017)*

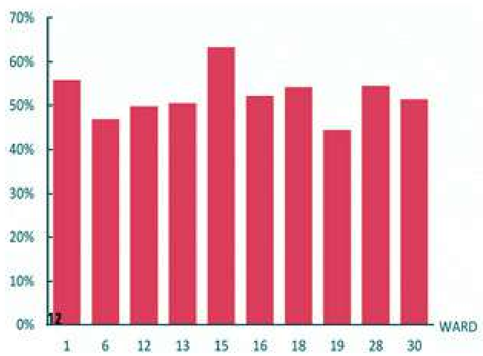


Fig: Top 10 wards in terms of % area that are poor settlements

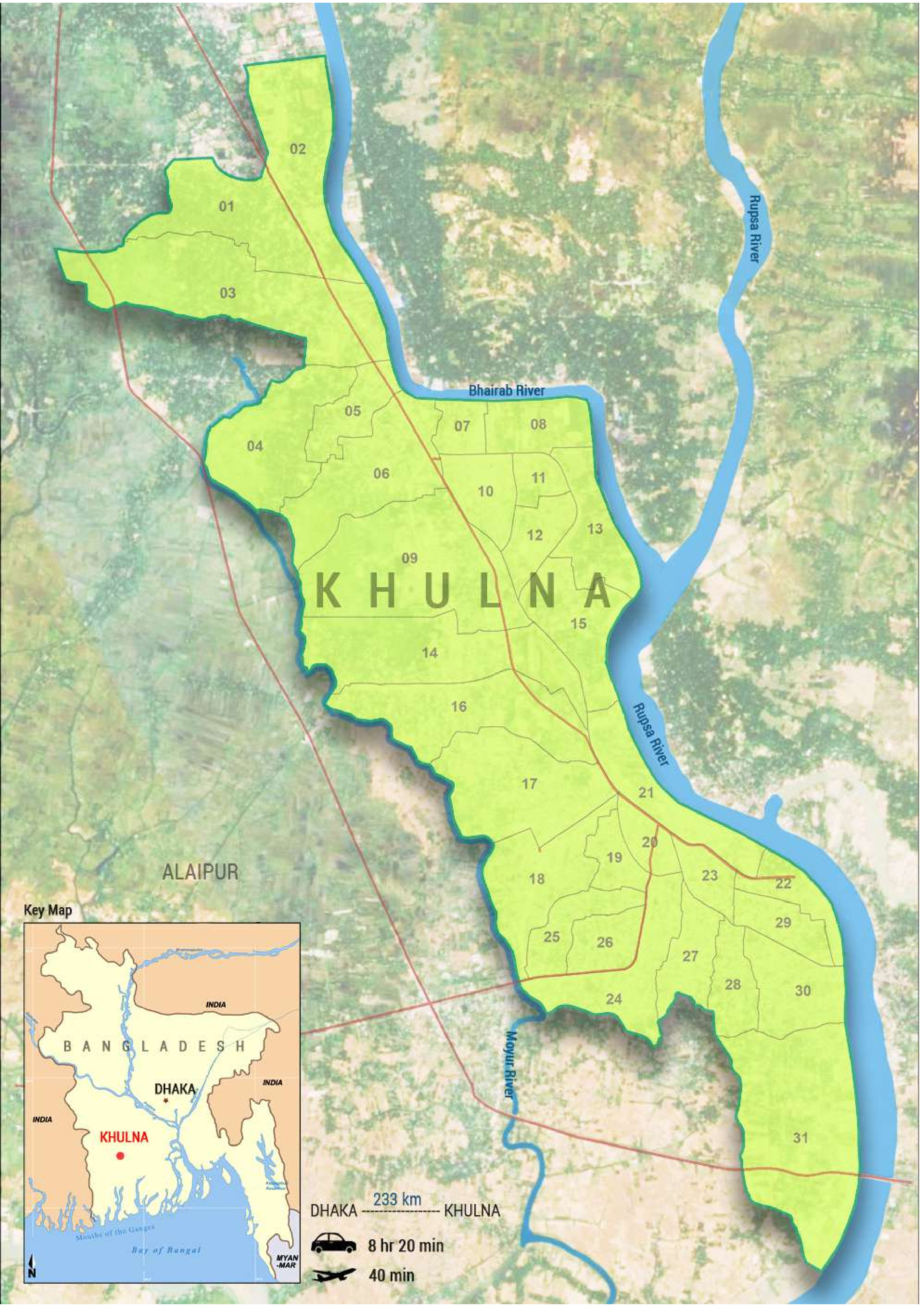
82% of poor settlements do not have drainage systems.

20km arterial road length

61% of households with septic tanks *(SNV 2017)*

2-15 m road width

The source for the above data is from; URBAN PROFILEURBAN POVERTY, Khulna City Corporation September 2018


Rupsa River
Bhairab River
KHULNA
02
01
03
05
04
07
08
06
11
10
12
13
09
15
14
16
Rupsa River
17
21
20
19
ALAIPUR
18
23
22
29
25
26
27
28
30
24
Moyur River
31
Key Map
INDIA
BANGLADESH
DHAKA
INDIA
INDIA
KHULNA
Mouths of the Ganges
Bay of Bengal
MYAN-MAR
N
233 km
DHAKA ----------------- KHULNA
8 hr 20 min
40 min

Chapter 2: Project Scope, Approach and Methodology

2.1 Project Scope

KWASA is planning to lay down sewerage network in some parts of the Khulna city and scope of the current study is to facilitate this decision making of authority by spatially delineating pockets which are suitable for relevant sanitation interventions. These identified pockets would be filtered through technical and socio-economic assessments and final decision will also aim to have consensus from the relevant stakeholders. Final output will also be spatially represented for clarity in identification of areas for recommended sewerage , FSM and DEWATS interventions. The project outcome can be also referred by KCC to understand the intensity of sanitation situation across the Khulna city and may have key inputs in decision makings of relevant infrastructure augmentation plan.

2.2 Approach

This process is overall divided into two sections; technical assessment of the settlements to understand its degree of technical conformity for sewerage , FSM and DEWATS intervention. These results would be spatially presented in form of overlays of the outputs of individual parameters and thereafter socio-costs benefit analysis (SCBA) will be undertaken for pockets showcasing conflicts. The SCBA will enable quantification of social benefits and hence will lead to a more acceptable and healthy decision making. These findings will also need to be discussed with relevant stakeholder groups (specially with the officials of relevant authority) to get their opinion and consent/feedback on the final identified pockets.

2.3 Methodology - Technical Feasibility and Spatial Representations

Grid based output analysis will be the basis of spatial representation for mapping performances of each parameters. The entire project area has been divided into 25m * 25m square grids and over laid on top of the GIS layers (each parameter has been mapped as a different layer). This grid-based tool is generally referred as fishnet grid framework. A common issue with such mapping is the potential discrepancy between the cell boundaries and the boundaries of the mapped parameter. To produce realistic boundaries the smallest possible cell size is needed – crucially the cell size must correspond with the spatial variability of the mapped parameters. That is why an optimum size, which can include required details of 25m x 25m grid has been used.

Based on data availability from different reliable sources and relevance of parameters towards sewerage and non-sewerage interventions, a detail decision making matrix for identifying areas suitable for sewerage and non-sewerage intervention would be developed. Following are the nine parameters based on which the decision making matrix needs to be built upon: -

Table 2.1 Parameters of suitability matrix and source of information

Sl. No.	Parameters	Rational	Data Sources
I.	Settlement Typology	Population and built up density, planned, unplanned, informal settlements etc. have key role in deciding the sanitation interventions.	GIS database SNV-2011
II.	Economic Vulnerability	Insecure land tenure, poor housing conditions, low income informal jobs, social issues are some of the important considerations while planning for sanitation improvement in the settlements	NURP, UNDP Report -2018
III.	Containment Coverage	Toilet availability (yes/no) of pit latrine, septic tank showcases the willingness to pay and paying capacity of user for new services.	GIS database SNV, 2011
IV.	Drainage Coverage and Types	Drainage is essential for safe transportation of grey water discharge and based on the types and availability, decision on suitable sanitation interventions can be taken.	GIS database SNV-2011
V.	Ground Water Vulnerability	Minimizing the ground water contamination should be a top priority while making decisions on selection of sanitation interventions	KWASA
VI.	Accessibility Level	Road access has a critical role in laying down the sewerage network and width of the carriage way is an important deciding parameter for selection of sanitation interventions.	GIS database SNV- 2011, Google images-2015
VII.	Water Sensitive Area	Khulna has many scattered water ponds which need to be protected from the inflowing waste water from surrounding/nearby settlements.	GIS database SNV- 2011, Google images-2015
VIII.	Topography	Topography has a key role in identifying depreciation and other water ponding areas which would need considerable improvement in terms of waste water management.	GIS database SNV-2011.
IX.	Water Supply Coverage	Adequate water supply is a pre-requisite for laying down and connecting the houses with sewerage network	KWASA

Parameter description, their sub-head are explained in detail in the next chapter.

The spatial analysis at this stage shall be based on secondary and tertiary data only and the findings will be further validated during field visits in the forthcoming deliverables.

These interventions are classified into three broad heads of sewerage, FSM and DEWATS. Individual parameters of suitability matrix are assessed in terms of all the three heads and are contributing in the spatial output map of final sanitation interventions. The entire suitability classification are broadly divided into two heads: -

Long term sanitation solutions

Areas identified that are suitable for either of Sewerage, FSM and DEWATS are predominantly the long-term intervention for the given pockets and should be feasible solutions for next 15-20 years.

Alternative sanitation solution

Areas identified under alternative sanitation solutions will have pair of sanitation intervention options (i.e. sewerage/FSM, FSM/DEWATS, sewerage/DEWATS) and based on availability of funds, resources, stakeholder consensus, relevant solutions can be finalized by KWASA.

Table 2.2 Broad understanding of sanitation intervention

Interventions	Suitable interventions	Remarks
Long Term Sanitation Solutions	Sewerage	Priority pockets to lay down the sewerage network of city
	FSM	Suitable pockets for desludging of existing tanks and continue with FSM operations in the long run
	DEWATS	Priority pockets for setting of DEWATS for identified houses. These pockets are not preferable for either of sewerage or FSM and DEWATS would help to address the handling of safe wastewater discharge as well.
Alternative Sanitation Solutions	Sewerage/ FSM	Both sewerage and FSM are suitable for these pockets and based on available funds, resources and stakeholder needs, authority may take final call on this.
	FSM/DEWATS	Both FSM and DEWATS are suitable for these pockets and based on intensity of on-site issue, available funds, resources and stakeholder needs, authority may take final call on this.
	DEWATS/Sewerage	Both FSM and DEWATS are suitable for these pockets and based on availability of nearby network coverage, funds availability and stakeholder needs, authority may take final call on this.

2.4 Socio-Economic Analysis for Selection of Sanitation Solutions

The aim of this section is to provide an approach to estimate the economic and social costs and benefits of a sewerage intervention (sewerage or non-sewerage) for an area, thus enabling selection of an apt sanitation solution offering maximum health and well-being to its local residents.

2.4.1 The concept

The concept behind this approach is to simply put together all the costs associated with sanitation solution (development – operation – maintenance) and also quantify the expected benefits from the proposed interventions to its local community/ users (direct economic – indirect economic and other social benefits) and the difference between the two will give its cost benefit analysis. Solutions wherein the benefits outweigh the costs, are deemed most suitable for an area.

2.4.2 Approach

In this approach the most crucial factor is accurate identification of the parameters of "costs" and "benefits" and also to quantify it with factual information. This section discusses these two aspects in more detail to enable mapping of these parameters at a later stage.

The costs of any interventions should always attempt to include the full investment and annual running costs. The benefits of the interventions can include time savings associated with better access to water and sanitation facilities, gain in productive time due to less time spent ill, health sector and patients costs saved due to less treatment of diarrhoeal diseases, and the value of prevented deaths.

2.4.3 Effects on health

The routes of pathogens to affect health via the medium of water are many and diverse. Five different routes of infection for water-related diseases are distinguished: water-borne diseases (e.g. cholera, typhoid), water-washed diseases (e.g. trachoma), water-based diseases (e.g. schistosomiasis), water-related vector-borne diseases (e.g. malaria, filariasis and dengue), and water-dispersed infections (e.g. legionellosis). While a full analysis of improved water and sanitation services would consider pathogens passed via all these routes, the present study focuses on water-borne and water-washed diseases. This is partly because, at the household level, it is the transmission of these diseases that is most closely associated with poor sanitation and poor hygiene. Moreover, water-borne and water-washed diseases are responsible for the greatest proportion of the direct-effect water and sanitation-related disease burden.

In terms of burden of disease, water-borne and water-washed diseases consist mainly of infectious diarrhoea. Infectious diarrhoea includes cholera, salmonellosis, shigellosis, amoebiasis, and other protozoal and viral intestinal infections. These are transmitted by water, person-to-person contact, animal-to-human contact, and food borne, droplet and aerosol routes. As infectious diarrhoea causes the main burden resulting from poor access to water and sanitation, and as there are data for all regions on its incidence rates and deaths, in this analysis the impact of interventions can exclusively be measured by indicators such as Reduction in incidence rates (number of cases reduced per year). Reduction in mortality rates (number of deaths avoided per year).

2.4.4 Non-health benefits

There are many and diverse potential benefits associated with improved water and sanitation, ranging from the easily identifiable and quantifiable to the intangible and more difficult to measure ones. Benefits can include both (a) reductions in costs and (b) additional benefits resulting from the interventions, over and above those that occur under current conditions . All these benefits, on the other hand, can be used in calculating the cost-benefit ratio (CBR), which is a broader measure of economic efficiency of a proposed sanitation solution. Limited by measurement problems, the aim of this analysis will be to include all the benefits, but to capture the most tangible and measurable ones, and identify who the beneficiaries are. This approach has been adopted not only because of the difficulties of measuring some types of economic benefit due to environmental changes, but also because the selected benefits are most applicable in regional context of Khulna.

For ease of comprehension and interpretation of findings, benefits of the proposed sanitation improvements not captured in the DALY estimates can be broadly classified into three main types;

1. Direct economic benefits of avoiding diarrhoeal disease;
2. Indirect economic benefits related to health improvements; and
3. Non-health benefits related to water and sanitation improvements.

The details on each of the above parameters and associated criteria (with quantitative assumptions and survey results) will be dealt with in the forthcoming deliverable.

2.4.5 Scope and use of the study

Waste Water Master Plan 2016 for Khulna City have already identified zones suitable for sewerage network installations. Since the current study takes into consideration several other relevant parameters there are often areas of conflicts being observed where the current recommendations suggest non sewer solutions in contradiction to earlier suggested traditional solutions. For such areas of conflict, where two different approaches render parallel results suggesting different alternatives (like FSM/ DEWATS or Sewerage network solutions being found suitable for the same location) the decision-making tool of socio economic assessments can come into play. These identified pockets "of conflict" would be filtered through socio-economic assessments and final decision will also aim to have consensus from all the relevant stakeholders. Final output will also be spatially represented for clarity in identification of areas for recommended sewerage and non-sewerage interventions. Although this assessment currently would be undertaken only for some identified sample conflict areas, with time and resources in hand this method can be replicated and the model can be re-applied in all areas for suitable decision making in case of existing conflict/contradictions in finalizing the most apt sanitation solution which can maximize heath and economic benefits to its user communities.

2.4.6 Expected outputs

It should be reinstated here, that this approach does not aim at ground level accurate projections in terms of actual incidences of social health/diseases, nor does it quantify the exact monetary benefits achieved through proposed solution; but a comprehensive assessment once conducted will surely enable identification of the most prudent and accurate zones for providing relevant and beneficial sanitation solutions for the community (in identified grids/ zones) and will have an overarching positive impact for its end users.

2.5 Conclusion

The parameters of the discussed approach for technical assessments have been detailed in the next chapter. The detailed methodology for socio-economic segment will be devised, documented and used in the forthcoming reports as it needs more expert consultations and ground validations.

Together the technical and socio-economic assessments described in the current chapter are expected to pave way to a very comprehensive model for decision making on spatial delineation of sewer or non-sewer solutions.

Chapter 3: Decision Support Matrix for Selection of Sanitation Interventions

3.1 Introduction

Generally, 80% water volume of different households uses are the main source of city waste water and this further categories in terms of black and grey water in line with varying sources of uses such as toilet, wash, bath, kitchen etc. City sanitation infrastructure has a vital role in managing these huge volumes of waste water produced daily, through on-site containment, transportation from abutting network (drainage or sewerage) and also by treatment in STPs and/or FSTPs.

In various urban jurisdictions, often there are diverse situations in term of existing built forms/settlements typology, socio-economic fabric and physiography. The City sanitation planning should consider these existing situations while planning to ensure safe and affordable sanitation solutions to all its end users.

Decisions on the choice of network (sanitation interventions) is usually subject to certain predefined considerations. The questions, a decision making authority should ponder on at this stage includes;

- Do we have adequate road width in all parts of the city to lay down the sewerage network?
- What timeline do we have for implementation of sewerage system and how are we going to factor/manage the inconvenience caused to existing establishment during the construction phase?
- What is the difference in costs in terms of operation and maintenance for the city authority – Sewerage network or FSM?
- Which has a higher service fee for end users (including HH, other establishments) - Sewerage or FSM?
- In case of undulating terrains, cost of (operation & maintenance) pumping station would be higher and will this model have enough user cost recoveries to cover the O&M cost?
- What percentage of houses are connected to drain networks and areas without drainage are in immediate need of managing waste water. Are these areas (on priority) suitable for laying down the sewerage network?
- In above case, most of the slums and urban poor settlements would be in more needs of sewerage facility whereas the cost recovery of O&M and other perquisite like accessibility, legal land tenure etc. would be very difficult in such areas. What should drive to the

decision making in such cases?

- What is the more suitable intervention for management of waste water considering the existing situation of ground water table and soil permeability?
- Which city areas have high concentration of water ponds/other surface water bodies and would need improved waste water management measures to avoid intermixing of pollutant?
- Water supply coverage is the pre-requisite for laying down the sewerage facility. Which areas have piped water coverage as well as adequate supply?
- The capital cost of laying sewerage networks is extremely high as compared to FSM. Thus is it okay to suggest sewerage facility in densely populated areas for minimising the per user cost of estimated capital investment? If yes than why not slums as they also have high population density?
- Management of waste water is directly linked to storm water in areas which are flood prone and vulnerable to water ponding. What sanitation solution should be given in such conditions?

The above thought provoking questions are not the deciding factors alone (they are mainly different scenarios) instead a set of additional parameters (with individually assigned weightages to each) decide the final selection of sanitation solution in a region.

The current chapter is expected to set a base for understanding and applicability of all relevant parameters for laying down the network based solution or opting for FSM or DEWATS in some suitable pockets within Khulna city. Further to this, parameter wise spatial scenarios in form of suitable areas in towns for undertaking sanitation interventions has also been delineated as first key output for performing the final city wide overlay analysis.

3.2 Parameters and implication for decision making on sanitation intervention

Relevant database in context of this assignment have been collected from different sources. A combined list of sources for individual parameters is mentioned in annexure . However, data validation from satellite images and cross verification from two difference sources was also undertaken to minimize the chances of errors in the processed data.

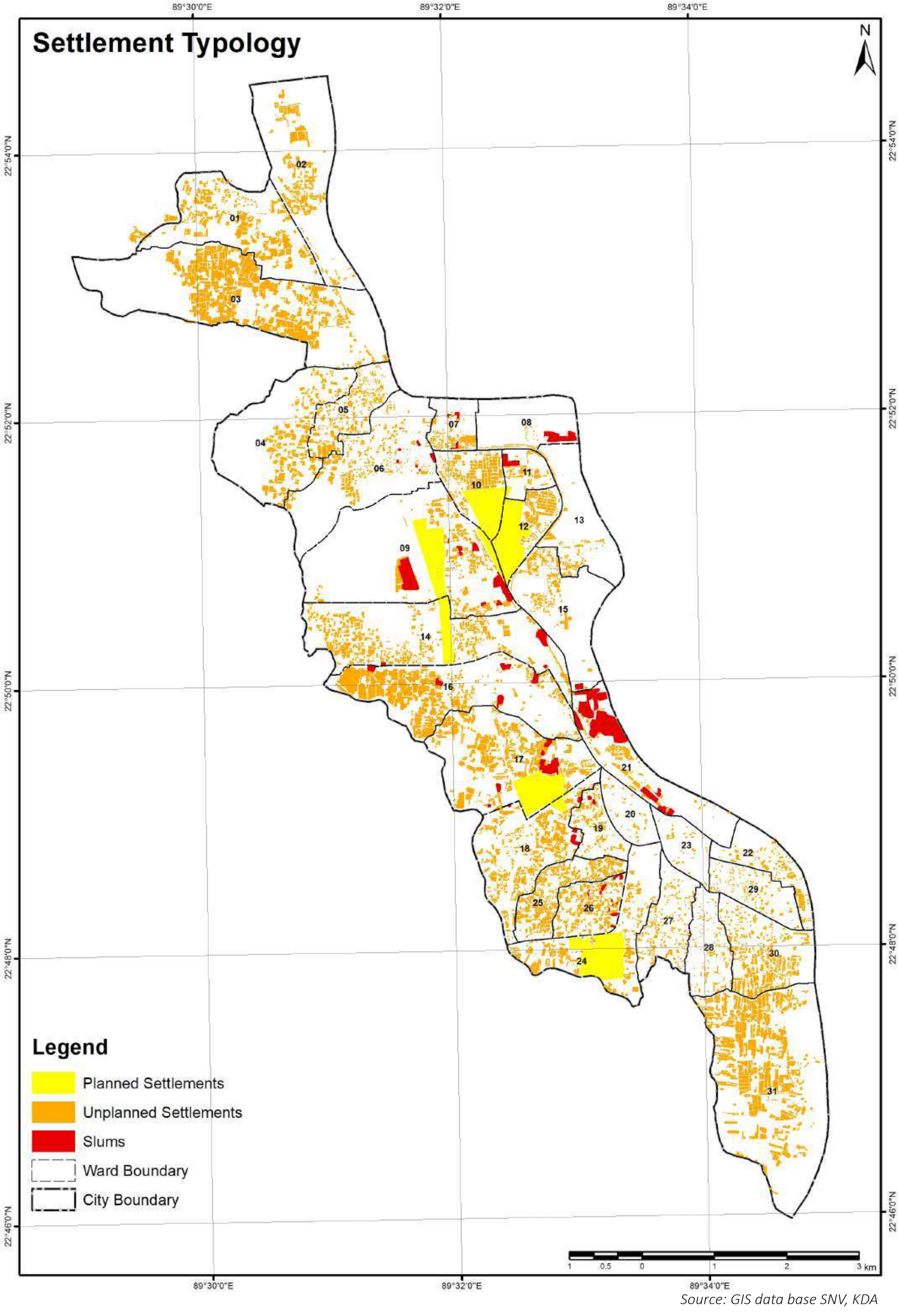
Nine different parameters have been used to develop suitability matrix for zone wise sanitation interventions through overlaying of spatial representation of each parameters as to form the decision making in terms of sewerage, FSM and DEWATS. Individual parameters, their sub-head, suitability scoring and detailed interpretation is explained in the following sections.

3.2.1 Settlement Typology

Khulna city consists of a mix of settlement typologies from high rise building scattered mostly in southern part, pockets of slums of varying size mostly in eastern and central part of the city , varying population and built-up residential density, clusters of commercial, institutional and other land uses including some of HH based polluting industries. Also there are few planned settlements (in form of residential colonies in city with mostly grid iron pattern road network) with a population size of 500 HHs to 4000 HHs. Settlement typology has a significant role in deciding the type of sanitation interventions. Decisions on sewerage network are mostly cost driven and one of the key factors as part of decision making is to explore the possibility to cover the maximum eligible users with services as to reduce the per capita capital cost on authority. However, this is not the case always and there are often instances where built density also plays a significant role in decision making. Mostly in urban poor settlements (including old city area), there are areas having congested population density within small built up space. Considering the inorganic/haphazard and congested settlement pattern, laying down sewerage is anyways not an appropriate solution. However, in case of high population density and high built up density (in multi-story buildings or expanded built up space to accommodate the populations) laying down sewerage is more advisable. In case if these high rise buildings are in isolation or not in close proximity of available/proposed sewerage network, DEWATS can be another suitable alternative options. This will help to cater a larger number of users with improved services and also system will have assured paying capacity of users on proposed O&M. Situation like low population density and high built up density are good with in-house plot areas and kept open for applicability of both the FSM and DEWATS interventions. Other than residential use buildings, premises such as commercial centre/market, education centre, offices and other institutional area are suitable for having improved waste water management option in terms of either sewerage or DEWATS option. Sewerage are viable in case of network based coverage of nearby settlements and thus same can be extended in others locality of close proximity as well.

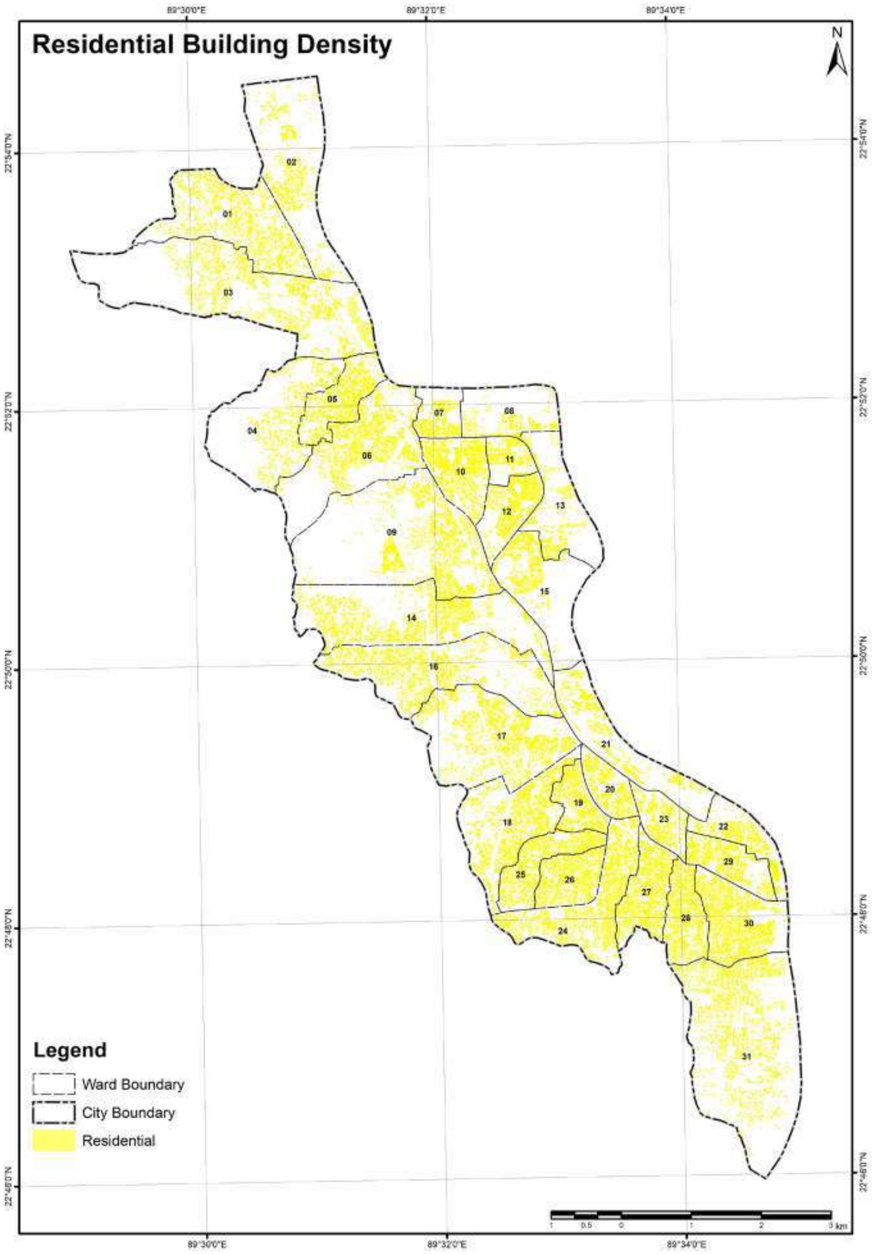
Sub-parameters, suitability score and rational are presented in table 3.1.

Figure 3.1 Settlement Typology Map



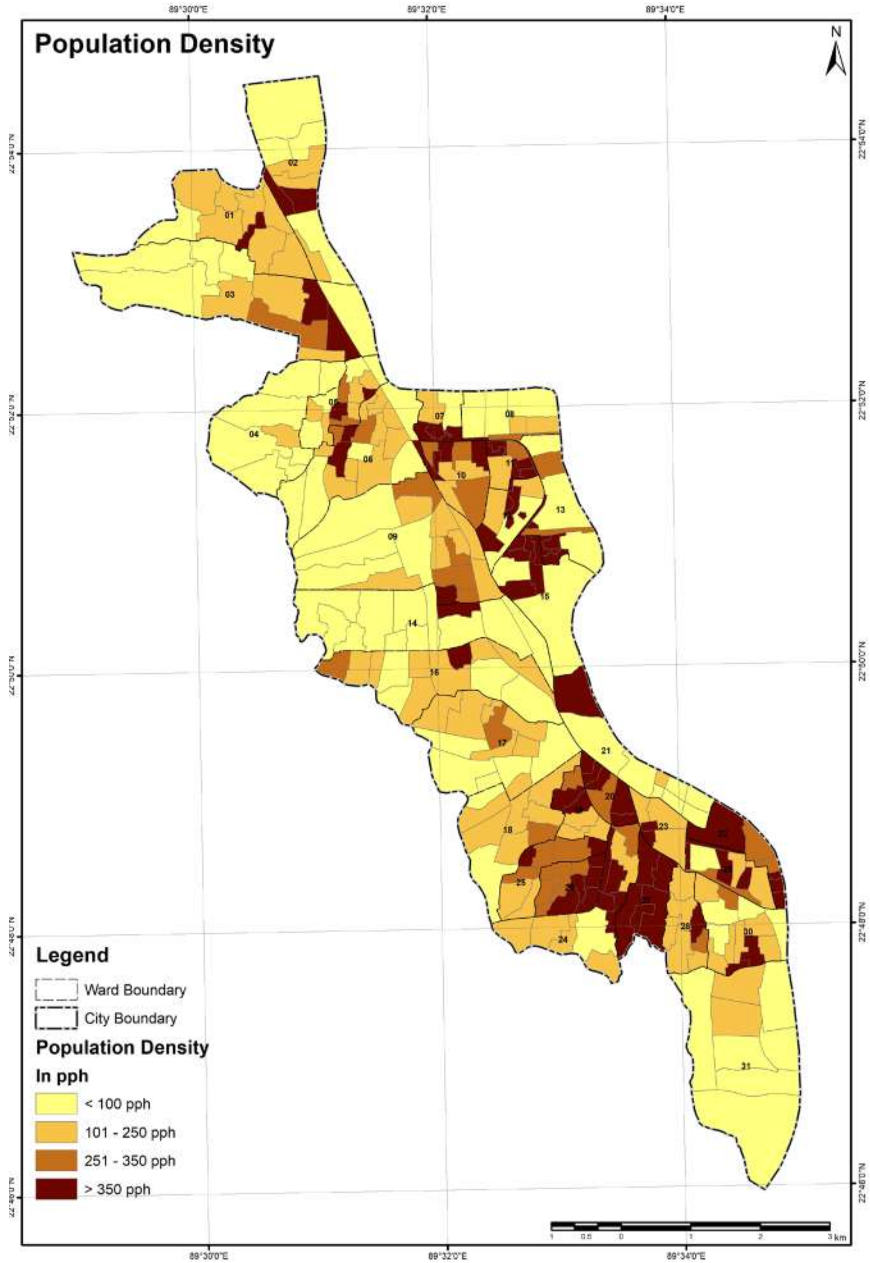
Source: GIS data base SNV, KDA

Figure 3.2 Residential Building Density Map



Source: GIS data base SNV, KDA

Figure 3.3 Ward wise Population Density (2011)



Source: Census 2011

Table 3.1 Decision making matrix for Settlement Typology

<table>
<tr><th colspan="3">Sub - Parameters and Components</th><th>Suitability</th><th>Rational</th></tr>
<tr><td rowspan="8">Residential</td><td colspan="2">Planned *</td><td>Sewerage /DEWATS</td><td>Grid pattern roads with ease of laying down the networks.</td></tr>
<tr><td rowspan="4">Unplanned</td><td>High Pop density and Low built up residential density</td><td>FSM</td><td>Highly congested urban settlements which mainly includes urban poor pockets (other than slums), old city area and other congested areas with haphazard road network.</td></tr>
<tr><td>Low Pop density and High built up residential density</td><td>FSM/ DEWATS</td><td>Mainly pockets of mostly multi story buildings, bigger plot areas with limited residing households. They are moderately suitable for both FSM and Sewerage intervention and situation of other prevailing parameters would be the deciding factor in this context.</td></tr>
<tr><td>High Pop density and High built up residential density</td><td>Sewerage /DEWATS</td><td>High rise building mainly with more than six story and suitable for either on site decentralized common treatment facility or connection with sewerage systems.</td></tr>
<tr><td>Low Pop density and Low built up residential density</td><td>FSM</td><td>Mainly scattered, town periphery and newly coming up settlements with much below state of reaching the overall built up development (saturation) limit and not suitable for laying down the sewerage networks</td></tr>
<tr><td colspan="2">Slums**(sewerage)</td><td>FSM</td><td>Physical infrastructure and/or land tenure would be poor situations where FSM services would be the support to ensure the safe sanitation access to vulnerable houses</td></tr>
<tr><td colspan="2">Multi story /apartments (+ 4 floors)</td><td>Sewerage /DEWATS</td><td>More population concentration in enclosed space where complete wastewater management become imperative.</td></tr>
<tr><td colspan="2">Polluting HH Industry</td><td>Sewerage /DEWATS</td><td>HH based polluting industry where normally HH toilet tank gets chemically infected are not suitable for both FSM and Sewerage system. Common treatment units or on-site sanitation solution are the possible solutions.</td></tr>
<tr><td>Non- Residential</td><td colspan="2">Similar interventions in line with nearby settlements</td><td>Sewerage /DEWATS</td><td>Premises such as commercial centre/market, education centre, offices and other institutional area are suitable for having improved waste water management option in terms of either sewerage or DEWATS option. Sewerage are viable in case of network based coverage of nearby settlements and thus same can be extended in others locality of close proximity as well.

Accessibility would also help in the decision of sanitation interventions.</td></tr>
</table>

Remarks -

** This is mask layer and indicates high suitability for sewerage network. This layer will supersede to all previous layer and their relevant information. The mask layer prime property will be final nature of relent grids.*

*** This is anti-mask layer and indicates least suitability for sewerage. This layer prime property will be deleted while overlaying of identified pockets.*

3.2.2 Economic Vulnerability

As part of the National urban poverty reduction programme, 2018 (NURP)[1], Khulna city corporation has undertaken the city-wide extensive primary surveys for detailed profiling of urban poor. Indicators namely land tenure, livelihood and wellbeing were factored as part of the study assessment. The final output was spatially presented while highlighting settlements having varying intensity of urban poor concentrations. However, as part of existing study since infrastructure has already been used for decision making matrix along with other parameters, details of other two remaining heads i.e. tenure, employment and income were primarily considered to identify the economically vulnerable pockets. Employment and income head is further categorised into critical and non-critical conditions. Pockets having critical conditions of employment and income are considered as low paying capacity used and mostly living into urban poor /old congested part of city with limited availability of other basic services including water supply network. Thus all such settlements are considered suitable for FSM intervention whereas pockets having non-critical employment and income are considered suitable towards sewerage network . In case of insecure land tenure FSM has been suggested as mask layer solution and will supersede to all other output layers.

Sub-parameters, suitability score and rational are presented in table 3.2.

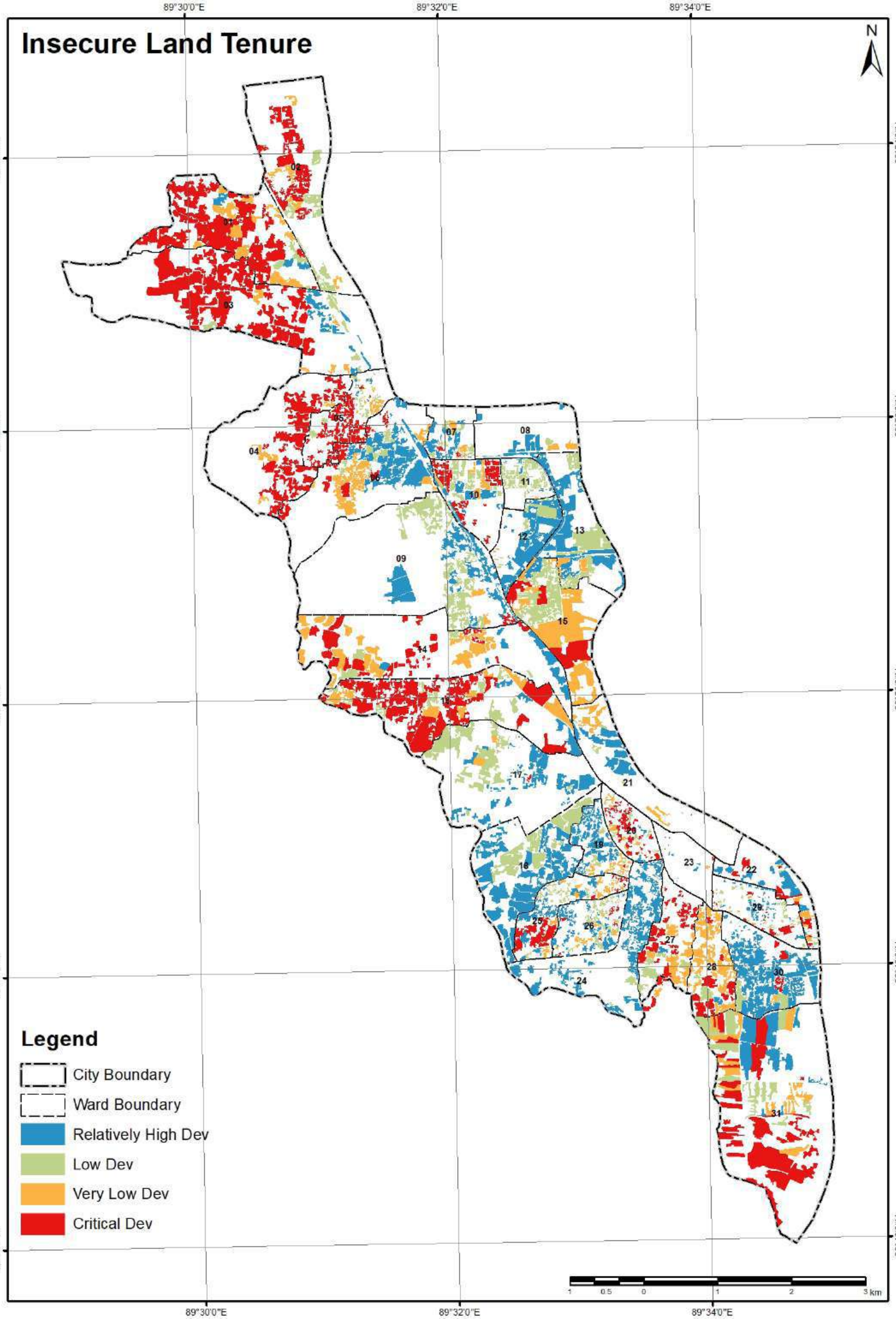
Table 3.2 Decision making matrix for Economic Vulnerability

Sub - Parameters	Suitability	Rational
Employment and income – Critical	FSM	Limited paying capacity and mostly these settlements are urban poor pockets with limited access of urban basic services
Employment and income – Non Critical	Sewerage	These settlements are comparatively well-off and mostly with improved services availability.
In secured land tenure *	FSM	Investing huge capital cost for insured land right will not be feasible and rather should rely on alternative and affordable solution of FSM. Pipe water connection would also not be available in such areas.

** This is mask layer and indicates high suitability for sewerage network. This layer will supersede to all previous layer and their relevant information. The mask layer prime property will be final nature of relevant grids.*

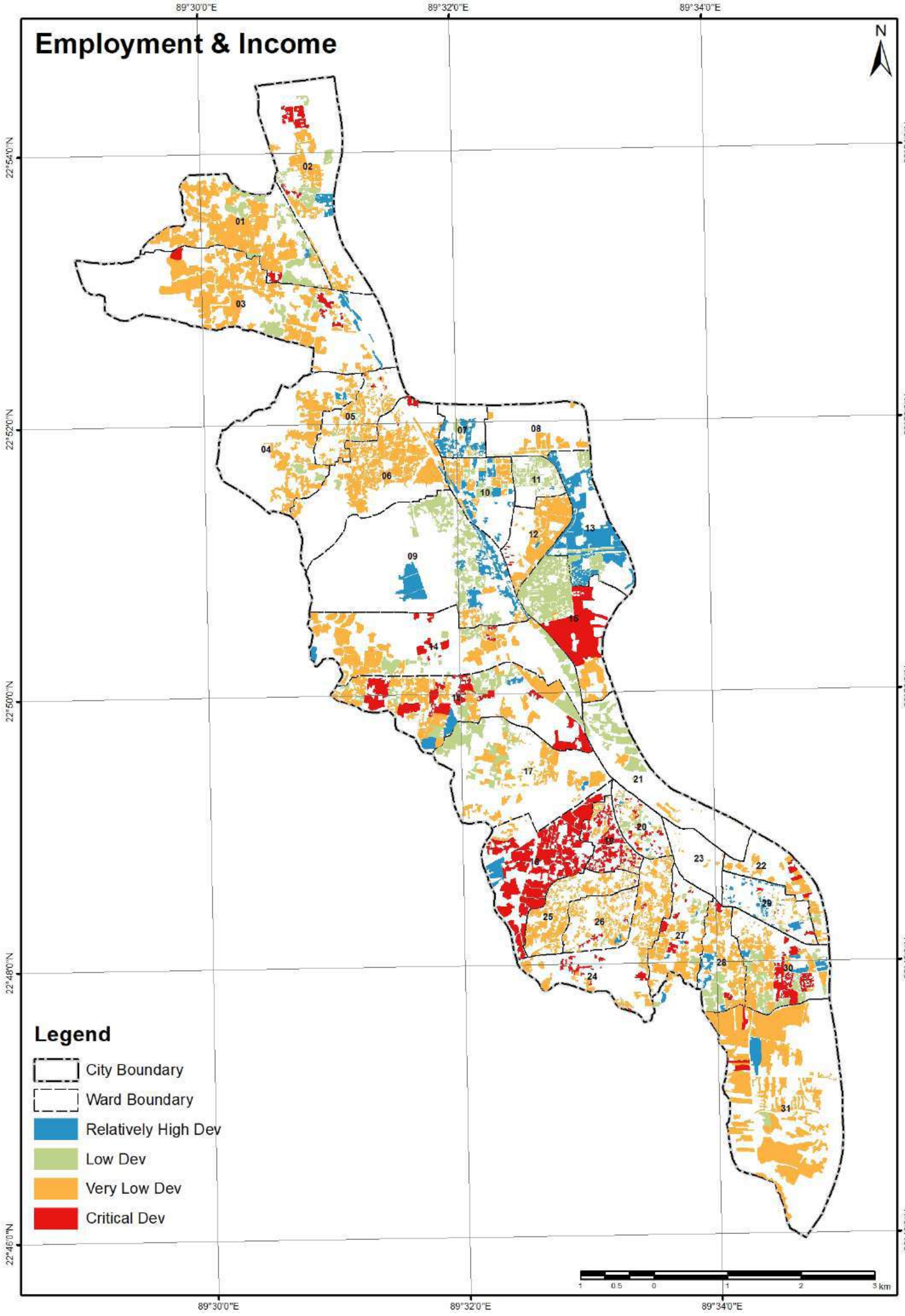
[1] United Nations Development Programme (UNDP): The National Urban Poverty Reduction Programme (NUPRP) and the Khulna City Corporation

Figure 3.4 Insecure Land Tenure



Source: National urban poverty reduction programme, 2018 (NURP)

Figure 3.5 Emplyment and Income



Source: National urban poverty reduction programme, 2018 (NURP)

3.2.4 Drainage Coverage and Typology

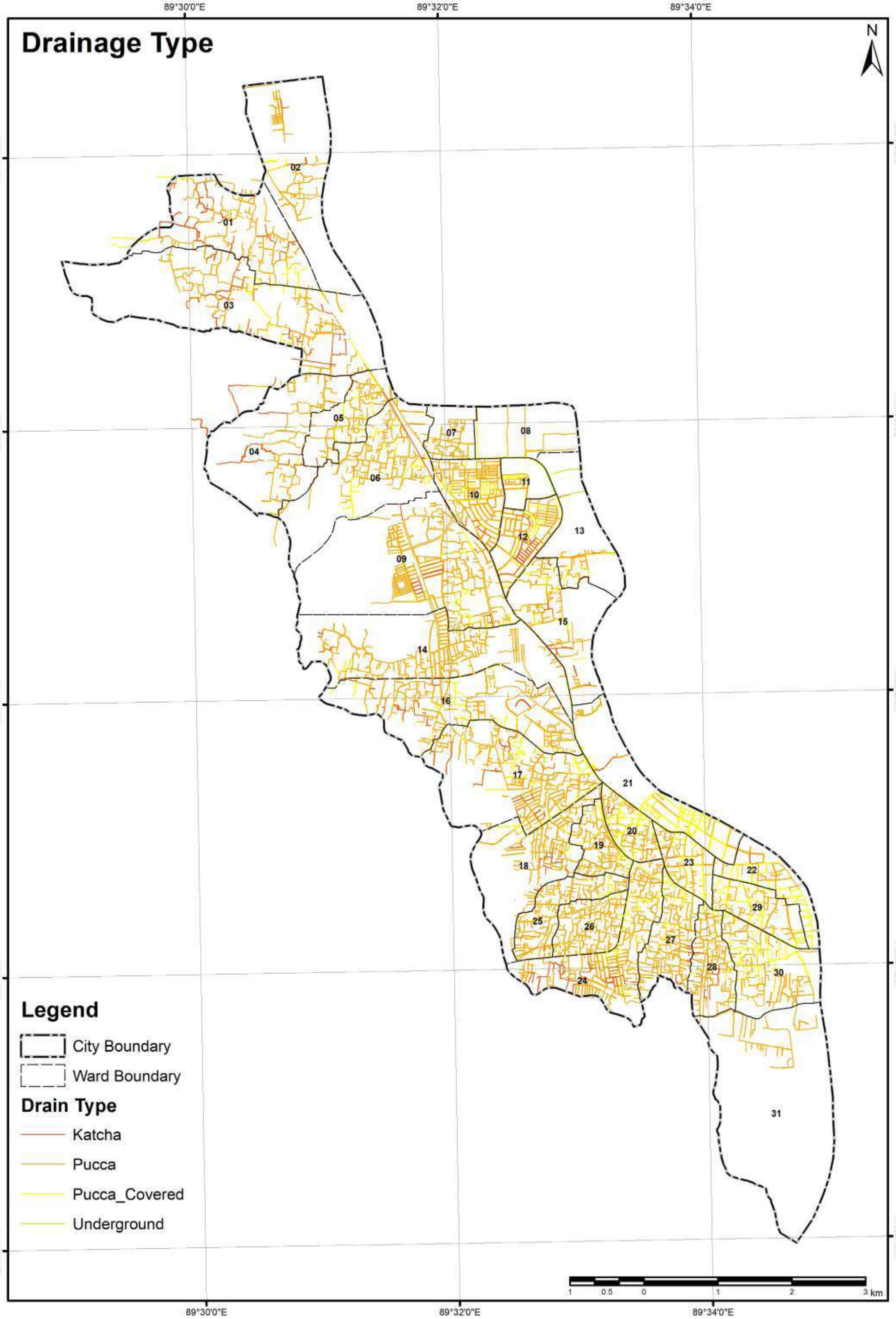
Waste water management includes safe handling of both grey and black water through combined or separate means of services. In case of FSM operations, normally grey water gets transported into abutting drains of houses whereas in case of sewerage network there is a combined transportation unit to treatment plant for both grey and black water. Unavailability of drainage network often poses serious issues with respect to safe handling of grey water discharge. Thus poor drainage coverage areas need immediate and proper grey water management systems which in turn makes these pockets more suitable for network based interventions (sewerage /DEWATS); whereas settlements having pucca covered drains are more suitable for FSM interventions. There are also cases where pucca drain exists, but are uncovered which becomes suitable for both sewerage and FSM intervention. However areas without any drainage network are critical and highly need an improved waste water management. These pockets are generally urban poor settlements and mostly part of old/congested part of city where laying down sewerage would not be viable and thus considering the necessity of waste water management; DEWATS would be more suitable option in such cases. Same logic would also apply in case of presence of Katcha drain as well.

Sub-parameters, suitability score and rational are presented in table 3.3.

Table 3.3 Decision making matrix for Drainage Coverage and Typology

Sub - Parameters	Suitability	Rational
Pucca drain and uncovered	Sewerage/FSM	Suitable for both sewerage and FSM and based on resource and fund availability , authority may take the decision.
Katcha drain/No drain	DEWATS	Waste water management is challenging and needs improved and affordable system to bridge the service improvement gaps.
Covered pucca drain	FSM	With the presence of covered pucca drainage networks, discharged grey waste water will be transported safely.

Figure 3.6 Drainage Type Map



Source: GIS data base SNV, KDA

3.2.5 Ground Water Vulnerability

Soil permeability and ground water table both have a combined effect on vulnerability of ground water from household water generations (including sanitation). Technically travel time of the surface water into the ground water table decides the associated risk of ground water contamination. Empirical evidence has shown that a separation between pollution source and water supply equivalent ensuring 25 days travel time is usually sufficient to reduce concentrations of faecal indicators and bacteria to levels where detention within most samples is unlikely. The generally accepted minimum separation for containment source and ground water supply is equivalent to 50 days travel time to bring water quality within WHO guidelines. This 50 day travel time is based on pm survival times of viruses from laboratory and field experiments. However this travel time is likely to result in prohibitive distances of separation in the developing country under certain circumstances. Three level of acceptable risk is defined as follows :-

- Significant risk – less than 25 days travel time
- Low risk – between 25 and 50 days travel time
- Very low risk – greater than 50 days travel time

It is important to understand that distance of ground water table would be factored from pollution sources i.e. base of containment (both pit/soak pit of septic tank). In line with varying soil patterns of city, their permeability factor and water table levels; travel time for each settlement typology would be calculated and mapped to find the expected degree of risk in terms of high, moderate and low. Khulna city has diverse soil patterns and considering its location along the river bank and various canals passing through the city; the water table also varies significantly in different parts of the city. These would be factored while calculating the travel time for each settlement typology. Sub-parameters, suitability score and rational are presented in table 3.4.

Assessment of ground water vulnerability are of paramount importance and methodology clearly spells out the detailed process to identify all such areas. However, in line with data requirement, relevant information still needs to be collected. The detailed output map of this head would be thus part of next forthcoming deliverables and spatial output of ground vulnerability will also feed into the further fine tuning of the output of overlay analysis for identification of suitable sanitation interventions.

Table 3.4 Decision making matrix for Ground Water Vulnerability

Sub- Parameters	Suitability	Rational
High risk-less than 25 days	Sewerage	Insufficient travel time from pollution sources to water table and would need measures in form of sewerage network to minimise the waste water ground percolation
Moderate risk- 25- 50 days	Sewerage/DEWATS	Reduced concentration of faecal indicators but there may be situation of non-removal of some other pathogens. This is considered as moderate condition and intervention are aligned towards situation of other prevailing parameters.
Low risk- More than 50 days	FSM	Sufficient travel time from pollution sources to water table and thus ground soil takes considerable care of waste water treatment (mostly grey and tank spill over water). This makes all such areas suitable for FSM intervention.

3.2.6 Accessibility Level

Accessibility has a key role in the process of decision making w.r.t. sanitation interventions .There are many instances where laying down the sewerage network is really difficult considering the single lane (or lesser width) carriage way. Mostly sewerage network installation is a time taking process and for considerable time the pathway which is getting these network installed gets totally blocked (for any access especially in narrow lane road) and cause big time inconvenience to locals. It also hinders basic services such as telecommunication, water supply etc. Considering this huge implication during construction period it is advisable to consider lanes with less than one carriage way width for non-sewerage intervention (FSM and DEWATS) and similarly lanes with availability of two lane carriage way widths are suitable for laying down the sewerage networks. There can be areas where access of desludging trucks also gets difficult. Such pockets are more suitable for DEWATS (located within reach of suction pipe of desludging trucks).

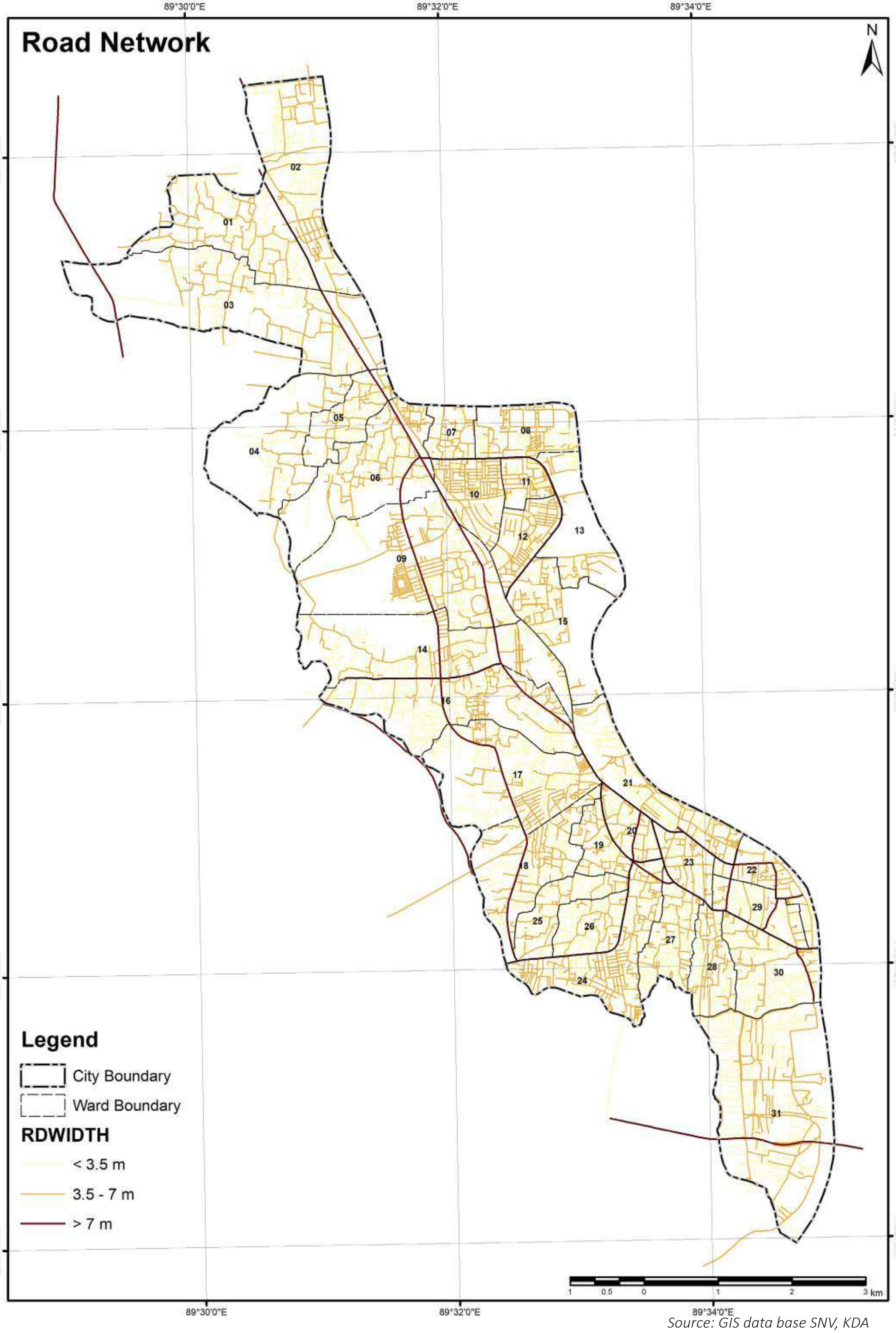
Sub-parameters, suitability score and rational are presented in table 3.5.

Table 3.5 Decision making matrix for Accessibility level

Sub - Parameters	Suitability	Rational
Abutting road width > 7 m (2 lane carriage way) *	Sewerage	Laying down the sewerage network would be possible as other lanes would work as intermediate access and also installation of sewerage network would not cause much adverse impacts to its surroundings.
Abutting road width ranges from 3.5 to 7 m	Sewerage/FSM	Difficult to lay down the sewerage network . However in such cases decision would rely upon the performance of other parameters as part of suitability matrix
Abutting road width Within range of 3.5 to 2 m	FSM	Really difficult to lay down the sewerage network and more suitable for FSM interventions for all such houses
Less than 2 meter road width and beyond the 100 feet accessibility buffer *	DEWATS	Not suitable for sewerage networks. FSM solutions can be explored or provide access towards on-site sanitation solution

** This is mask layer and indicates high suitability for sewerage network. This layer will supersede to all previous layer and their relevant information. The mask layer prime property will be final nature of relent grids.*

Figure 3.7: Road Network Map



Source: GIS data base SNV, KDA

Inferences

- Overall Khulna city has issues in terms of wider road access i.e. more than two lane road access to settlements area. Only city main arterial and some of its sub-arterial have this adequate width and significant number of city road are of single lane carriage way (or even of lesser road width).
- Ward number 1,2,3 4,14,16,17,21,30,31 have significant settlement areas covered through single lane (or lesser width) road access which in turn indicate more suitability towards non-network based interventions. Some of the wards even have land locked areas.
- However ward number 7,8,10,11,12,1518,19,25,26,20,23,22,27,24,28 have significant settlement coverage through road width of around 3.5 meter to 5 meter and also have some pockets having access to two lane road.

3.2.7 Water Sensitive Area

Khulna city is located along a river bank and also has various canals and river estuaries running across the city area. It also has a large number of scattered water ponds in different settlement areas. Multiple locations have been identified as water ponding/low lying areas/depreciation areas which are prone to water logging and seasonal flooding in the city.

The need for provision of efficient waste water handling in some of the city areas is imperative considering the following:-

I. Some ponds are concentrated in large numbers adjacent to or in the settlement areas itself and hence generated waste water from houses gets transported/diverted towards these city ponds directly thus degrading its water quality and creating serious health hazards for the dependant settlement population. Increase in pollution of pond water may also harm the water quality level of ground water and hence proper management of waste water of the nearby houses is absolutely must as a preventive measure to avoid any contamination of the city ponds.

II. Settlement areas in close proximity to or within the exiting flood line of a river (similarly also for the canal embankment settlements and coastal, riverine flooding) are often prone to flooding and would need considerable improvement measures in storm and waste water management . In case of flooding (or high water logging), toilet sludge and grey water often experiences back flow from toilets and may cause significant problems to the surrounding areas. It also increases the health risks to neighbouring communities and hence implies need for an effective sanitation solution. Sewerage system would in such cases functions as a complete solution, by not only taking care of sludges but also ensuring safe transportation of both grey and black water for safe treatment and disposal. Such areas are highly recommended to be connected to network based system.

III. There are identified pockets in Khulna city with frequent water ponding incidences. In areas with undulating terrain and further low lying, water logging may become a potential management issue. Such zones are more suitable for provision of efficient waste water handling and dependency on adjoining city drains should be negligible. Network system are better suitable in all such pockets. .

Sub-parameters, suitability score and rational of decision making matrix are presented in table 3.6.

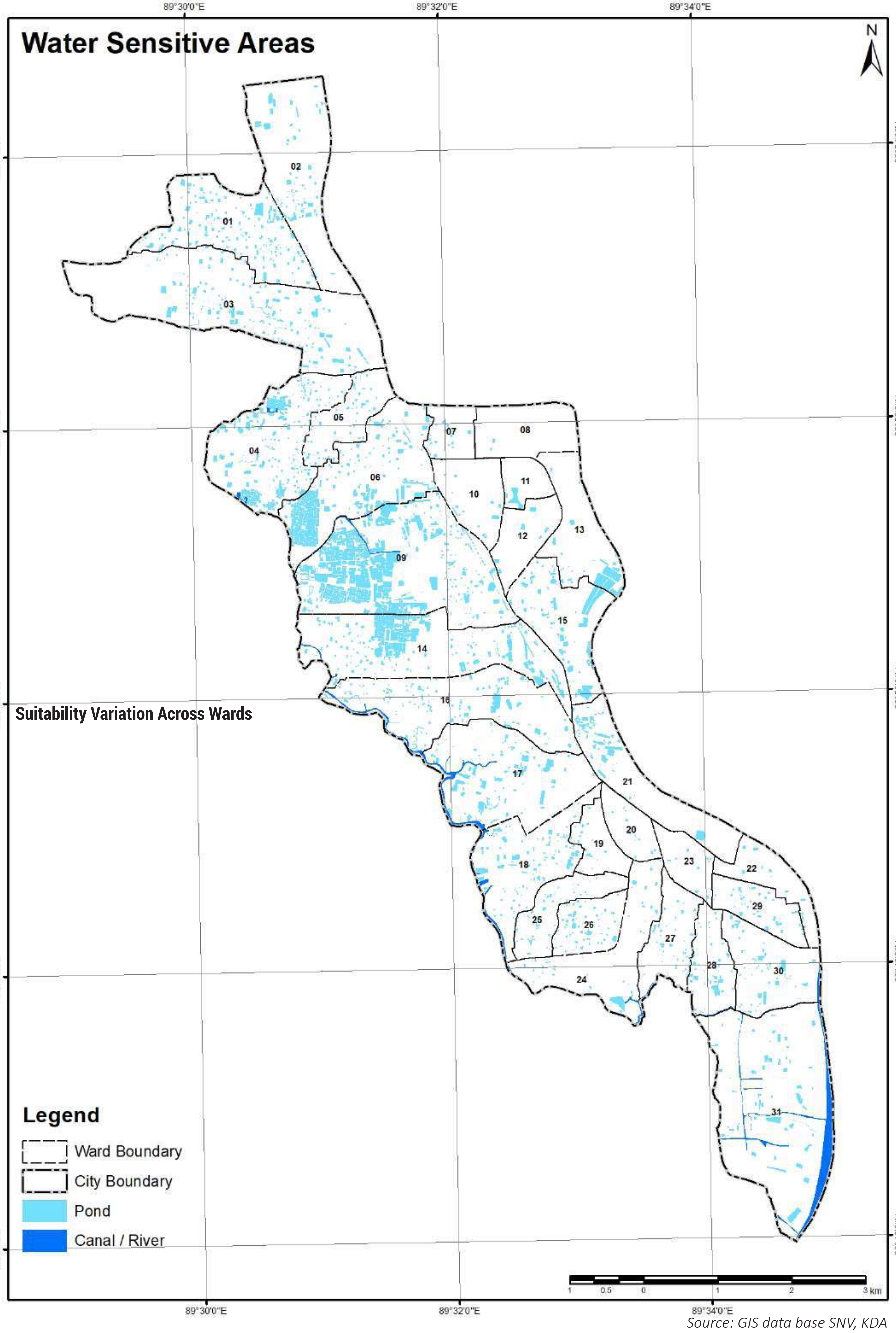
Table 3.6 Decision making matrix for Water Sensitive Area

Sub - Parameters	Suitability	Rational
Water ponding area/depreciation area/ Low lying areas	Sewerage/DEWATS	Refer point III of above paragraph
Flood prone area*	Sewerage	Refer point II of above paragraph
Settlements with higher concentration of nearby ponds	Sewerage/DEWATS	Refer point I of above paragraph

Inferences

- Khulna has water ponds all across the city area. It also has an adjoining river flowing on both eastern and western part of the city boundary . This makes the city a highly likely contender for the management of these water bodies and also ensuring the safe discharge/contact of city wastewater to these water lifeline of the entire population.
- Areas with higher concentration of these water ponds in close proximity to settlement area are critical for improved waste water management and needs an efficient wastewater management system to safely transport the waste for treatment. Ward number 9 and 14 are completely such wards whereas ward number 4 and 3 have partial coverage of such settlement.
- However data for areas falling under the flood line of river body are still needs to be collected from Khulna city and post availability of this, the output map is further expected to improve.

Figure 3.8 Suitability Map - Water Sensitivie Areas



Source: GIS data base SNV, KDA

3.2.8 Topography

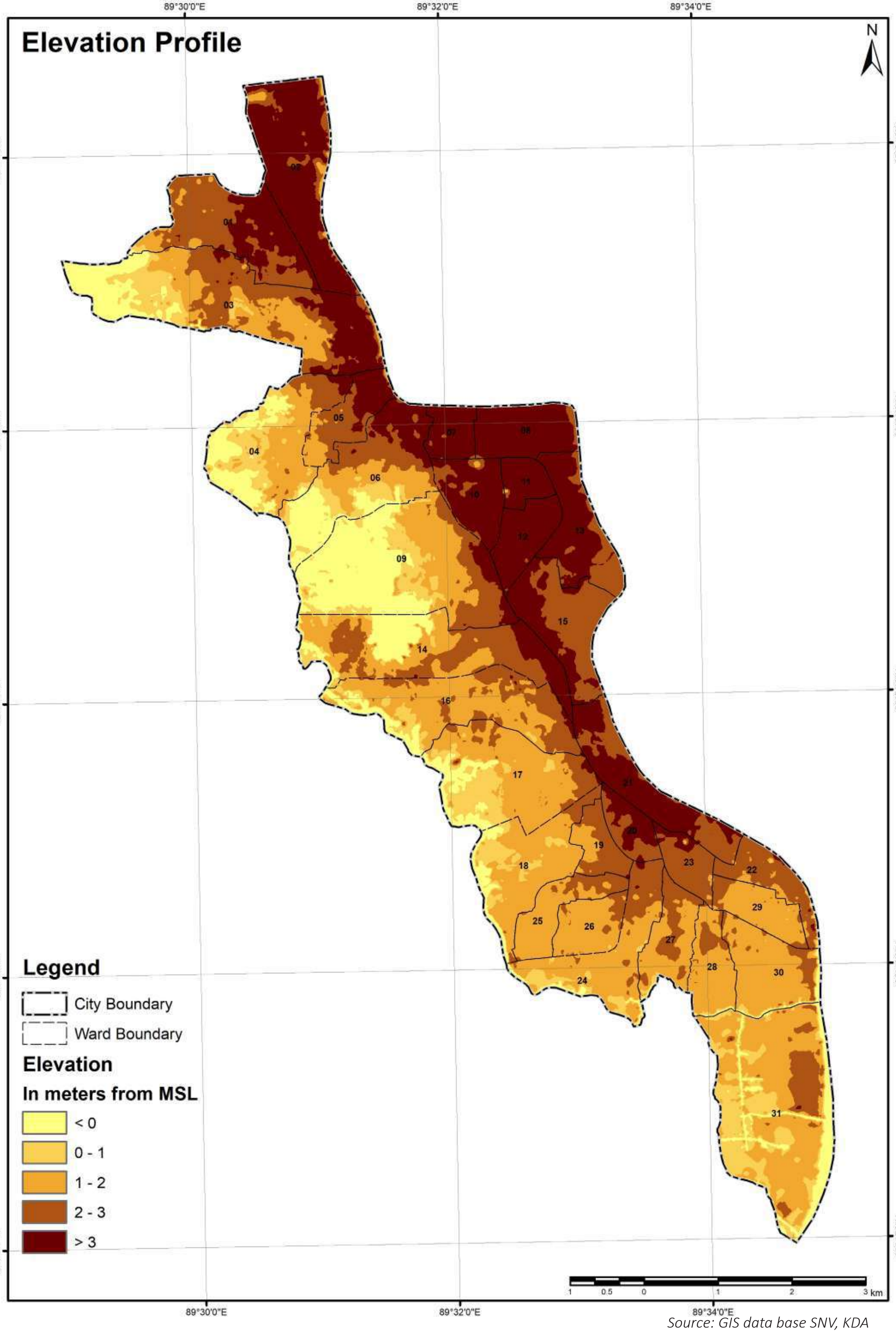
Topography/slope guides the process of evacuation/ transportation of water across various parts or outside the city area. It also plays a role in decision making for sewer and non-sewer intervention. Some of the terrains are ideal for laying down the sewerage network as with gravity, it reaches the required discharge velocity levels naturally. However in case of undulating terrain, intermediate pumping is essential for laying down the sewerage network causing substantial increase in costs (both CAPEX & OPEX). In Khulna, elevated zones (mostly three meter and less than that) are mostly concentrated towards north-eastern part of the city. Most of the western part of the city is comparatively low lying with minimum variation in elevation. This clearly implies that westerns part of city are more suitable for FSM solutions as compared to the eastern parts. Khulna city has largely not much frequent difference in elevations and town area towards the eastern portion (along with river bank) has comparatively higher elevations.

Similarly western portion of town has slightly lower elevation range thus overall slope of the city is from eastern to western zone while gradually degrading the elevation range from 5 to 1 meter MSL.

Table 3.7 Decision making matrix for Topography

Sub - Parameters	Suitability	Rational
Flat terrain	Sewerage/FSM	This has an unbiased approach towards both sewerage and FSM interventions. Output would be factored based on site situation and other prevailing parameters.
Undulating terrain	FSM	Undulating terrains are difficult in terms of laying down of network services and also includes several pumping costs which make these more suitable for FSM intervention
Consistent slope terrain	Sewerage	Consistent slop terrain helps to achieve self-running velocity of the waste water (including faecal matters) and hence is suitable for provision of sewerage system.

Figure 3.9 Elevation Profile



Source: GIS data base SNV, KDA

3.2.9 Water Supply Coverage

Adequate water supply coverage is the pre-requisite for installation of sewerage network in any settlement area. This is mainly considering the minimum required run-off velocity to transport the wastewater flow within the sewerage network. Normally these minimum numbers are not same as required LPCD in an urban setup (as per the standard, Bangladesh urban area has 120 LPCD as required water consumption by per person) and 70 LPCD is considered as a minimum supply capacity in order to run smooth operation of the sewage flow in network line. Coverage mapping of water supply services for Khulna city needs to be undertaken and piped water supply coverage to individual HHs with equal or more than adequate supply volume of LPCD should be considered suitable for laying down the sewerage network. However cases like non-piped water supply (and other means as stand post coverage etc). are suitable for FSM.

Sub-parameters, suitability score and rational of decision making matrix are presented in table 3.8.

Table 3.8 Decision making matrix for Water Supply Coverage

Sub - Parameters	Suitability	Rational
Piped water supply coverage to HH	Sewerage	HHs with minimum water supply coverage of 70 LPCD and having in house tap water connection can be connected towards sewerage line networks
Stand post coverage to locality(sewerage)**	FSM	HHs with even served with stand post coverage to their locality are not suitable for sewerage system where are more inclined towards FSM services.
No piped water supply coverage(sewerage)**	FSM	HHs with inadequate supply coverage are suitable for FSM services.

***- This is anti-mask layer and indicates least suitability of particular interventions. The layer prime property if comes sewerage in any case would be deleted while overlaying of identified pockets.*

Understanding of existing coverage (and also areas which are going to be served in another 1 year) of water supply line are essential as adequate water supply coverage is a pre-requisite for laying down the sewerage network. The current spatial coverage and supply numbers are required to be collected from relevant department of Khulna city. The detailed output map of this head would be thus part of next forthcoming deliverables and spatial output of water supply coverage will also feed into the final overlay analysis for identification of areas suitable for non-sewerage and sewerage interventions.

3.3 Suitability Matrix for Decision Making

Table 3.9 Combined Suitability Matrix

Sl.No	Priority Ranking	Parameters	Sub - Parameters			Suitable for
I	3	Settlement Typology	Residential	Planned *		Sewerage/DEWATS
				Unplanned	↑Pop density & ↓ built up density	FSM
					↓ Pop density & ↑ built up density	FSM/DEWATS
					↑ Pop density & ↑ built up density	Sewerage/DEWATS
					↓ Pop density & ↓ built up density	FSM
				Slums (sewerage #)		FSM
				Multi story buildings /apartments (with more than 4 floor)*		Sewerage/DEWATS
				Polluting HH Industry		Sewerage/DEWATS
			Others	Education centre, Offices , Commercials etc.		Sewerage/DEWATS
II	5	Economic Vulnerability	Employment and Income - Critical			FSM
			Employment and Income - Non critical			Sewerage
			Insecured land tenure *			FSM
III	5	Drainage Coverage and Typology	Pucca drain and uncovered			Sewerage/ FSM
			Katcha drain			DEWATS
			Covered pucca drain			FSM
			Unserved area			DEWATS
IV	4	Ground Water Vulnerability ^	High risk -less than 25 days			Sewerage
			Moderate risk - 25- 50 days			Sewerage/DEWATS
			Low risk - More than 50 days			FSM
V	1	Accessibility Level	Abutting road width more than 7 m (2 lane carriage way) *			Sewerage
			Abutting road width within range of 3.5 to 7 m			Sewerage/ FSM
			Abutting road width within range of 3.5 m to 2 m			FSM
			Less than 2 m road width and beyond the 100 feet accesibility buffer*			DEWATS
VI	4	Water Sensitive Area	Water ponding area/depreciation area/Low lying areas			Sewerage/ DEWATS
			Flood prone area*			Sewerage
			Settlements with higher concentration of nearby ponds			Sewerage/DEWATS
VII	5	Topography	Flat terrain			Sewerage/ FSM
			Undulating terrain			FSM
			Consistent slope terrain			Sewerage
VIII	2	Water Supply Coverage	Piped water supply coverage to HH			Sewerage
			Stand post coverage to locality (sewerage #)			FSM
			No piped water supply coverage (sewerage #)			FSM

** This is mask layer and indicates high suitability for sugegsted interventions. This layer will supersede to all previous layer and their relevant information. The mask layer prime property will be final nature of relent grids.*

^ Travel time between the polluting point and ground water table

 # This is anti mask layer and indicates least suitability of particular interventions. The layer prime property will be deleated while overlaying of identified pockets.

3.4 Conclusion

Suitability matrix for decision making on area identification for non-sewer intervention largely covers all relevant parameters and are building different output scenario against each of the case. However, some of the relevant details of parameters like water supply coverage , ground water vulnerability etc are yet to be collected and thus their respective spatial outputs would be a part of the forthcoming deliverable. Rational for assigning score to each sub-parameters has been explained in this chapter and is purely based on technical understanding of the subject.

The individual output maps are overlaid and findings are presented in next chapter. Both final sanitation interventions at city and ward level are presented to arrive on the final decision.

Chapter 4: Final Spatial Outputs - A Key to Decision Making

4.1 Introduction

Baseline report findings were presented in city level workshop on 21st August'19 to all key stakeholders. Participants included senior officials from KWASA, KCC and representatives of active NGOs, working in the sanitation sector of Khulna city. Individual feedback on varying priority of parameters were discussed and relevant suggestion have now been incorporated in this draft report. Some of the important suggestion were as followings: -

- Accessibility and water supply coverage has much bigger role in the decision making of sanitation intervention (especially in case of sewerage)
- Parameters like Settlement typology, ground water vulnerability and water sensitivity are second level of parameters in the decision-making process
- In case of Khulna city, drainage coverage, economic vulnerability and topography would have least impact in the decision-making process

4.2 Spatial Output Maps of Sanitation Intervention

This chapter showcases the final result of individual sanitation intervention in terms of their varying suitability level for Khulna city. All three-individual output of sewerage, DEWATS and FSM are overlaid to arrive at final decision map of sanitation intervention for the entire Khulna city. The interventions are classified into two broad heads of long-term sanitation interventions and alternative sanitation intervention. The outputs in terms of specific interventions have been calculated for each ward and are presented graphically. Suggestions would be than incorporated as part of submission of final project report.

Figure 4.1 Sanitaton Intervention for Sewerage

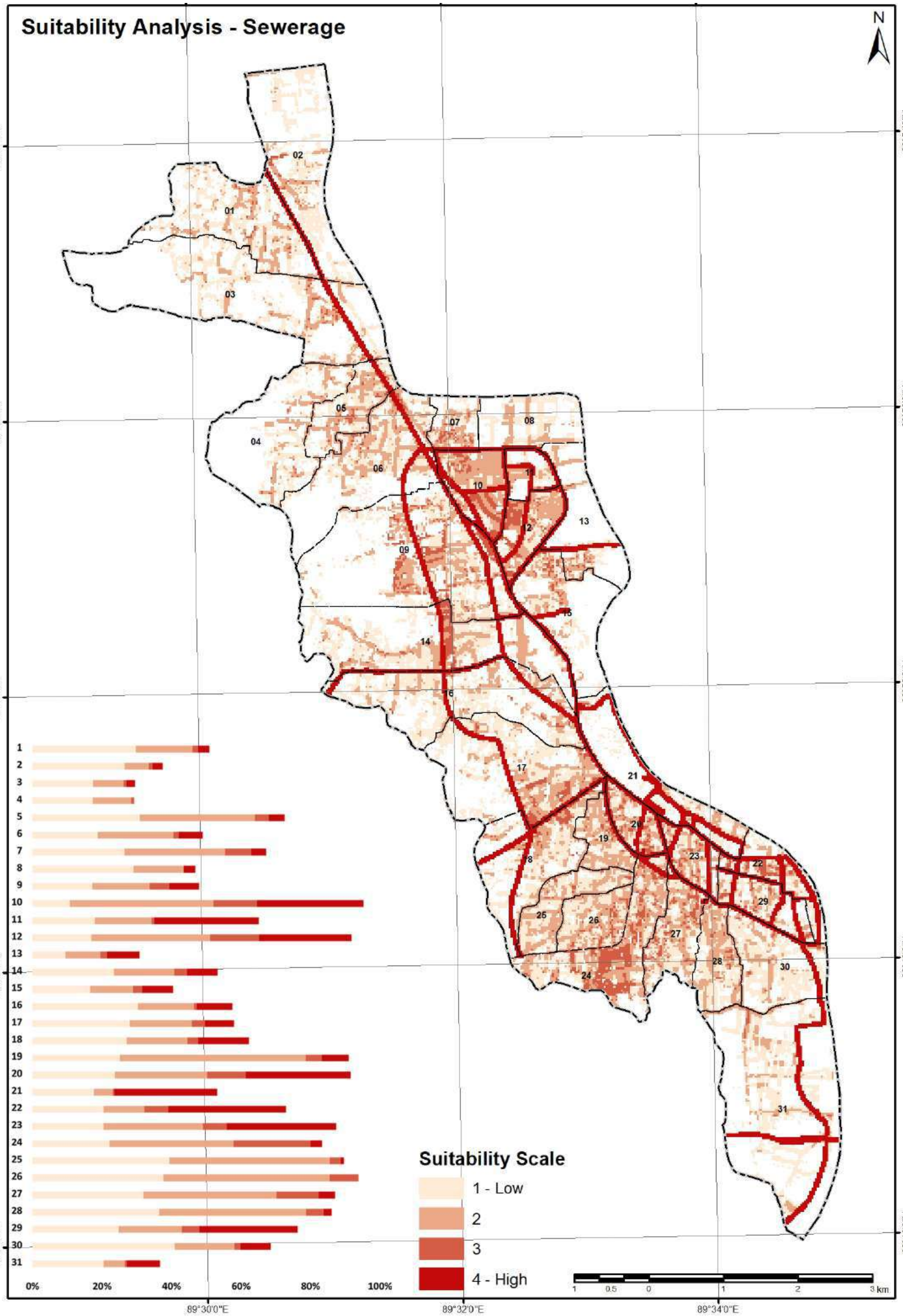


Figure 4.2 Sanitaton Intervention for FSM

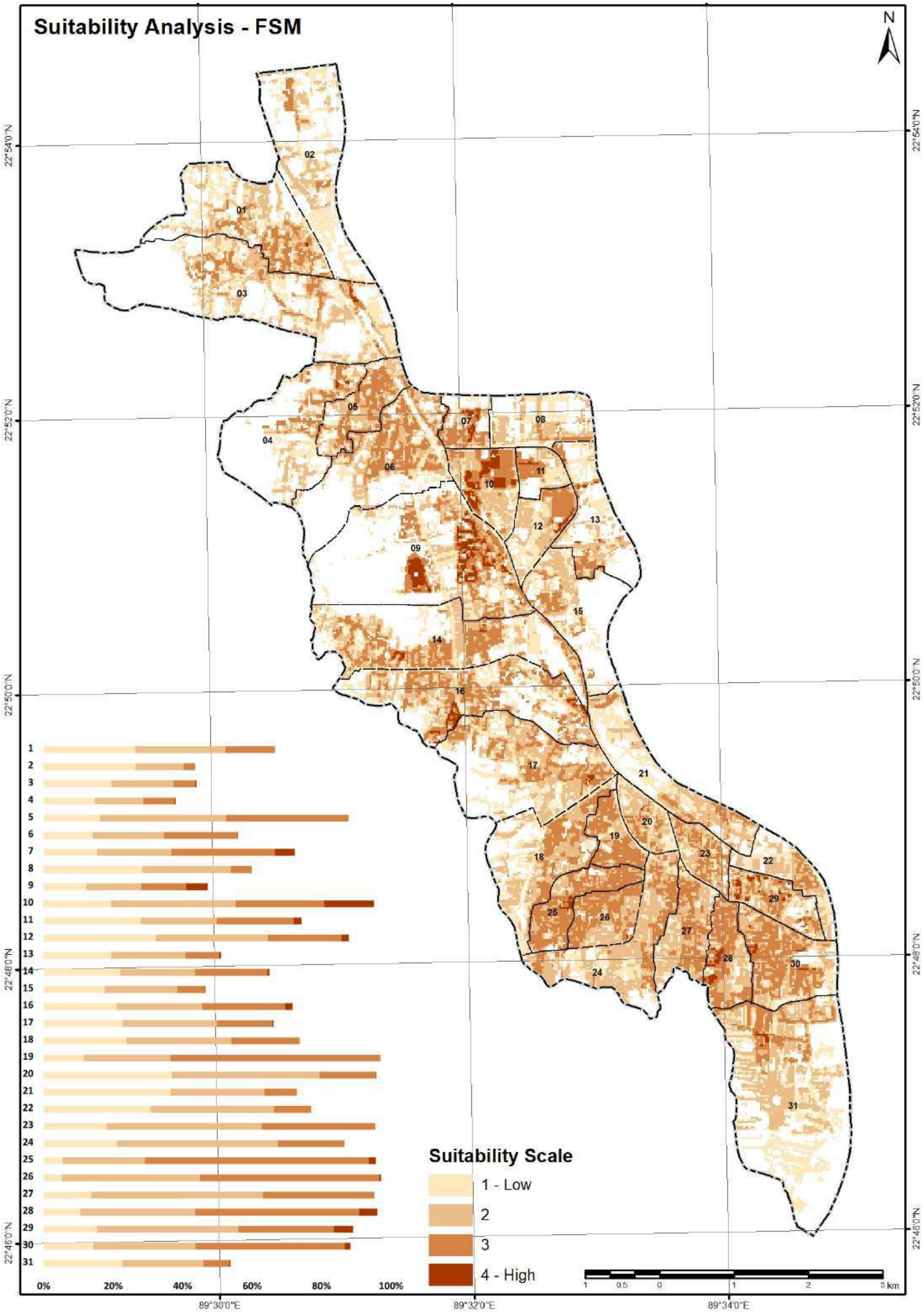
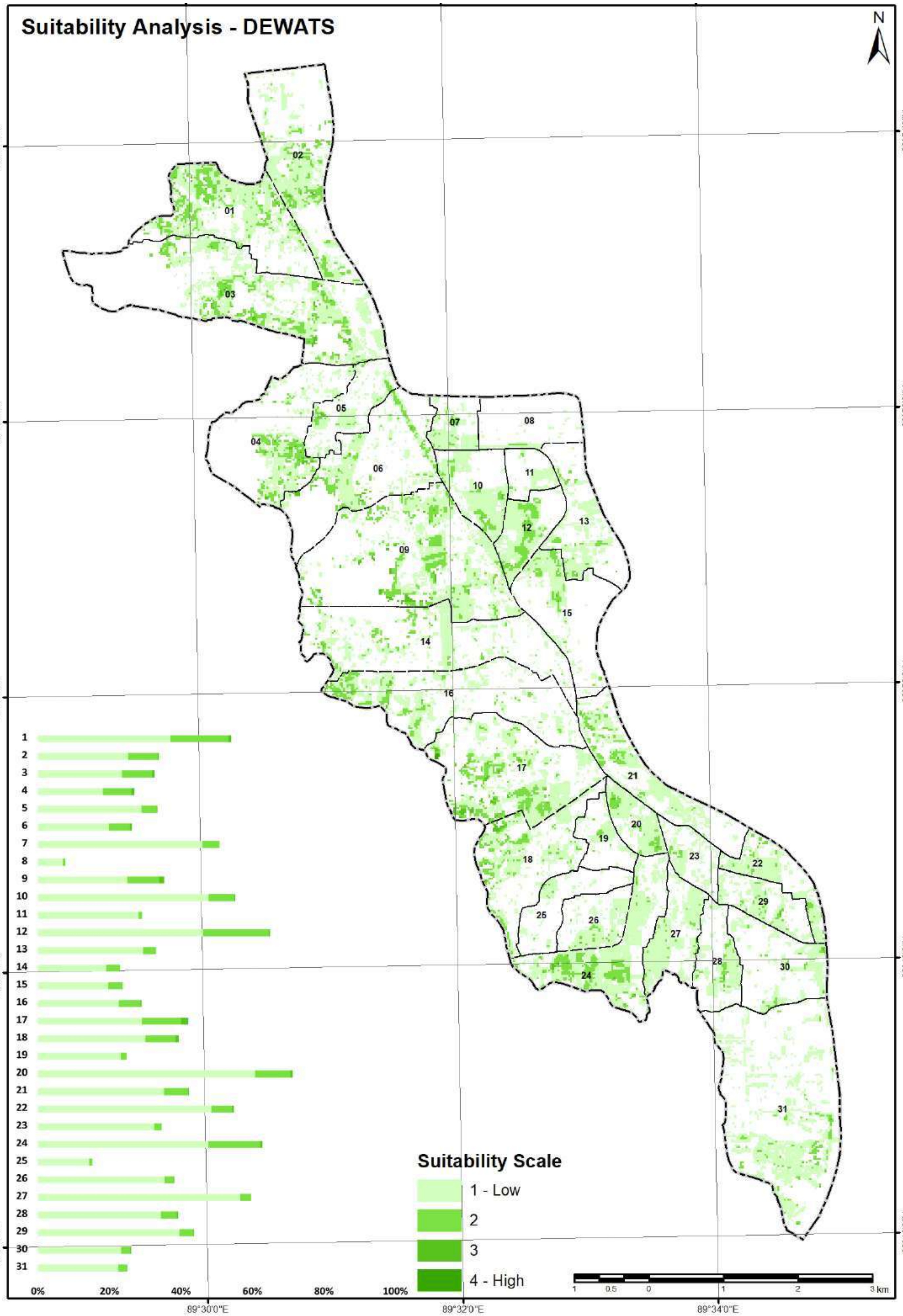


Figure 4.3 Sanitaton Intervention for DEWATS



4.2.1 Inferences from Individual Sanitation Interventions

Sewerage

- Visible suitability of sewerage coverage can be observed all along main road network of city (both arterial and sub-arterial roads)
- Ward 10,11 and 12 indicate high suitability towards laying down the sewerage network. This is also considering the presence of planned colony in some of these wards.
- Southern ward such as 20,22,23 are also more feasible for sewerage network
- Sewerage tends to expand more towards the existing network base and serve nearby pockets/settlements on priority during expansion. This trend may continue in case of Khulna city as well.

FSM

- Southern part of city comprising of ward number 28, 29,30,19,25,26 are more suitable for FSM
- Central regions of the city like ward 15,17,20,21,22 have limited suitability towards FSM. Since these wards are aligned more towards central road network of city, hence will have greater scope to get covered as a part of the proposed sewerage network.
- In northern lower part of city like in ward 05,06,07 and 10 have significant chunk of built up population as more aligned towards FSM interventions.
- Wards with significant slums population like 21 and part of 14 are also suitable for undertaking FSM interventions

DEWATS

- Northern part of the city i.e. wards 1, 2, 3 and 4 indicates more suitability towards DEWATS solutions as compare to other parts especially to southern portion.
- Central part of the city along the main road network which is ward 10,12,07 and 09 also showcase suitability of DEWATS for number of pockets.
- Planned colony of ward 10,12,9 are also suggested to be considered for DEWATS if in case these are not being served by proposed upcoming sewerage network.
- Settlements along with western periphery of city boundary are also more feasible for DEWATS.

4.3 Final Sanitation Intervention, Khulna city

The final sanitation intervention of Khulna city has been categorized into two broad heads as following:

Long term Sanitation interventions

Exclusive interventions of FSM, DEWATS and Sewerage are proposed for different suitable pockets of Khulna city. These interventions are based on output overlay of individual parameters and suggested to be included as priority sanitation actions for implementation. Available funds and resources of authority needs to be given to these pockets as first preference in project phasing. However as per the study findings, exclusive interventions are only capturing 20% of the city areas, whereas 62% area is found suitable for a combination of sanitation interventions

Alternative Sanitation Interventions

These interventions are in form of pair options i.e. FSM/Sewerage, FSM/DEWATS and DEWATS/Sewerage. Decision would be taken from either of these two given options for the selected pockets of city. For instance, majority of interventions i.e. around 49% of city area are indicating towards option of opting for either sewerage or FSM. This is followed by 11% of option either in terms of sewerage/DEWATS. It is important to understand here that these optional interventions are completely dependent on availability of funds, resources and stakeholder demands. However, this surely facilitates the authority to take a call on selection of final intervention in line with prevailing ground situations.

4.3.1 Inferences

- Wards like 10,11,12, 20,23 are recommended to be served by sewerage and in case of unavailability of funds and resources, this can also be partly aligned with FSM and/or DEWATS interventions.
- Significant portion of ward area (more than 30%) of 10,11,20,21,22,23 are suggested to be covered as part of sewerage intervention.
- Northern portion of city area are largely indicating towards both FSM and DEWATS i.e. ward 01,02,03 and these trends are continuing along the top western periphery i.e. ward 04, 09 of city boundary.
- Southern bottom portion of city especially ward 31 has significant portion of area suggested to be covered under FSM interventions.
- All along main road network, city has high concentration of sewerage as priority interventions and in case of unavailability of funds, large portion of suitable areas would also have option to choose FSM as intermediate solutions.
- For laying down the sewerage network as phase 1, ward 17,20,21,23,24,29 as part of upper southern portion and 10,11,12,9 as core city centre are predominantly suitable.
- For taking up the installation of DEWATS some of the predominately suitable locations are Uttar Banik Para Paschim Para of ward 1, Purba Sen Para of ward 2, Shah Para and Moddho Danga C of ward 3, Dewana Purbo Para of ward 5, Hardboard Gate of ward 13, Hafiz Nagar of ward 17.
- There are only limited pockets (~10%) of city which is exclusively suitable for FSM and DEWATS intervention. However, as part of mix option with sewerage, there are significant portion of city area suitable for non-sewer intervention as alternative solutions.

Figure 4.4 Final Sanitaton Intervention

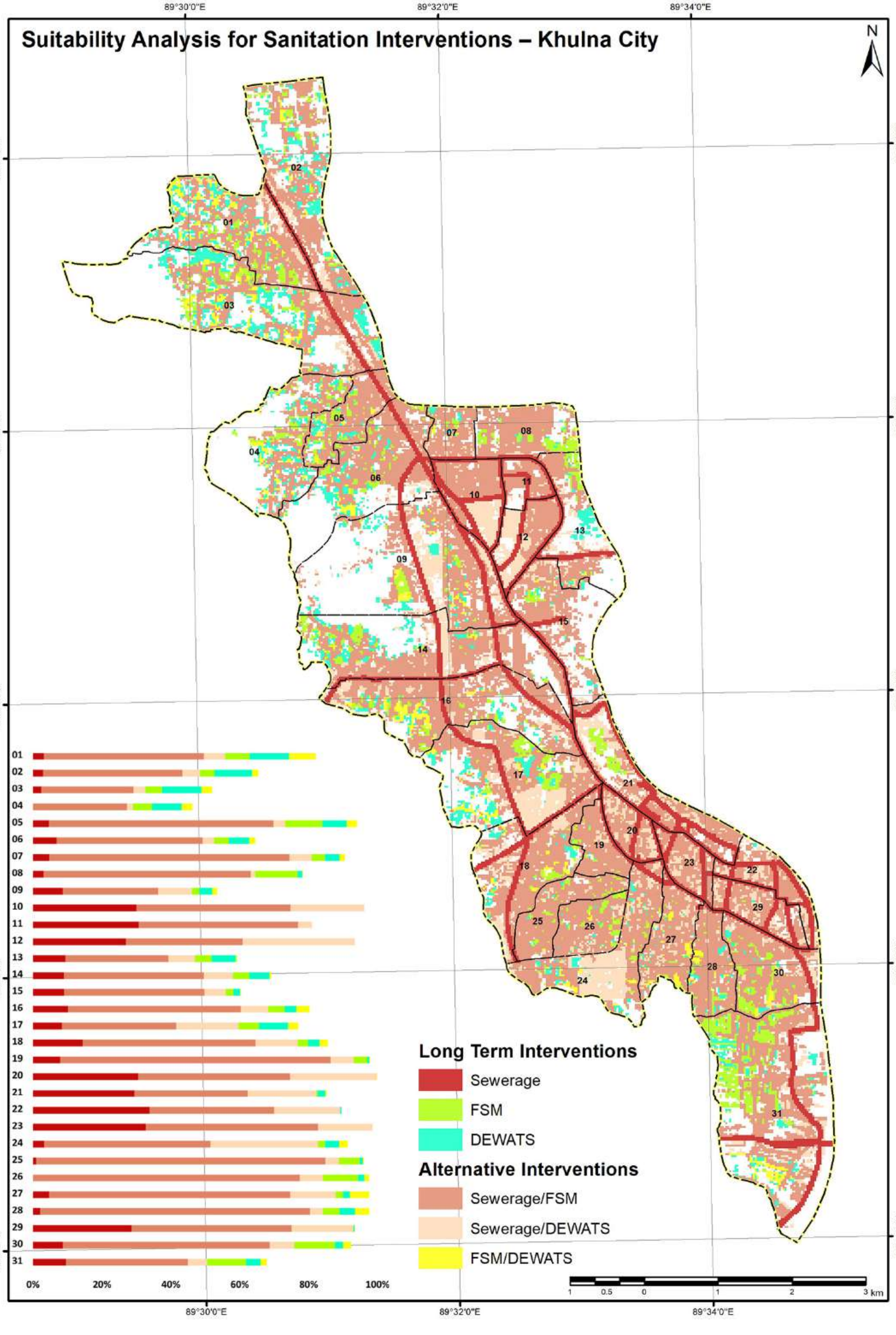
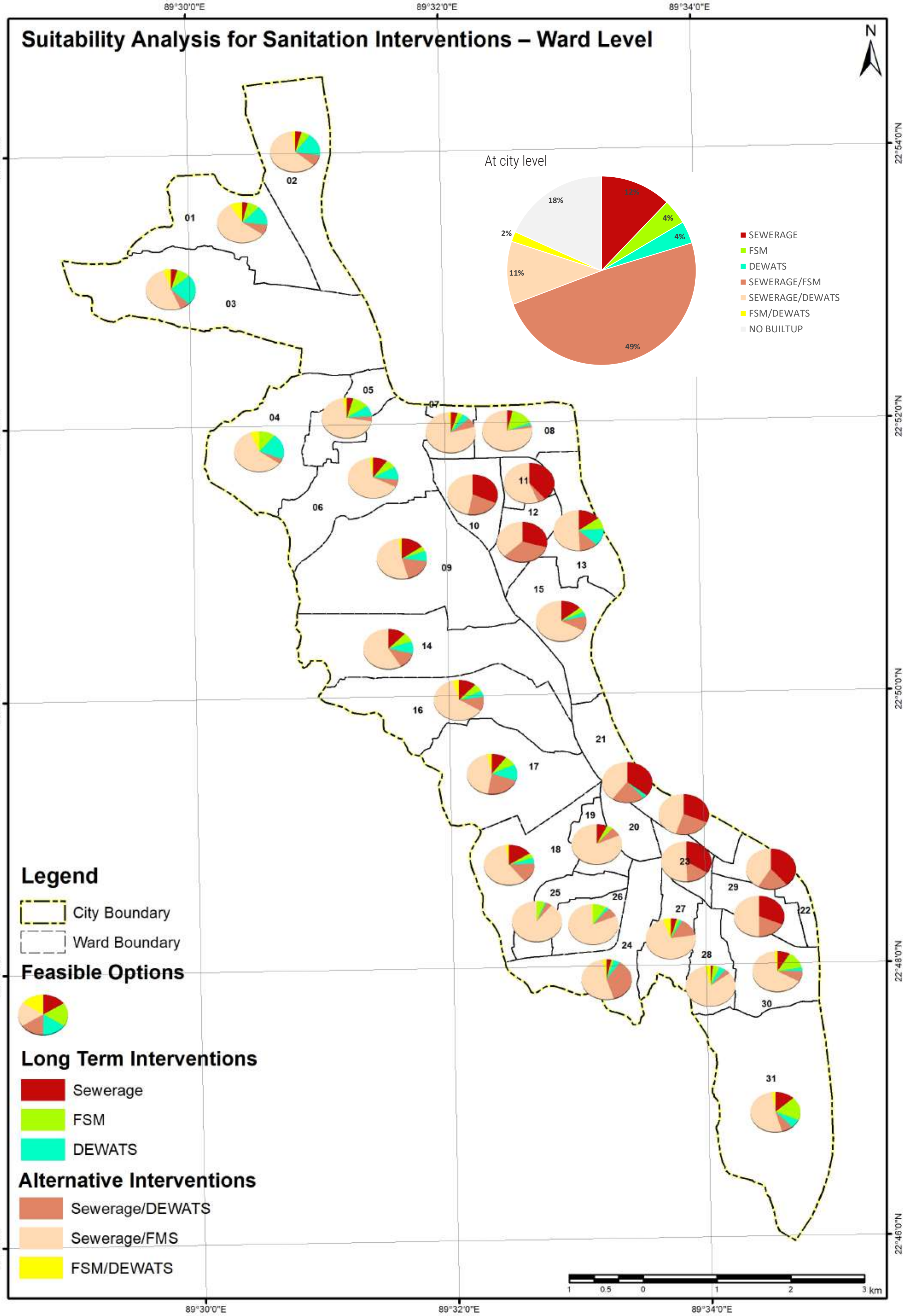


Figure 4.5 Ward wise Sanitaton Intervention



4.4 Ground Validation of Spatial Findings

Some of pocket of exclusive sanitation interventions in form of sewerage, FSM and DEWATS have been considered for ground testing of spatial model outputs. The objective of this assessment was to update the spatial information in case of any recent ground changes and also to broadly validate the survey results and characteristics of individual parameters. This was also to gather more ground understanding for better preparedness before going to the final city level stakeholder workshop. Other key objective was to understand the conflict and compatability with with other proposed sanitation interventions as part of other study undertaken by KCC and KWASA. It was also understood that KWASA has recently completed a feasibility report of phase wise sewerage network installation in various parts of the Khulna city. This study has been taken as one of the base information to understand the relevant conflict/sync with approved sewerage expansion plan of KWASA.

4.4.1 Methodology

Four steps process has been followed (from pocket identification to the rapid survey assessment) to understand the suitability towards all three interventions.

1. Suitability findings overlaid with the proposed sewerage network
2. Assessing Mohalla level outputs
3. Identification of pockets for suitable interventions
4. Rapid area survey for selected Pockets

This image is an illustration of selection for the pocket for the rapid area survey to validate the spatial model findings. Highlighted box has prominent nature of similar interventions and thus clubbed as separate pockets for exclusive sanitation interventions. There may be also areas of conflict where proposed sewerage network and spatial model has conflict in terms of suggested interventions. Such pocket have also been considered for the field testing. Total 27 such pocket have been identified mostly as part of sewerage phase 1 zone for taking up the level 1 field testing exercise.

Maps of all identified 27 locations with their names are shown below for better understanding.

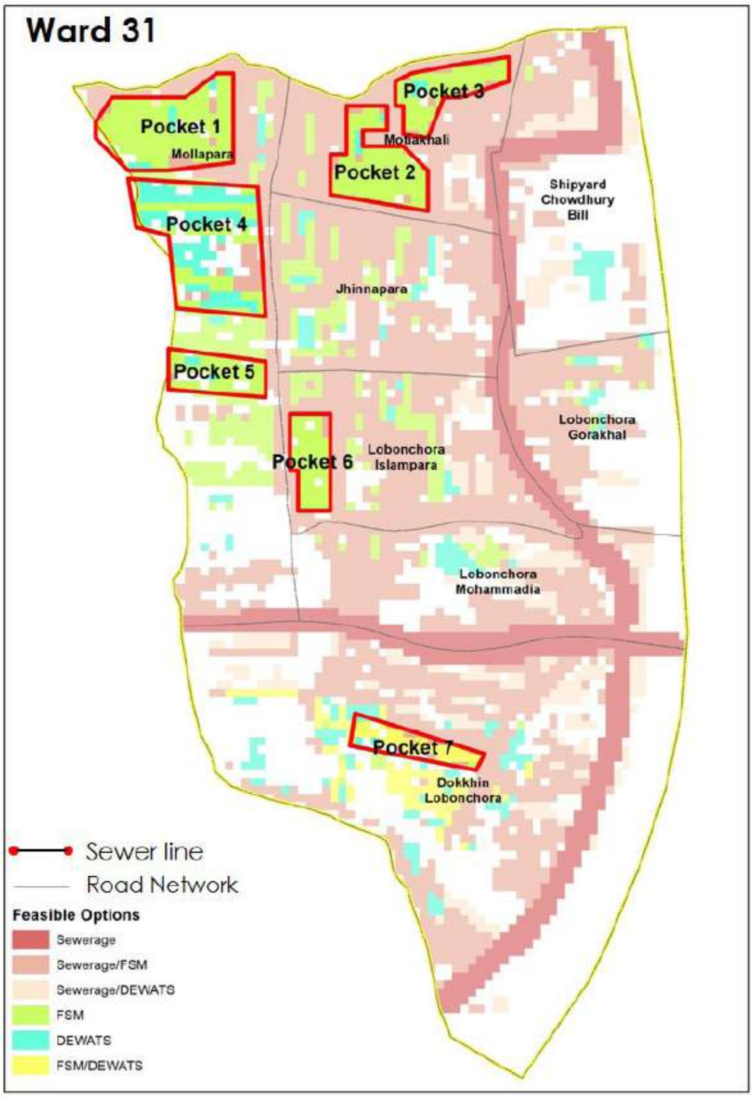
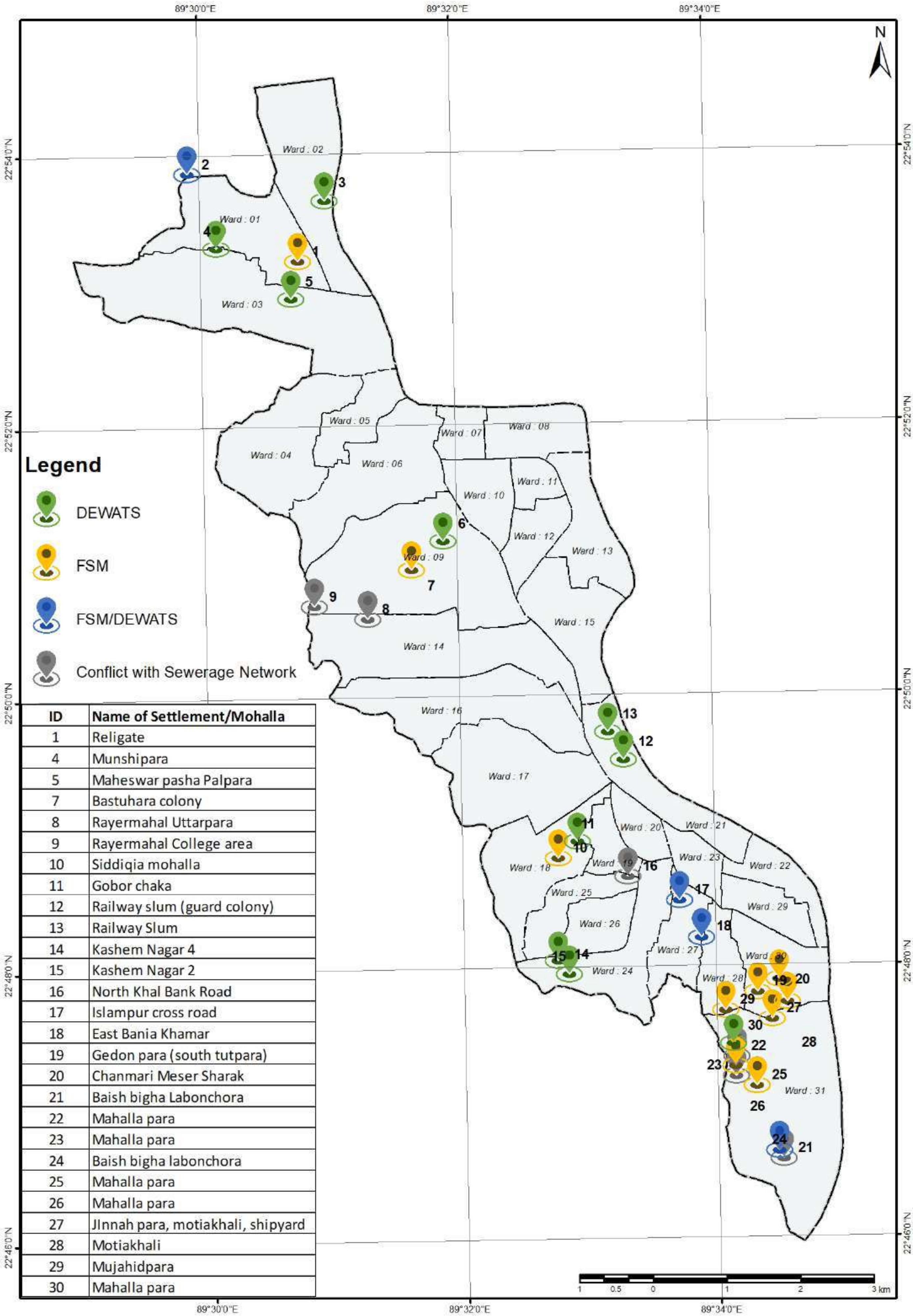


Figure 4.6 Location Map for Level 1 Surveys



ID	Name of Settlement/Mohalla
1	Religate
4	Munshipara
5	Maheswar pasha Palpara
7	Bastuhara colony
8	Rayermahal Uttarpara
9	Rayermahal College area
10	Siddiqia mohalla
11	Gobor chaka
12	Railway slum (guard colony)
13	Railway Slum
14	Kashem Nagar 4
15	Kashem Nagar 2
16	North Khal Bank Road
17	Islampur cross road
18	East Bania Khamar
19	Gedon para (south tutpara)
20	Chanmari Meser Sharak
21	Baish bigha Labonchora
22	Mahalla para
23	Mahalla para
24	Baish bigha labonchora
25	Mahalla para
26	Mahalla para
27	JInnah para, motiakhali, shipyard
28	Motiakhali
29	Mujahidpara
30	Mahalla para

4.4.2 Survey Findings

Suitability towards DEWATS

Pocket 30, Ward 31
Name: **Molla para**
Area: **13 ha**
Number of Houses: **420**

Observations:

- Drainage coverage
- Narrow lane (Road width – 2 meter)
- Presence of water body/wetlands
- Clutter build up space/houses
- Availability of land – yes
- May be taken for DEWATS and plus FSM coverage area
- Fall under SD 6 (Phase I)



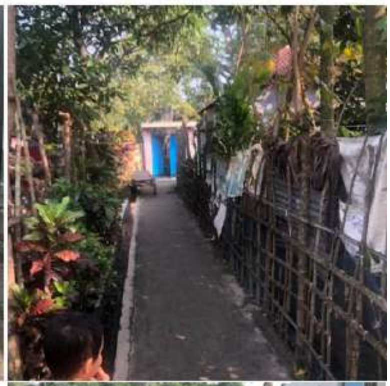


Pocket 5, Ward 3
Name: **Maheswar Pasha Palpara**
Area: **10 ha**
Number of Houses: **300**

Observations:

- Part of settlements are urban poor
- Narrow road throughout with less than 2 meters width
- Water body surrounded
- Scattered in multiple cluster
- Outside sewerage district (beyond 7)

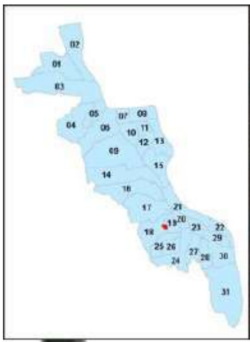




Pocket 11, Ward 18
Name: **Gobor Chaka**
Area: **2 ha**
Number of Houses: **70**

Observations:

- Drainage condition severely bad with large open drain and overflowing
- Visibly black water
- Presence of nearby wetland
- Fall under sewerage district -3 (phase 2 –intermediate)






Suitability towards FSM

Pocket 13, Ward 21
Name: **Railway Slum**
Area: **13.2 ha**
Number of Houses: **870**

Observations:

- Insecure land tenure
- Critical economic vulnerable society
- No municipal water supply
- No sewerage proposal

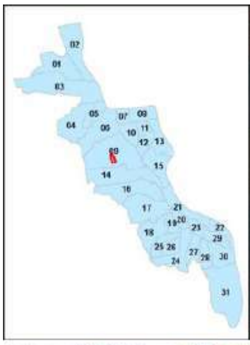





Pocket 7, Ward 9 - FSM
Name: **Bastuhara colony**
Area: **7 ha**
Number of Houses: **695**

Observations:

- Urban poor settlements with secure tenure
- Some narrow lane can have DEWATS options as well
- Presence of one large water body
- Outside sewerage district (beyond SD 7)

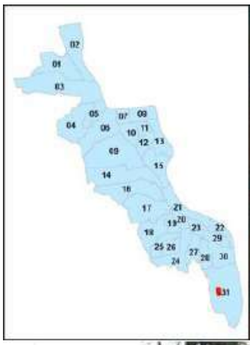




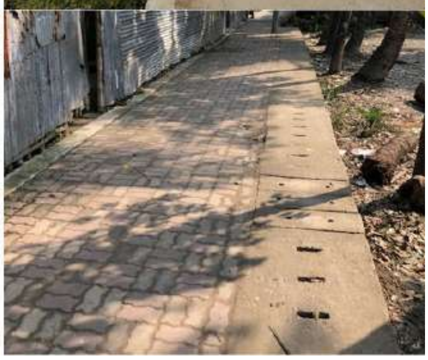

Pocket 25, Ward 31
Name: **Molla para**
Area: **3.6 ha**
Number of Houses: **200**

Observations:

- Mix income group settlements
- Some pockets with narrow lane can be taken up under DEWATS
- Accessible by desludging trucks
- Fall under sewerage district (phase I)





4.5 Final workshop

The findings were presented during the final workshop on 14th November'19 held in Khulna city. The participants included from KCC, KWASA, KDA, Khulna University including some of consultants and NGO's representatives working to improve upon the non-sewer sanitation condition in city area. Also, officials from some of the other municipalities of Bangladesh participated in the workshop to understand the study applicability in their context. Presentation brief included recap and learnings from the last workshop and then briefing on broad agenda of this final workshop. Detailed approach and key findings were shared, and their further use/benefits were also discussed. Three level approach i.e. city, ward/Mohalla and pocket was presented to understand the scale of assignment. The interactive presentation was followed up by a group activity session where individual participants were encouraged to write and present their understanding of individual applicability of all three sanitation interventions of sewerage, FSM and DEWATS. It was very encouraging to share that findings from this study are in sync with most of the proposed sewerage intervention zones of KWASA where it has given a clear outline to expand the phase II operations of sewerage expansion in future operations. KCC officials showed keen interest towards the applicability of study for taking up the DEWATS solutions in some of left-out area from desludging operations. Some of key learning area summaries as following: -

- The general understanding of DEWATS is not as clear in comparison with FSM and Sewerage. DEWATS description and various optional modules were presented which included option with limited or without Gov. land pockets availability i.e. linear ABR or underground DEWATS below the abutting road of built settlements
- The responsibility of DEWATS lies down to KCC and phase wise expansion can be taken up in line with study findings
- Some of proposed DEWATS can directly be taken up by available grants as ready to launch projects
- DEWATS are not just solutions for inaccessible poor settlements pockets whereas it is also a good solution in case of large institutional set-up, colony and high-rise building which are not being catered by sewerage system. A city wide sanitation regulation can be drafted where such isolated large built-up structure with high user interface should have in-house DEWATS system installed.
- Study findings are almost 95% in sync with proposed phase 1 sewerage coverage of KWASA
- KCC can prepare the long-term budget on basis of the study findings and plan to efficiently cater the left-over settlements from sewerage network

Some of the testimonials:-

Managing Director - KWASA

" *Content of presentation is comprehensive. This analysis showed the effective planning of phase 1 of KWASA sewerage network and would be a guideline for next phase of KWASA sewerage system. This will be also really helpful as part of present plan of KCC for efficiently managing FSM and DEWATS*

Town Planner, KCC

" *This is a useful finding for us. However, we also need to look into land requirement and need of acquisition in case of DEWATS installation. It would be good to include such mechanism in city sanitation planning and also in formulating relevant policy*

Officials, KDA

" *Khulna is a disaster-prone area and a lot of low-income people live in the city. FSM/ DEWATS are very important for city and plan should be inclusive in nature to cater all city dwellers. Training session can be arranged for the community people for the maintenance of DEWATS facility.*

Chapter 5: Pocket Selection and Field Survey for DEWATS Interventions

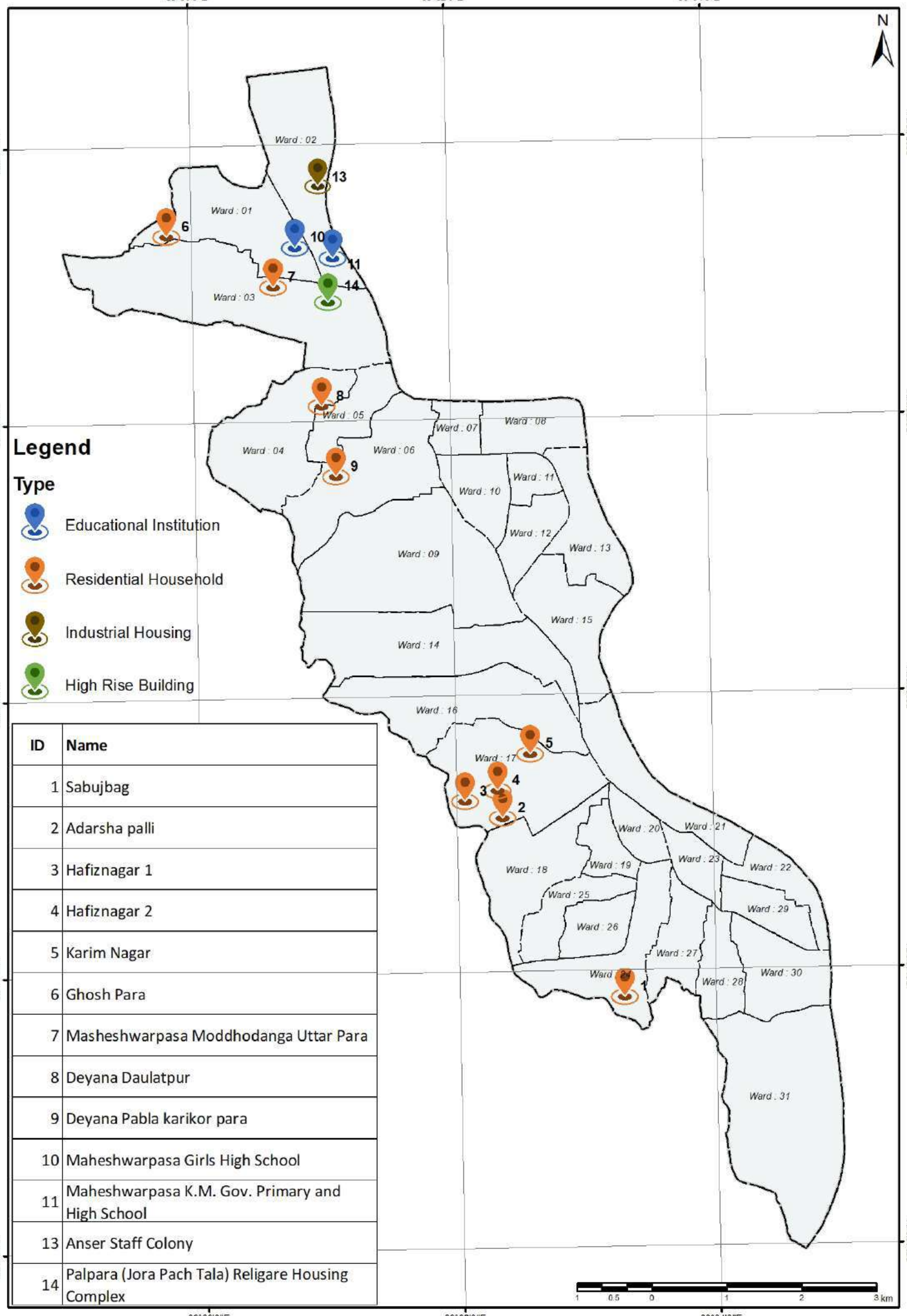
5.1 Introduction

All three sanitation interventions are both exclusive and also overlaps in different ground situations. FSM serves as intermittent gap filling situation where laying down sewerage system is not feasible or not planned by KWASA. However, DEWATS is mostly a situation-based phenomenon and is more suitable in comparison with both FSM and Sewerage interventions. KCC has clear mandate to address and respond to all the desludging request from the available set-ups and also expanding the number of trucks in line with increased demand. However, sewerage coverage expansion is a time taking process and involves multiple engineering and implementation complications. DEWATS bridge the sanitation gaps in more effective manner and even serve the areas which are sometimes left out by FSM operations and/or provide a better sanitation solution to large isolated set-up having significant user dependency. This section attempts to showcase most of the suitable pockets for DEWATS intervention in Khulna city and explain an approach to be followed for all future selection process. Areas which are not covered by DEWATS or Sewerage are obvious to get served by ongoing demand driven FSM operations and thus this chapter gives more focus on DEWATS suitable pockets which would need immediate attention to widen the safe treatment coverage of the residing population of Khulna city.

5.2 Methodology

It was understood as part of final suitability map analysis that KWASA sewerage plans are mostly in sync with the current study. However even in existing wards having proposed sewerage coverage, mostly 60-70% areas are only proposed to get connected and rest will have to depend on FSM and DEWATS. There are also wards which fall under phase 2 KWASA plan and not included for the immediate coverage within around next 10 (or may be more) years of operations. Some of selected settlements which are not covered by sewerage network, although part of phase 1 wards and further settlements which are outside phase 1 district wards are the main consideration for the DEWATS pocket selections. It was also realized that a mix of settlement types should be captured to showcase the varying suitability. Residential locality, industrial housing, high rise apartments, large institutional centre are the selection group for finalizing total 13 priority pockets at pan city level to undergo with filed survey and to validate the suitability towards DEWATS interventions. For residential locality and industrial housing, both overall locality and separate sample HHs surveys were undertaken to better understand the situations. Entire survey was loaded on m-water survey application in order to closely monitor the outputs and also collect large numbers of geo-tagged site photographs for further validations. This also expedited the entire process and in around two weeks' time, entire survey was completed. All thirteen individual results are separately presented in info-graphics, clearly highlighting the assessment results and glimpse of ground situation's photographs.

Figure 5.1 Location Map for Level 2 Surveys

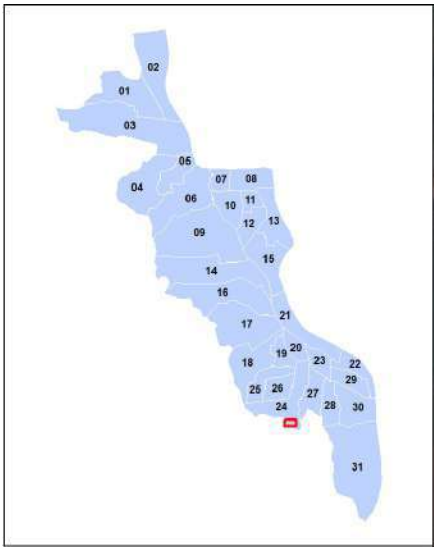


ID	Name
1	Sabujbag
2	Adarsha palli
3	Hafiznagar 1
4	Hafiznagar 2
5	Karim Nagar
6	Ghosh Para
7	Masheshwarpasa Moddhodanga Uttar Para
8	Deyana Daulatpur
9	Deyana Pabla karikor para
10	Maheshwarpasa Girls High School
11	Maheshwarpasa K.M. Gov. Primary and High School
13	Anser Staff Colony
14	Palpara (Jora Pach Tala) Religare Housing Complex

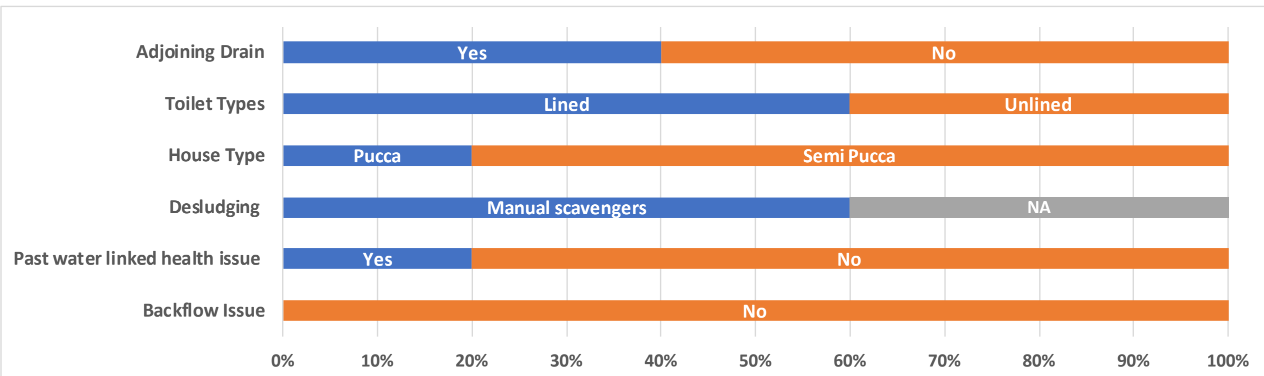
5.3 Survey Findings

5.3.1 Residential Pockets

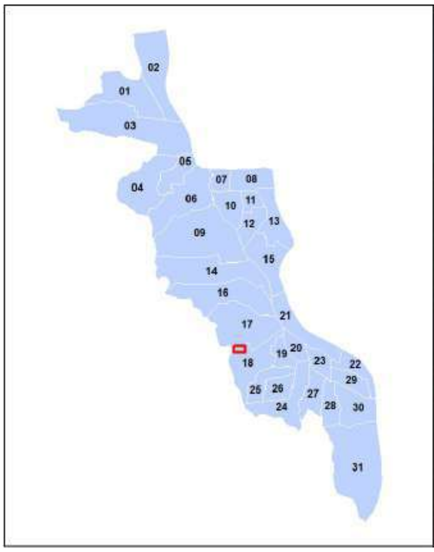
i. **Sabujbag (Nirala);** Households: **50 (approx.)**



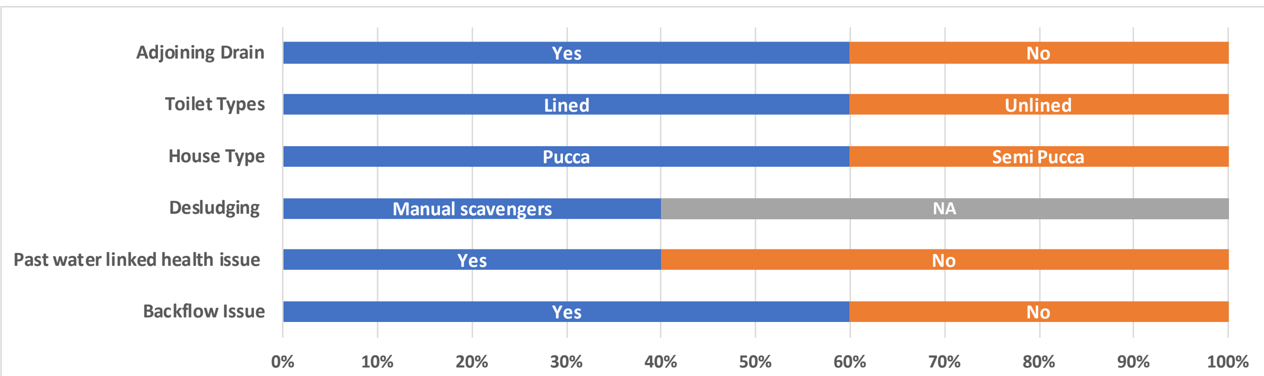
- Mostly narrow road width (less than 2 meter) and inadequate drainage coverage all across the settlements
- Settlement is close to water pond and no water ponding issues
- Some of the houses has KWASA piped water connection whereas mostly this is covered by hand pumps and bore bells
- Residents are mostly mix of LIG, MIG and HIG community
- Secured land tenure and high population, built-up density



ii. **Adarsha palli**; Households: **80 (approx.)**

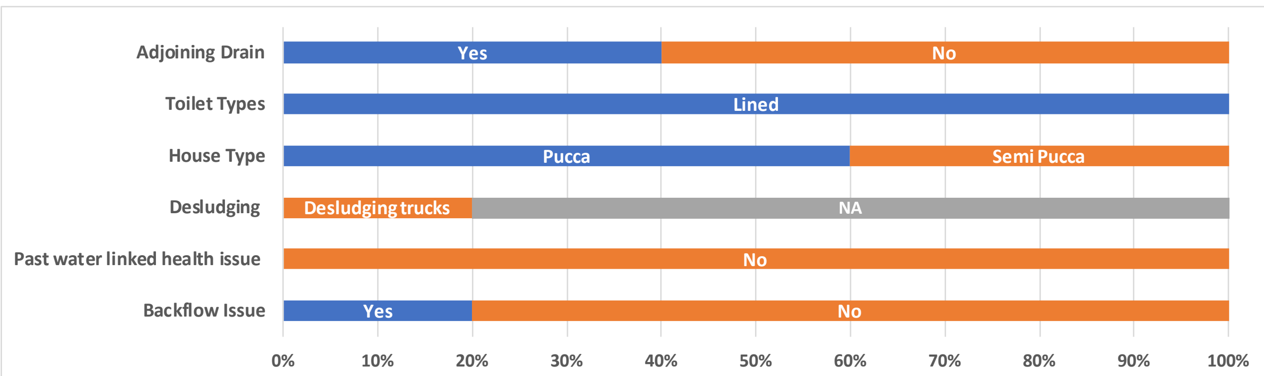


- Narrow road width (less than 2 meter) and adequate drainage coverage all across the settlements
- Settlement is close to water pond and only part of the area are facing issues with water ponding
- Locality has KWASA supply coverage but HHs are mostly using hand pumps
- Residents are mostly low-income community
- Most residents are secured tenants and with high population and built up density



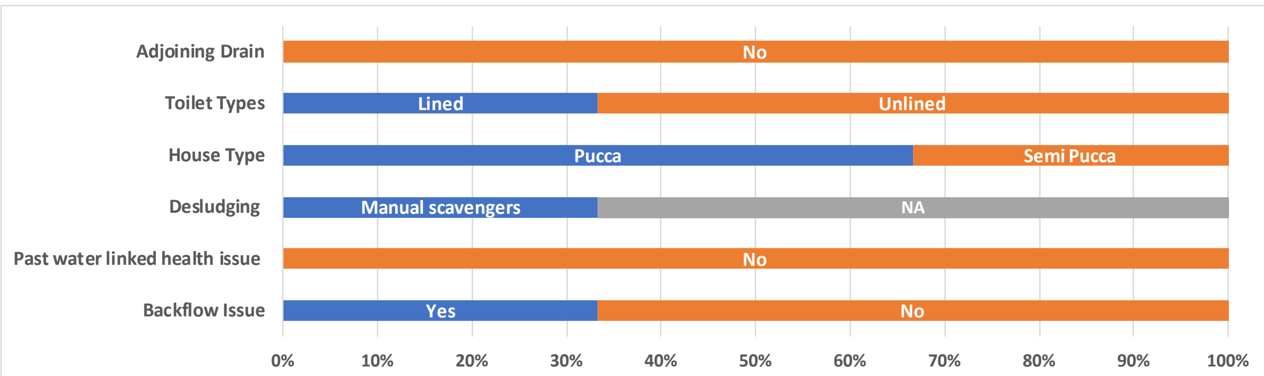
iii. **Hafiznagar 1**; Households: **60 (approx.)**

- Good access road conditions but internal roads are mostly narrow and mix of pucca and kutcha
- Most of the internal roads are covered with drainage networks
- Locality has KWASA supply coverage but mostly HHs are mostly using hand pumps and bore well
- This is close to water pond and significant portion of settlements are falling under water depreciation zone and leading to frequent water ponding
- Residents are mixed income group and includes all LIG, MIG and HIG group
- Secured land tenure and moderate population, built-up density



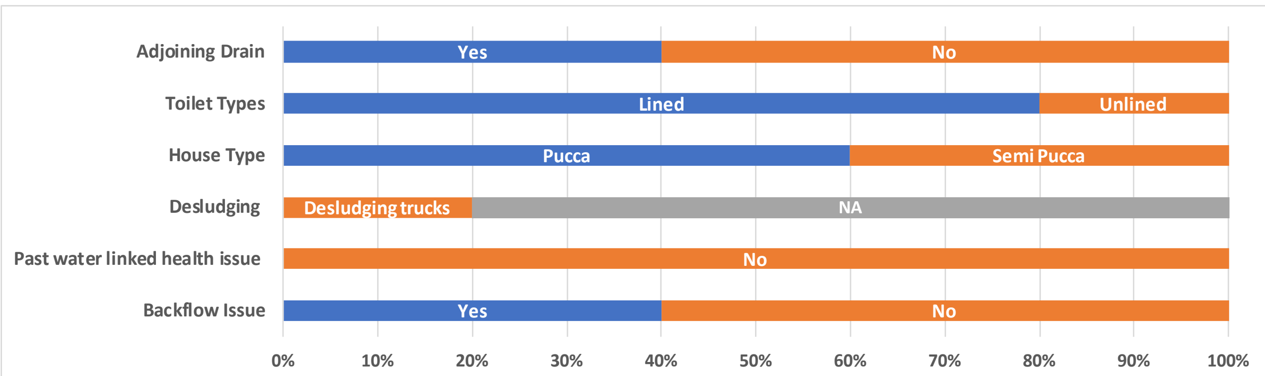
iv. **Hafiznagar 2**; Households: **25 (approx.)**

- Mostly narrow road width (less than 2 meter) while some of internal roads are even kutcha
- Poor drainage coverage and in most of the lane drainage is not available
- There is no water body nearby the settlements and portions of area are falling under water depreciation zone and leading to frequent water ponding
- Locality has KWASA supply coverage but almost all HHs are mostly using hand pumps and bore wells
- Residents are mostly HIG and MIG community
- Secured land tenure and low population, built-up density

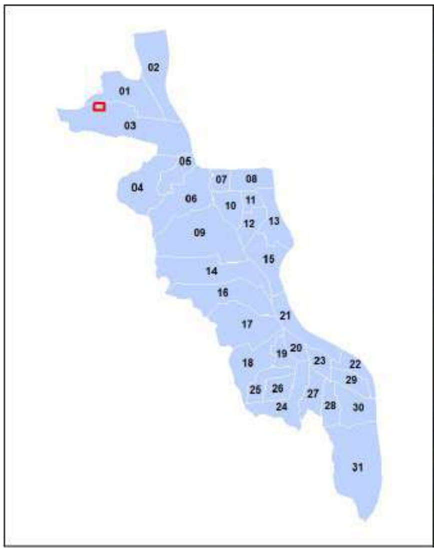


v. **Karim Nagar (choto boyra);** Households: **35 (approx.)**

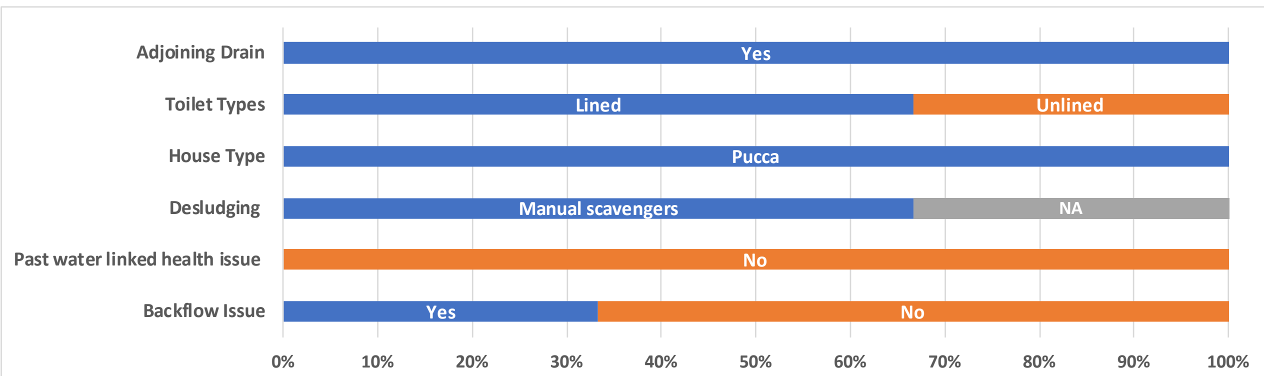
- Part of road width less than 2 meter and mostly covered with pucca drainage network.
- Locality has KWASA supply coverage but HHs are mostly using hand pumps and bore well
- Settlement is close to water pond and only a part of the area is facing issues with water ponding
- Residents are mixed income group from LIG to HIG.
- Secured land tenure and moderate population, built-up density



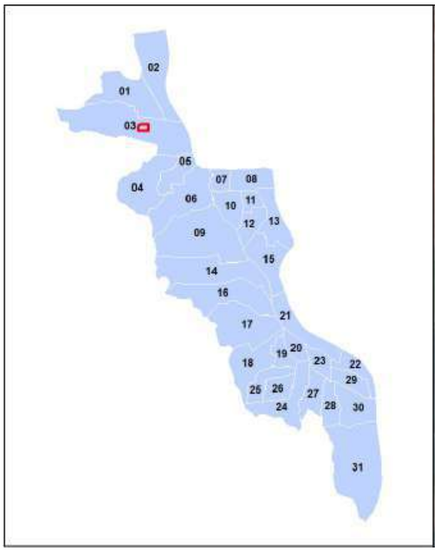
vi. **Ghosh Para;** Households: **25 (approx.)**



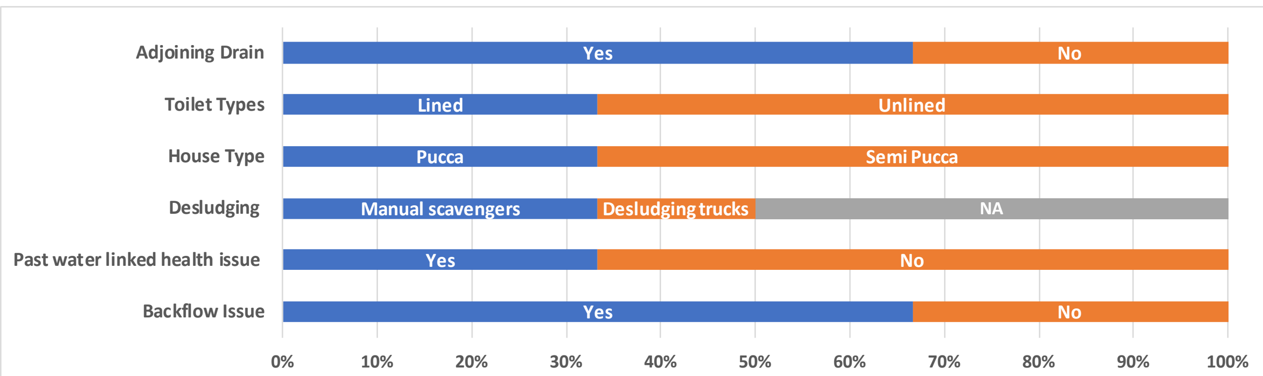
- Narrow road width (less than 2 meter) all across the settlements and partly covered with pucca drainage network
- Locality has KWASA supply coverage but HHs are mostly using hand pumps
- Settlement is close to water pond and only a part of the area is facing issues with water ponding
- Residents are mostly low-income community
- Mostly secured land tenure and low population, built-up density



vii. **Masheshwarpasa Moddhodanga Uttar Para**; Households: **30 (approx.)**

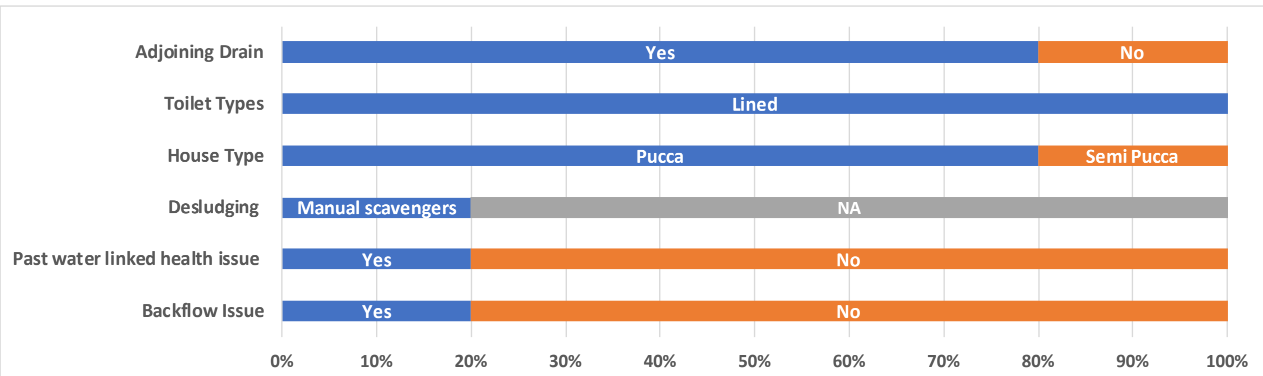


- Narrow road width (less than 2 meter) and poor drainage coverage all across the settlements
- Locality has KWASA supply coverage but HHs are mostly using hand pumps and bore well
- There is no water body nearby settlements and portions of area are falling under water depreciation zone and leading to frequent water ponding
- Residents are mostly low-income community
- Secured land tenure and moderate population, built-up density

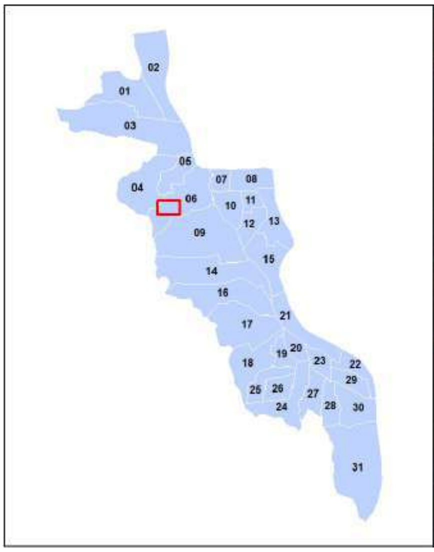


viii. **Deyana Daulatpur;** Households: **100 (approx.)**

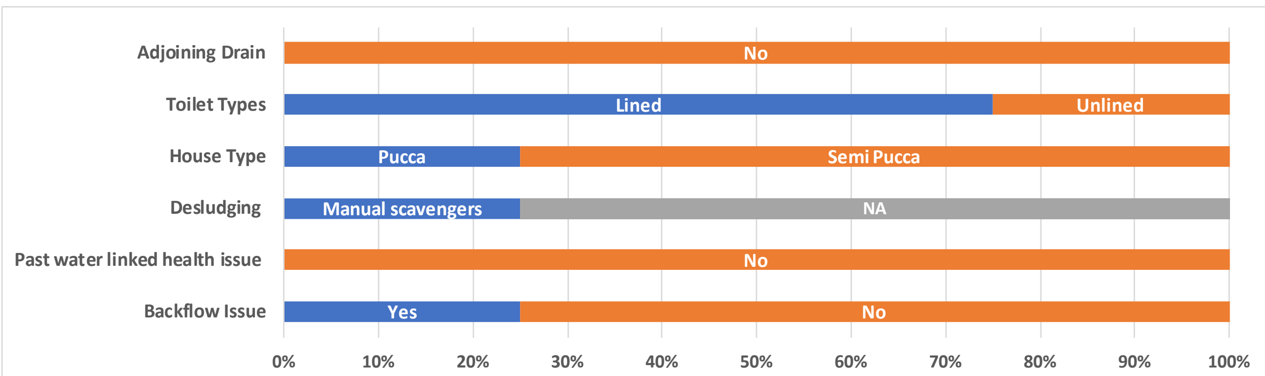
- Mostly narrow road width (less than 2 meter) and adequate drainage coverage all across the settlements
- Locality has KWASA piped water household coverage
- This is close to water pond and significant portions of settlements are falling under water depreciation zone and leading to frequent water ponding
- Residents are mixed income group from LIG to HIG.
- Secured land tenure and high population, built-up density



ix. **Deyana Pabla karikor para;** Households: **120 (approx.)**

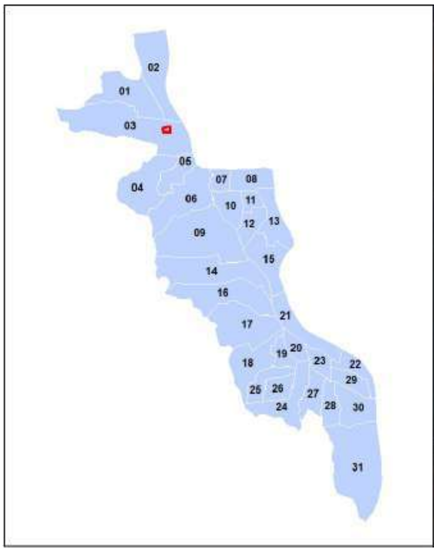


- Narrow road width (less than 2 meter) and poor drainage coverage all across the settlements
- Locality has KWASA supply coverage but HHs are mostly using hand pumps and bore well
- This is close to water pond and significant portions of settlements are falling under water depreciation zone and leading to frequent water ponding
- Residents are mostly low-income community
- Secured land tenure and moderate population, built-up density



5.3.2 High Rise Residential Building

i. **Palpara (Jora Pach Tala) Religare Housing Complex;** No. of floors: **5**



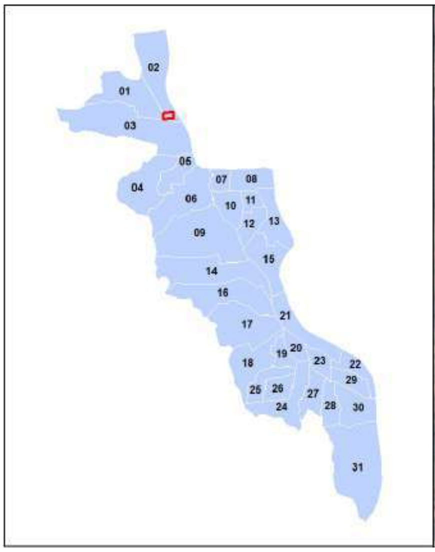
- Around 40 family residing into this five-story building with access road width as 3.5 meter
- A common large septic tank is built the serve the purpose which has outlet open to abutting drain with frequent tank choking issues
- Approx. size of tank is 10*12*20 feet
- This was manually desludged last time in 2016 with approx. charges of 1500 BDT
- During consultation household acknowledge the issue of poor handling of wastewater discharge and were willing to have wastewater treatment solutions installed in the premises with given technical support

5.3.3 Educational Institutions

i. **Maheshwarpasa Girls High School**

- This is one of the oldest girl's high school of Khulna city and established in year 1864
- Total plot area is 04. Acre with four different building premises each having two floors with main access road width around 3.5 meter
- There are total 300 students currently commuting here regularly, and four staffs stays as full-time
- There are two large lined tanks situated in school premises with outlet directly getting discharged into open drain
- No on-site treatment is available and school administration showed keen interest towards setting of DEWATS provided technical supports are provided
- Last desludging was undertaken in year 2017 with manual operation and fees payment of around 1500 BDT
- It was informed that tank choking is an occasional issue but sometimes even had to take call manual scavengers to handle the situation

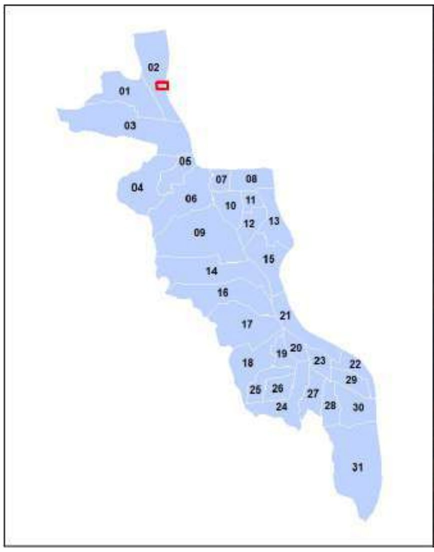
ii. Maheshwarpasa K.M. Gov. Primary and High School



- This education centre is running since 1921 and also considered among the old league
- Total plot area is 1 acre with five different building blocks and height up to four story with main access road width around 7 meter
- There are total 426 students currently commuting here regularly, and two staffs stays as full-time
- There are three large lined tanks situated in school premises with outlet directly getting discharged into open drain
- No on-site treatment is available and school administration showed keen interest towards setting of DEWATS provided technical supports are provided
- Respondents were not informed about last desludging operations
- It was informed that tank choking is an occasional issue but sometimes even had to take call manual scavengers to handle the situation

5.3.4 Industrial Colony

i. Anser Staff Colony (flour mill)



- This colony is located along the Bhairab river and most of internal road stretches are less than 2-meter road width
- For some of houses, there are some common sludge collection chamber, and this is directly getting discharged into the River
- Colony have mix toilet typology of lined, unlined and directly connected to adjoining water body
- Settlement population and built density is moderate and residents mostly consist of LIG and MIG households
- Houses are pucca/Semi-Pucca and mostly secured tenant

5.4 Common consideration for DEWATS suitability

- All existing large institutional areas, residential colony and high rise building if not covered (or proposed to be covered) as part of sewerage operations should always have DEWATS system installed in their premises. Similarly, for any new constructions of similar usage should have DEWATS mandatory at the stage of building plan approval itself.
- All settlements with narrow road access and beyond the reach of desludging pipe should have DEWATS installed at accessible location.
- DEWATS necessity become higher in case of settlements having adequate water supply coverage with higher built-up density and prone to water ponding
- Other higher suitability case of DEWATS would be in settlements with high frequency of water borne diseases
- DEWATS system has no direct relation with socio-economic status of households

5.5 Project Applicability

- KCC is considering this as good base to plan the augmentation of non-sewer infrastructure including building new DEWATS units and purchasing of desludging trucks for future planning. A project proposal (DPP) for national government funds is being prepared for DEWATS.
- KWASA has shown keen interest to take up this study as a good base for phase II of the sewerage augmentation plan of Khulna city. The research results showed around 95% match of KWASA's sewerage coverage map.
- National Urban Poverty Reduction Project (NUPRP) is being implemented by UNDP, which profiled city's urban poor areas. Some of the pockets for DEWATS identified by the study, with higher degree of economic vulnerability, can potentially be supported by the project for immediate implementation.
- A separate study is being undertaken (supported by SNV) as financial outlay tool for non-sewer and sewer interventions in Khulna. Different scenarios are being defined according to study findings, while factoring existing infrastructure/resources available.
- Other cities, like Gazipur, have also showed keen interest in the study and the model, to pragmatically approach the expansion of sanitation collection systems and coverage.
- This study is being developed in form of GIS based replicable model to explore an automation option to provide the spatial results with data inputs of relevant parameters for any gepgraphy.

Decision Support Tool for Sanitation Intervention (DSTSI)

Key Benefits

Rapid assessment tool to identify the pan city sanitation interventions

Can be integrated as part of **city sanitation feasibility** assessment and will serve as a good foundation before any detailed engineering study and related implementations

Giving directions on related city sanitation interventions to avoid any duplications/overlap of any future schemes and plans

Support city to achieve **inclusive and safe sanitation for all** (aligned with CWIS principles)

Designing the sanitation interventions basis to related issues and challenges and help to firm up a **customized sanitation solutions** for each settlement area

Applicability at City Scale

More applicable for bigger city having need or plan of sewerage scheme implementations

Designing of sanitation intervention in terms of sewerage, FSM and DEWATS

Area based intervention prioritization in terms of **fixed sanitation solutions** and **alternative sanitation options** to ease out on decision making process

Guide on **regulatory action** for city sanitation improvement including identified building premises and locality with need for setting of DEWATS, estimations on operations cost recovery through city sanitation tariffs etc.

Critical Success Factor

Availability of **geo-spatial** data base

Active participation of line agencies

Way Forward

Link the final interventions with broad cost-estimations and further add another scenario of suitability basis to available **project financing options** and assured plan for **operational cost recovery**

Integrate with platform of **artificial intelligence** so as to reduce the data dependency requirement and improve on **system automation** for decision making

5.6 Conclusion and Way Forward

This study would facilitate suitable and alternative sanitation solutions in various parts of Khulna city to be taken up for phase wise implementation by KCC and KWASA and is further expected to maximize the access of safe treatment wider population and spatial coverage. Apart from technical parameters, project sustainable financing can be also explored as part of decision-making framework. A board cost estimation can be worked out basis to sanitation interventions and further linked with project financing options and assured plan for operational cost recovery.

With geo-spatial technology, significant field information can be gathered in limited time frame to apply the full version of this model in any other geography. As a way forward Integration of this decision-making tool with other sanitation tools can be also explored to maximize overall benefits. By using the latest ArcGIS Pro software, the decision-making model can be redeveloped by integrating Artificial Intelligence (AI) and Deep Learning tools to easily interpret and extract information such as building footprints, heights, road network, width, land cover etc. from satellite imageries and OpenStreetMap. This will reduce the dependency on data collection and improves upon the automation for final sanitation intervention. Interestingly because of AI, the system would become more experienced and improves over time with respect to its output efficiency and accuracy.

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