FLOOD MANAGEMENT IMPROVEMENT SUPPORT CENTRE
Water Resources Department, Government of Bihar

FINAL REPORT

BIHAR KOSI FLOOD RECOVERY PROJECT

Consultancy Services for Designing, Developing and Deploying Embankment Asset Management System for Kosi Basin (K-EAMS)
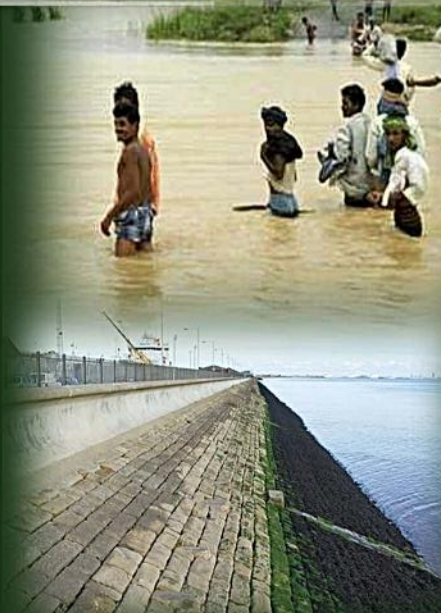

(Revision -II)

July 2015

LEA Associates South Asia Pvt. Ltd.,
New Delhi

1. INTRODUCTION

1.1 PROJECT BACKGROUND

Water Resources Department, Government of Bihar (GoB) has embarked upon several major initiatives and projects under the Bihar Kosi Flood Recovery Project. Embankment Asset Management System (EAMS) for Kosi River with assistance from the World Bank is one of the important project amongst them.[1]

EAMS is a major project and has several important components in it. Development of Asset Management System (AMS) for the Kosi Embankments is one of the important mandates of EAMS. The AMS is envisioned to assist the Flood Management Improvement Support Center (FMISC), Water Resources Department (WRD) to rationalize decision making process at various levels in maintenance and strengthening of existing embankments, anti-erosion works and flood protection works.

In view of the scope of the present system under development for the Kosi Basin, it is appropriate to call it as Kosi Embankment Asset Management System and hence referred to as **K-EAMS**. WRD has retained LEA Associates South Asia Pvt. Ltd. (LASA), India as a consultant for this purpose.

1.2 PROJECT DESCRIPTION

For K-EAMS, Embankment Management System has been developed on GIS platform with capability of populating the information/data to GIS based application having capacity to house multiple file types that may be used for different activities related to embankment. During inspection, all the information about embankments will be collected along with photographs of affected portion of embankments or its assets on Android Tablet with GIS platform. As these data records of information would keep on increasing day-by-day, a database has been established that is capable of tracking and linking to multiple file types. Though each file type will have potential to be different, all file types would be stored in an information system.

Engineering Information records will be available on web based system with user defined access. Dynamic Engineering information like rainfall, water level and discharge etc have been integrated in the system - gaugewise and yearwise. Soil investigation data along with location surveyed, date of survey & reports of bore-hole logs have been integrated within river system. Records of design Formation Level & HFL, Inundation records are also integrated and available with a click on desired location along the embankment. Topographical survey, morphological and flood plain topographical data has been maintained - yearwise and riverwise.

Post flood inspection of entire Embankment should be performed by field engineers by hand held device (Android tablet) along with photographs of the damaged works which would be uploaded. After assigning a particular rank of the damage depending on its intensity (as A, M and U), concerned Chief Engineer (CE) will prepare Damage Assessment Report and formulate appropriate schemes for approval of works to be taken up for their remediation. A Detailed Performance Report of such works (completed during pre- flood period) should be prepared. Relevant schemes detailing future protection measures or re-designs of scheme components, if required, shall also be prepared by CE for approval. The Consultant have also proposed Asset

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[1] The Government of Bihar (GoB) through the Government of India (GOI) has received a loan from the International Development Association (IDA) for implementation of Bihar Kosi Flood Recovery Project (BKFRP) and intends to apply a portion of this loan to finance consultancy services for establishing an Embankment Asset Management System for Kosi Basin.

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Monitoring System in K-EAMS wherein the findings of Post-Flood Site Inspection and Intermediate Site Inspection undertaken by field inspectors would be incorporated.

Various reports and approvals as per Standard Operating Procedure (SOP) will be uploaded and viewed by WRD officials. Thus SOP monitoring system will have two components:

- Status of Approval - It will update all reports for site visit by Anti Erosion Committee, sub-committee of Kosi Committee, Kosi High Level Committee, recommendations of TAC, SRC, administrative approval of schemes etc.
- Monitoring of Tendering Process - It will contain all tenders floated for works defined/approved under 'status of approval' and status of execution.

SOP monitoring system will be accessible to all higher officials of WRD from administrative level officers to Executive Engineers.

There is also provision of Store Material Information System in K-EAMS to access current status of flood fighting material available in various stores. The locations of stores (Flood Store, Mechanical Store and Site Store) along with current status of availability of flood fighting material, is shown on web enabled GIS which can be accessed by concerned officer at any time. This will help field inspector to get quick information about the availability of flood fighting material during critical times.

1.3   NEED FOR CENTERALISED ASSET MANAGEMENT SYSTEM

Understanding the morphological behavior of highly meandering river like Kosi has always been a challenge. It becomes all the more significant during floods, when it poses a threat to life and property. To minimize these losses it is vital to monitor the changes occurring in the river basin with time and protection measures adopted to cope with these changes. Thus it calls for collective effort of local community and Bihar Govt. officials who have observed Kosi flood damages over the years for preventing and controlling the river damages. Embankments constructed for controlling the river course are an important asset and therefore, their regular supervision and maintenance is of utmost importance.

Presently, there exists a time-consuming conventional practice for planning and maintenance of embankments which is not able to cope up with the frequent damages to which these embankments are subjected to. Therefore, the focus of the the project "Designing, Developing and Deploying Embankment Asset Management System for Kosi Basin" is to ensure that the WRD is able to assess the problem in right perspective in real time, plan the remedial measures and effectively prioritize works which have to be executed for the damages, as well as to quickly report on its physical status/condition using a computerized EAMS suitable for operating on a GIS platform. This will, in turn, help to improve the quality and delivery of WRD services in the management of the embankment network.

The K-EAMS will enhance the capabilities of the WRD by providing a source of readily accessible, relevant and valid information on the embankment system as well as improved support for decision-making by providing analytical tools.

The operation of the embankment database and the evaluation tools will be easy and logical, so that K-EAMS outputs are useful to decision-makers and the WRD.

The specific objectives of services will be:
- To develop and establish an electronic Embankment Asset Management System (EAMS) at the headquarters
- To establish community participation system, so that local community can also give their feedbacks on Embankment maintenance and functioning during floods.

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- Transfer skills and procedures to adequate number of staff in the WRD to sustain the use of the EAMS during, as well as after the end of the consultancy services

1.4 PROJECT STATUS

Agreement of the Consultancy services for ***Designing, Developing and Deploying Embankment Asset Management System for Kosi Basin***, was signed by LEA Associates South Asia Pvt. Ltd (Consultants) on 6th Jan 2014 and the work commenced on 5th Feb 2014 as per contract schedule.

In partial fulfillment of the tasks of the assignment, the consultants have so far submitted following reports as per agreed project schedule of deliverables:-

Sl. No.	Report Submitted / Workshop Conducted	Date of Submission	Submittal No. as per Appendix-B
1	Inception report	10 Mar 2014	**First**
2	Final Inception Report (After incorporation of all comments on Inception Report)	30 Apr 2014	**First**
3	First Quarterly Progress Report	22 May 2014	Second
4	First Workshop conducted at Birpur	24 May 2014	
5	Second Workshop Conducted at Patna	30 May 2014	
6	Design Report	14 Aug 2014	**Third**
7	Second Quarterly Progress Report	28 Aug 2014	Second
8	Third Quarterly progress Report	26 Nov 2014	Second
9	Final Design Report after incorporating comments	29 Nov 2015	**Third**
10	Training Plan Beta Version of EAMS System	12 Dec 2015	**Fourth**
11	Fourth Quarterly progress Report	18 Feb 2015	Second
12	Draft Final Report including Users' and Operational Manuals and Reporting Protocols	14 April 2015	**Fifth**
13	Deployment Manual	22 May 2015	
14	Final Report	29 Jun 2015	**Sixth**
15	Final Report after Incorporation of all comments	06 July 2015	**Sixth**

"Inception Report" covering analysis of data availability & data quality, conceptual design of embankment asset management system, methodology for development of system, identification of data input for the system, output expected and fortnightly schedule of work plan etc. was submitted on **10th March 2014,** as **First** deliverable. Final Inception Report was submitted on **30th Apr 2014** as a part of First Submittal after incorporation of all comments received on Inception Report.

This was followed by **"First Quarterly Progress Report"** submitted on **22nd May 2014,** as per scheduled deliverables, as the **Second** submittal.

In addition to it, the consultant has conducted two Stakeholders' Consultation Workshops for need analysis and feedback from stakeholders about the K-EAMS as a part of First submittal. The first workshop was conducted at Birpur on **24th May 2014** and the second workshop was conducted at Patna on **30th May 2014.**

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The "**Design Report**", was the **Third** submittal submitted on 14th Aug 2014 followed by the "**Second Quarterly Report**" which was submitted on 20 Aug 2014 as a part of **Second** Submittal.

The "**Third Quarterly Progress Report**" was a part of **Second** submittal and has been submitted on 26th Nov 2015.

The **"Design Report"** as a part of third submittal was resubmitted as "**Final Design Report**" on 29 Nov 2014 after incorporation of all comments on Design Report received by the client on 18 Sep, 22 Sep & 26 Sep 2014. Replies of these comments have already been submitted separately.

The **"Training Plan Beta Version of EAMS System"** as a part of fourth submittal was submitted on 12 Dec 2014.

The "**Fourth Quarterly Progress Report**" was a part of **Second** submittal and has been submitted on 18th Feb 2015.

"**Draft Final Report including Users' & Operational Manuals and Reporting Protocols**" is the **Fifth** submittal as per scheduled deliverables. These include Users' & Operational Manual, Reporting Protocols and their formats for acceptance.

"**Deployment Manual**" was in addition to the submittal given in Appendix-A and was submitted on 22nd May 2015

"**Final Report**" is the **Sixth** and last submittal among the agreed deliverables and was submitted on 29 Jun 2015. The same is being resubmitted after incorporation of all comments on 06 July 2015.

1.5   PURPOSE OF THIS REPORT

As part of the EAMS Project for WRD, the most crucial objective is not only to design and develop a web based GIS tool and android tablet data collection solution, but to integrate and automate workflows and provide all stakeholders a decision support tool for management of embankment, its assets and floods within the Kosi basin. This will help in streamlining the entire process of collection, storage, management and processing of embankment asset data, coupled with its quick availability on a centralized computerized system. This Completion Report is an assessment of recent, relevant information in the design and development of an Embankment Asset Management. The focus is primarily on the development of the beta version based on users' need studies and subsequent design showcased to the WRD Review Committee. It also focuses on the various issues and compatibility of the EAMS that govern the functioning of the solutions.

1.6   STRUCTURE OF THIS REPORT

The entire "**Draft Final Report**" has been divided into seven chapters (including this) as given below:
Chapter-2:   Kosi Embankment Assets
Chapter-3:   Design Concept of K-EAMS
Chapter-4:   Reporting Protocols & Formats
Chapter-5:   System Architecture & Technology
Chapter-6:   Non-Functional System Requirement
Chapter-7:   Design Constraints

2. KOSI EMBANKMENT ASSETS

2.1 OVERVIEW

After the floods in Kosi river in Aug 2008, which breached Kosi Eastern Afflux Embankment from 11.37 Km to 13.60 Km at 13km upstream of the Kosi Barrage and 8 km north of the India-Nepal border, Water Resources Department, Government of Bihar (GoB) took up several major initiatives and projects under the Bihar Kosi Flood Recovery Project. Embankment Asset Management System (EAMS) for Kosi River with assistance of the World Bank is one of the important projects amongst them.

Water Resources Department" (WRD), Government of Bihar is the implementing agency for implementing the project for Strengthening Flood Management Capacity in Kosi Basin with the assistance of **"Flood Management Improvement Support Centre"** (FMISC), a unit of WRD.

Presently, there exists a time-consuming conventional practice for planning and maintenance of embankments which is not able to cope up with the frequent damages to which these embankments are subjected to. Therefore, the focus of the the project "Designing, Developing and Deploying Embankment Asset Management System for Kosi Basin" is to ensure that the WRD is able to assess the problem in right perspective in real time, plan the remedial measures and effectively prioritize works which have to be executed for the damages, as well as to quickly report on its physical status/condition using a computerized EAMS suitable for operating on a GIS platform. This will, in turn, help to improve the quality and delivery of WRD services in the management of the embankment network. The K-EAMS will enhance the capabilities of the FMISC, WRD by providing a source of readily accessible, relevant and valid information on the embankment system as well as improved support for decision-making by providing analytical tools.

The aim of this effort is to create EAMS suitable for sustainable implementation in Kosi Basin. This will streamline the entire process of collection, storage and processing of embankment asset data, hydrologic and hydro-meteorological data and silt data for the embankment system on annual basis. Keeping in view the limitations of FMISC and WRD, the task of data collection may have to be simplified as much as possible. The operation of the embankment database and the evaluation tools should be easy and logical, so that K-EAMS outputs are useful to decision-makers and the FMISC, WRD.

The specific objectives of the services are, to:

- Develop and establish an electronic Embankment Asset Management System (EAMS) at the headquarters; and
- Transfer skills and procedures to adequate number of staff in the WRD to sustain the use of the EAMS during, as well as after the end of the consultancy services.

2.2 ASSETS

K-EAMS will be consisting of following assets (Embankments & Structures) of the Kosi River Basin (Refer Table 2-1 and Figure 2-1).

Table 2-1: Details of Embankments

Sl. No.	Name of the Embankment	River	Jurisdiction	Length
1	Eastern afflux embankment (EAB) at u/s of Kosi Barrage	Kosi	CE, WRD, Birpur	32 km
2	Western afflux embankment (WAB) at u/s of Kosi Barrage	Kosi	CE, WRD, Birpur	12 km
3	New Nepal Embankment (Above EAB)	Kosi	CE, WRD, Birpur	15 km
4	Eastern Kosi embankment (EE)	Kosi	CE, WRD, Birpur	125 km

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Sl. No.	Name of the Embankment	River	Jurisdiction	Length
5	Western Kosi embankment (WE)	Kosi	CE, WRD, Birpur	47 km
6	Nirmali Ghoghrdia Link Road	Kosi	CE, WRD, Birpur	8.5 km
7	Ghoghrdiha Ghoghepur Embankment (GGE)	Kosi	CE, WRD, Birpur	54 km
8	Sikrahatta – Majhari Low Embankment (SMLE)	Kosi	CE, WRD, Birpur	18 km
9	Extended Sikrahatta – Majhari Low Embankment (ESMLE)	Kosi	CE, WRD, Birpur	21.5 km
10	Tiljuga left and right Embankment	Tiljuga	CE, WRD, Birpur	25 km
11	Bhutahi Balan left and right Embankment	Bhutahi Balan	CE, WRD, Samastipur	54.70 km
12	Badlaghat – Nagarpara Embankment (BME)	Kosi	CE, WRD, Samastipur	35.65 km
13	Nagarpara – Narayanpur Embankment (MNE)	Kosi	CE, WRD, Bhagalpur	31.0 km
14	Tirmuhani – Kursela Enbankment (TKE)	Kosi	CE, WRD, Bhagalpur	28.0 km
15	Kamala Balan Left Bank Embankment from Indo Nepal Border (Jainagar) to Kothram (leaving gap from 12.5 km to 22.5) – (KBLBE)	Kamala Balan	CE, WRD, Samastipur	103.0 km
16	Kamala Balan Right Bank Embankment from Indo Nepal Border (Jainagar) to Kothram – (KBRBE)	Kamala Balan	CE, WRD, Samastipur	96.5 km
			Total Length (A)	**706.85 km**
17	Jamindari Bunds			
	i) Telhar	Kosi	CE, WRD, Samastipur	17.50 km
	ii) Chorhli	Kosi	CE, WRD, Samastipur	13.50 km
	iii) Lagma-Bharpura	Kosi	CE, WRD, Samastipur	3 km
	iv) Baltara	Kosi	CE, WRD, Samastipur	3.50 km
	v) Bagjan	Kosi	CE, WRD, Bhagalpur	10 km
	vi) Mahadev ring bund	Kosi	CE, WRD, Birpur	3.70 km
			Total Length (B)	**51.20 km**
			Total Length (A+B)	**758.05 km**

The list of Structures on Embankments is provided in Table 2-2.

Table 2-2: List of Structures on Embankments

Name
Kosi Barrage, Head Regulator & Siphon
Bank protection works like Spurs, studs and revetments
Bed Bars on Western Afflux Embankment
Sluice, Silt Excluder and Ejector
Stream / Drainage Outfall
Bridges

The list of other Assets on Embankments is provided in Table 2-3.

Table 2-3: List of other Assets on Embankments

Name
Flood Store
Mechanical Store
Site Store

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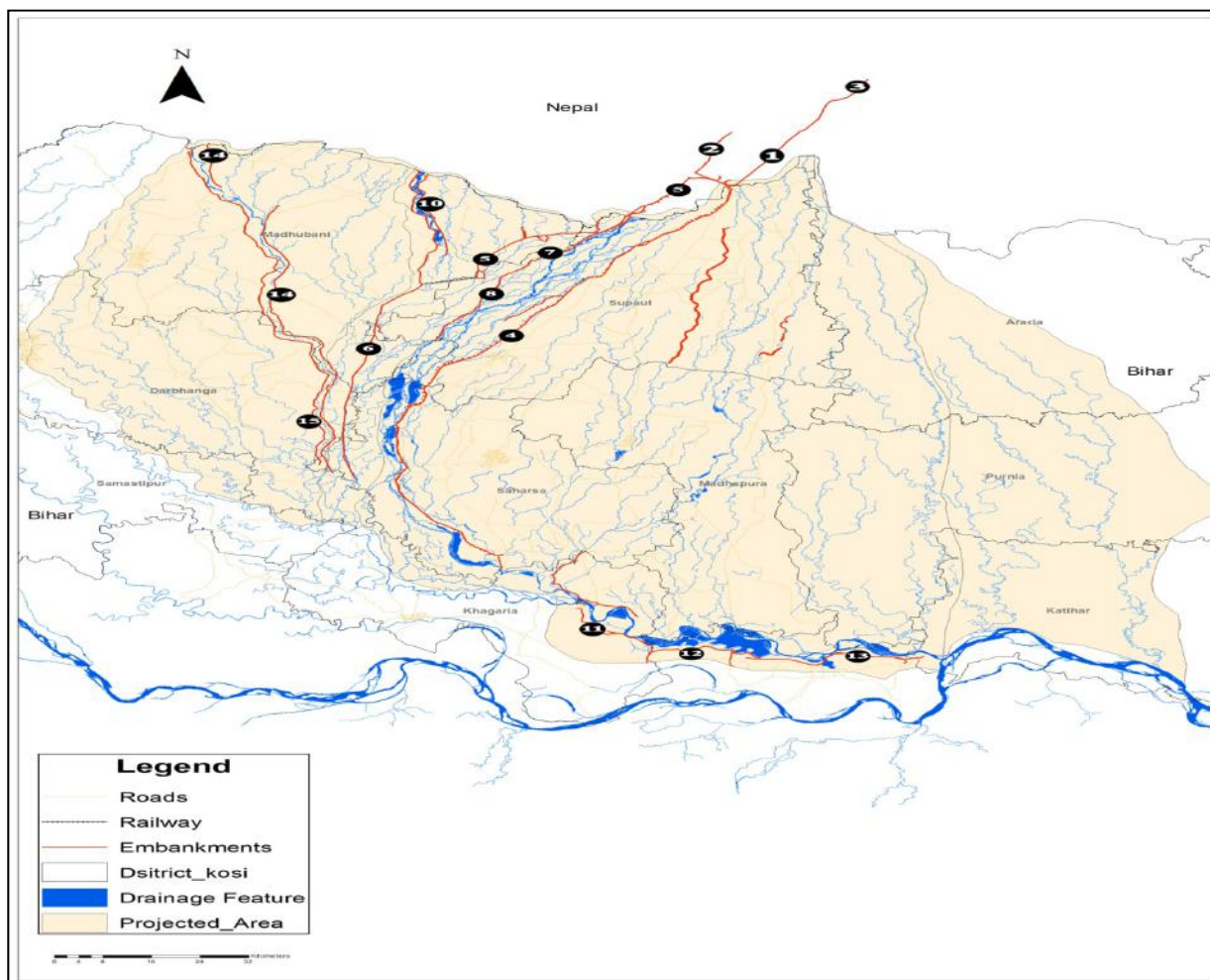Asset Management System for Kosi Basin (K-EAMS)

Figure 2-1: Location of Embankments in Kosi Basin

3. DESIGN CONCEPT OF K-EAMS

3.1 OVERVIEW

K-EAMS is a web based application on GIS platform. K-EAMS has been formulated which comprises of various modules according to the functionality. A user can access all the modules from home page itself. Furthermore, the components shall be accessible via an internet browser for viewing, updating & reporting purposes. In addition to viewing of various outputs, it will also be possible to extract information from K-EAMS through an internet browser. The WRD, HQ or FMISC will be able to administer the system on LAN or VPN for updating administrative master data, satellite images etc. Design concept of the K-EAMS is based on the various functional modules as given in the Figure 3-1.
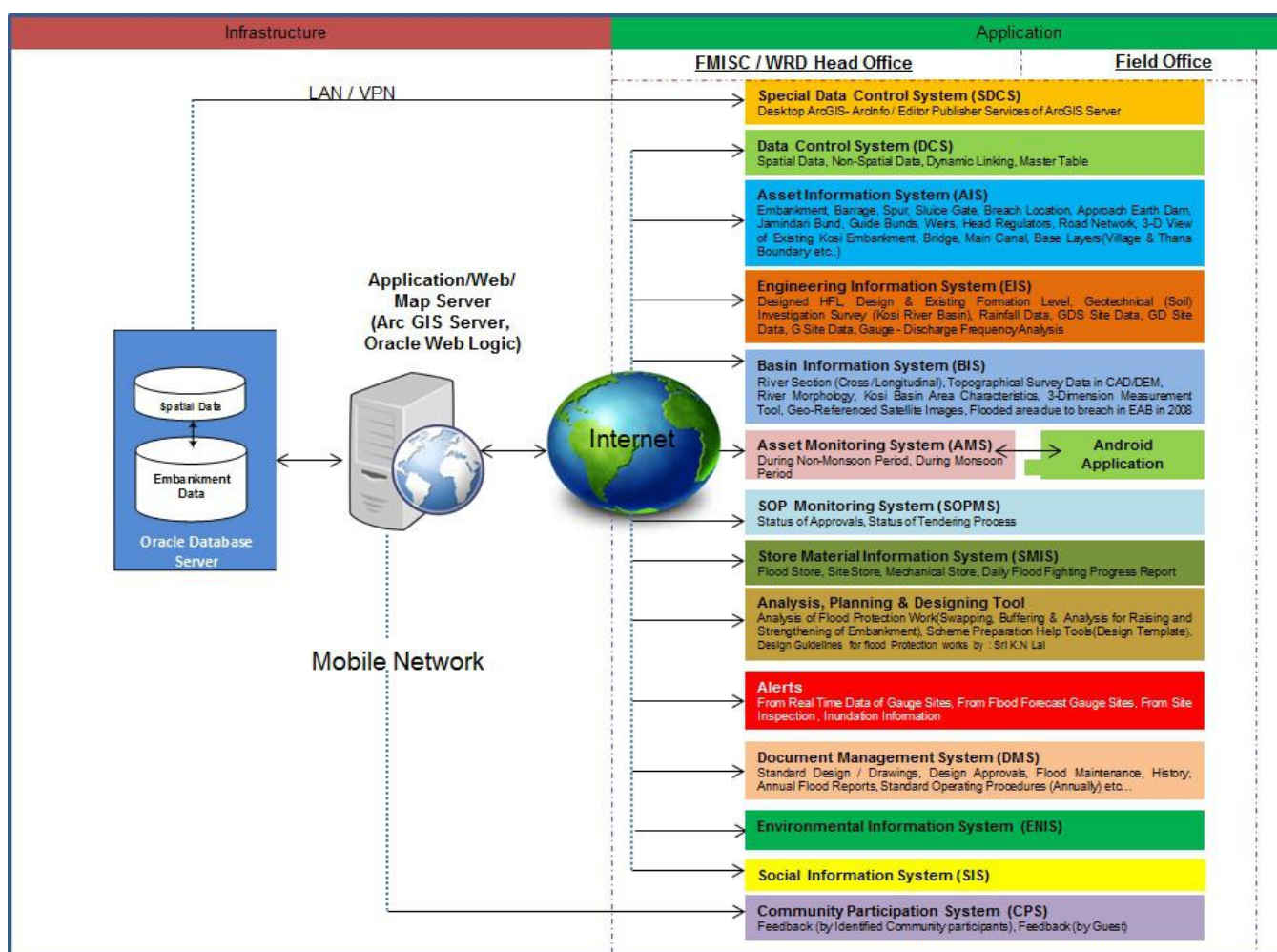
Figure 3-1: Functional Modules of K-EAMS

3.2 K-EAMS MODULES

The K-EAMS comprises of following major Modules / Systems:

1. **Special Data Control System (SDCS)**

   - Desktop ArcGIS-ArcInfo / Editor
   - Publisher Services of ArcGIS Server

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2. **Data Control System (DCS)**

- Spatial Data
- Non- Spatial Data
- Dynamic Linking
- Master Table

3. **Asset Information System (AIS)**

- Km stone Survey
- Bridge on Embankment
- Bridge on River
- Anti-Flood Sluice
- Sluice Gate
- Site Store
- Flood Store
- Mechanical Store
- Silt Ejector
- Silt Excluder
- Head Regulator
- Weir
- Drainage Outfall
- Siphon
- Vulnerable Site
- Breach Location
- Barrage
- Divide Wall
- Main Canal
- Guide Bundh
- Jamindari Bundh
- Approach Earth Dam
- Revetment Works
- Revetment works under soil
- Spur
- Embankment
- Flood Camp Site
- WRD Office
- Barrage Control Room
- Base Layers – International Boundary, District Boundary, Village & Thana Boundary, River, Railway Network, Railway Station, Road Network, Proposed Strengthening Work by EKE , Road Constructed by WRD , Dhar, Project Area

4. **Engineering Information System (EIS)**

   a. Design HFL & Formation Level-GFCC(2008)
      - Eastern Kosi Embankment
      - Western Kosi Embankment

   b. Geotechnical (Soil) Investigation Survey
      - Kosi River Basin – from BSHPC - DPR prepared by WAPCOS

   c. Rainfall Data

   d. Gauge & Discharge Data

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- Kosi
  - ➢ Barahkshetra
  - ➢ Birpur
  - ➢ Baltara
  - ➢ Basua
  - ➢ Kursela

- Kamala
  - ➢ Jayanagar

- Kamala Balan
  - ➢ Jhanjharpur
  - ➢ Jhanjharpur (Railpul)
  - ➢ Agropati
  - ➢ Darjee
  - ➢ Gausaghat
  - ➢ Pirokhar
  - ➢ Uchait

e. Sediment Load
  - Kosi
    - ➢ Barahkshetra
    - ➢ Birpur
    - ➢ Baltara

  - Kamala
    - ➢ Jayanagar

  - Kamala Balan
    - ➢ Jhanjharpur

f. Borrow Area

g. Discharge Frequency Analysis

h. Silt Factor and Grain size

i. Existing Cross Section of Embankment (2013)

5. **Basin Information System (BIS)**

   a. Kosi River Section (Cross-section /Longitudinal)
   b. Topographical Survey Data of Kosi - AutoCAD
   c. Topographical Survey Data of Kosi - DEM
   d. Geo-referenced Satellite Images
   e. Kosi River Morphology from NIH report
   f. Kosi Basin Area Characteristics
   g. Flooded area due to breach in Eastern Afflux Bundh in 2008

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6. **Store Material Information System (SMIS)**

   a. Flood Stores
   b. Site Stores
   c. Mechanical Stores
   d. Daily Flood Fighting Progress Report

7. **Analysis, Planning & Design Tool**

   a. Analysis of Flood Protection Works

   - Analysis for Raising and Strengthening of Embankments
   - Swapping Tool (for annual River Migration Analysis)
   - Buffering Tool (for New Bank Protection Works / New Flood Effected Area)
   - Life Cycle Analysis
   - River Morphology

   b. Help Tools

   - Planning of New Flood Protection Works
   - Scheme Preparation (Design Templates)
   - Design Guidelines for Flood Protection Works by Sri K N Lal

   c. Training Material
   - Analysis & Design of Dams
   - Design Flood Estimation
   - Design of Weirs, Barrage and Canals

8. **Inform Site Specific Observation to WRD**

   a. Feedback (by Identified Community participants)
   b. Feedback (by Guest)

9. **Document Information System (DIS):**

   A). Legacy Data

   a. Standard Drawings
   b. Flood Maintenance History
   c. Annual Flood Reports
   d. Standard Operating Procedures (annually)
   e. Schemes Approved by G.F.C.C. & Fund provided by G.O.I.
   f. Geo Referenced Satellite Imageries (annually)
   g. Report - Sub-Committee of Kosi High Level Committee (annually)
   h. Report of Technical Advisory Committee (TAC) – annually
   i. Report of Kosi High Level Committee (annually)
   j. Report of Scheme Review Committee (annually)
   k. Geo-Technical Investigation Report
   l. Topographical Survey Data on AutoCAD
   - Kosi River and Embankment
   - Kamala River and Embankment
   - Bhutahi Balan River and Embankment
   m. DEM
   - Kosi River and Embankment

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- Kamala River and Embankment
- Bhutahi Balan River and Embankment

B). Codes & Manuals

a. ISI / BIS Codes
b. Manual

C). Guidelines from Other Sister Organizations

D). Miscellaneous Documents

a. Disaster Management Manual
b. GFCC Master Plan for Flood Management for Kosi Basin
c. Technical Reports of 1965 & 1971
d. CWPRS Pune Report of 2008
e. Breach Closure of 2008 – process adopted and experience gained
f. Kosi Barrage History 1 & 2

10. Environmental Information System (EIS)^

11. Social Information System (SIS)^

^ These modules have been added on the request of the client beyond scope of the ToR. Client will provide format / structure for these modules and all related data. Design of these modules can be finalized and can be included afterwards.

Kosi Basin's extensive data in form of historical records, flood & damage reports, approved work drawings etc. are available in Govt .offices of WRD, Bihar. However within WRD offices, there is a lack of instant alert/warning procedure & thereafter communication to concerned as well as higher authorities, in case of any embankment or asset failure, water level above design HFL, village submergence etc. Keeping this in view, K-EAMS has been designed to have both functionalities. Whereas, K-EAMS Database will hold valuable engineering records related to Kosi Basin Embankment and its assets, for instant display of any warning related to Kosi basin, home page has been designed to have following three sections:

12. Updates

a. Asset Monitoring
  ➢ During Non Monsoon Period (Routine Measures)
  ➢ During Monsoon Period (Emergency Measures)
b. SOP (Status of Approval)
c. SOP (Tender Monitoring)
d. View Community Observations
e. Maintenance History (Asset)
f. Maintenance History (River)

13. Risk Analysis and Management

a. Site Inspection
g. View Community Observation
h. Real Time
i. Flood Forecast
j. Discharge Hourly - Barahkshetra
k. Discharge Daily - Barahkshetra
l. Inundation
m. Swipe Tool
n. Buffering Tool
o. Asset Monitoring

14. Important Links

Client's interest in getting as much as information related to Kosi basin has been taken care of by adding useful links on the Home page itself. Following links are available on Home screen which are self-explanatory:

- Kosi Weather-Nepal
- India-WRS
- Birpur Barrage Gate
- Kosi Hydro (Nepal)
- ICIMOD
- FMISC
- WRD, Bihar
- CWC
- IMD
- ISRO
- Bihar Weather Forecast
- *Mausam* Bihar

Useful Articles/information vital to Kosi Basin Management have been made available in downloaded icon on Home screen.

3.3   DESIGN CONCEPTS

Design concepts of various modules have been finalized based on the requirement of the ToR, which is being summarized below in terms of Input and Output of various modules.

3.3.1   *Asset Information System*

INPUT

All the input files related to asset information system have been already incorporated in K-EAMS database.

OUTPUT

For the output of asset information system, user can see the following details :

Asset Layers Details:

Asset Layers	Attributes Details
Embankment	• Embankment Name • Design Width of Formation (m) • Design Slope-River Side • Design Slope-Country Side • Section Start Chainage (km) • Section End Chainage (km) • Section Length (km) • Start Chainage of Embankment-Original (km) • End Chainage of Embankment-Original (km) • Total Length of Embankment-Original (km) • Start Chainage of Embankment-Present (km)

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Asset Layers	Attributes Details
	• End Chainage of Embankment-Present (km) • Total Length of Embankment-Present (km) • River Name • Construction Start Date (Year) • Construction End Date (Year) • Section Name • Sub-Division Name • Division name • Circle name • Zone name • Updated by • Updated on • Remarks
Revetment Works	• Embankment name located at • Start Chainage (km) • End Chainage (km) • Revetment Length • River Name • Section Name • Sub-division Name • Division Name • Circle Name • Zone Name • Updated by • Updated on • Remarks
Revetment Under Soil	• Embankment Name • Revetment Start Chainage (km) • Revetment End Chainage (km) • Revetment Length (km) • Updated by • Updated on • Remarks
Spur	• Embankment name located at • Spur Chainage-Original (km) • Spur Chainage-Present (km) • Spur Length-Original (m) • Spur Length-Present (m) • Construction Year Of Spur • Section Name • Sub-Division Name • Division Name • Circle Name • Zone Name • Village Name • Updated by • Updated bn • Remarks
Sluice Gate	• Embankment name located at • Location (km) • Sluice Gate Size (Feet) • River Name

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Asset Layers	Attributes Details	3-8
	• Section Name • Sub-division Name • Division Name • Circle Name • Zone Name • Updated by • Updated on • Remarks	
Anti-Flood Sluice	• Embankment name • Location (km) • Anti-Flood Sluice Gate Size (feet) • River Name • Section Name • Sub-division Name • Division Name • Circle Name • Zone Name • Updated by • Updated on • Remarks	
Drainage Outfall	• Embankment Name Located at • Location-Original (km) • River Name • Village Name • Section Name • Sub-division Name • Division Name • Circle Name • Zone Name • Updated by • Updated on • Remarks	
Approach Earth Dam	• Name • Total Length (km) • River Name • Construction Start Date(Year) • Construction End Date(Year) • Section Name • Sub-division Name • Division Name • Circle Name • Zone Name • Updated by • Updated on • Remarks	

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Jamindari Bundh	• Name • Offtaking Chainage on Eastern Embankment (km) • Joining Chainage on Eastern Embankment (km) • Start Chainage-Original (km) • End Chainage-Original (km) • Total Length-Original (km) • Start Chainage (km) • End Chainage (km) • Total Length (km) • River Name • Construction Start Date(Year) • Construction End Date(Year) • Updated by • Updated on • Remarks	
Barrage	• Barrage Name • Construction Start Date(Year) • Construction End Date(Year) • River Name • Catchment Area (sq km) • Distance of Barrage From Barahskhetra (km) • Design Discharge (cumec) • Length-WRD (m) • Looseness Factor of Barrage • Silt Factor • Number of Bays • Number of Bays - Left Under Sluice • Number of Bays - Spillways • Number of Bays - Right Under Sluice • Length of Bays - Left Under Sluice (m) • Length of Each Span - Left Under Sluice (m) • Length of Each Span - Right Under Sluice (m) • Length of Silting Basin with Friction Block (m) • Lacey Scour Depth - Spillway (m) • Lacey Scour Depth - Under Sluice (m) • Intensity of Under Sluice Discharge (cumec) • Intensity of Spillway Discharge (cumec) • Present Pond Level (m) • Future Pond Level (m) • Crest Level of Under Sluice (m) • Crest Level of Spillways (m)	

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Asset Layers	Attributes Details
	- Gate Size of Under Sluice (m x m) - Gate Size of Spillways (m x m) - Width of Main Pier (m) - Width of Double Pier (m) - Width of Dummy Pier (m) - Left Guide Bundh (m) - Right Guide Bundh (m) - Eastern Weir - Western Weir - Division Name - Circle Name - Zone Name - Updated by - Updated on - Remarks
Guide Bundh	- Name - Length-Original (km) - Length-Present (km) - River name - Construction start date (Year) - Construction end date (Year) - Sub-Division Name - Division Name - Circle Name - Zone Name - Updated by - Updated on - Remarks
Weir	- Weir Name - Weir Length (m) - River Name - Section Name - Sub-division Name - Division Name - Circle Name - Zone Name - Updated by - Updated on - Remarks
Head Regulators	- Head Regulator Name - Number of Gate - Canal Name Located at - Section Name - Sub-division Name

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Asset Layers	Attributes Details
	• Division Name • Circle name • Zone name • Updated by • Updated on • Remarks
Mechanical Store	• Mechanical Store Name • JCB Number • Dredger Number • Number of Cranes • Drogger Number • Number of Truck • Number of Roller • River Name • Division Name • Circle Name • Zone Name • Updated by • Updated on • Remarks
Bridge on Embankment	• Embankment Name Located at • Chainage Original • Bridge Length • River name • Bridge Construction (Year) • Updated by • Updated on • Remarks
Bridge on River	• Bridge Name • Right Embankment Chainage (km) • Left Embankment Chainage (km) • River Name • District Name • Block Name • Village Name • Updated by • Updated on • Remarks
Main Canal	• Canal Name • Discharge (cumec) • Culturable Command Area (lakh hectare) • Updated by • Updated on • Remarks
Silt Excluder	• Silt Ejector Name

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	• Updated by • Updated on • Remarks
Silt Ejector	• Silt excluder name • Updated by • Updated on • Remarks
Siphon	• Located at • Syphon Name • Construction Year • Updated by • Updated on • River name • Remarks
Flood Store	• Flood Store Name • Flood Store Location • Nylon Crates • Empty Cement Bag • B.A.Wire Crates in (3*1.5*0.60 m) • B.A.Wire Crates in (1.05*1.05*0.60 m) • B.A.Wire Crates in (1.25*1.25*1.25 m) • B.A.Wire Crates in (3*1.5*0.75 m) • B.A.Wire Crates in (1*1*1 m) • B.A.Wire Crates in (10 S.W.G.) • Geo Bag • Mega Geo Bag • Purcupine • Boulder (cu.ft.) • Geo Textile Filter • River Name • Division Name • Circle Name • Zone Name • Updated by • Updated on • Remarks
Site Store	• Location • Sand Bag • Nylon Crates • Loose Sand • Boulder • River Name • Division Name • Circle name • Zone name

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Asset Layers	Attributes Details
	• Updated by • Updated on • Remarks
Km. Stone Survey	• Embankment Name Located At • Embankment Chainage (km) • Km. Stone
Divide Wall	• Divider Length • Divider Location • Updated by • Updated on • Remarks
Vulnerable Site	• Embankment Name • Embankment Chainage
Breach Location	• Embankment Name • Breach Location (km) • Breach Year • Updated by • Updated on • Remarks
Flood Camp Site	• Flood Camp Site Name • Chainage (km)
WRD Office	• Name • Location
Barrage Control Room	• Name

Base Layers Details:

Base Layers	Attributes Details
International Boundary	• International boundary name • Updated by • Updated on • Remarks
District Boundary	• District Name • State Name • District Area (Sq Km) • District Area (Ha) • Updated by • Updated on • Remarks
Block Boundary	• District Name • State Name • Block Name • Block Area (sq km) • Block Area (ha) • Updated by

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Base Layers	Attributes Details
	• Updated on • Remarks
Village Boundary	• Village Name • State Name • Village Type • Village Category • Village Area (Sq Km) • Village Area (Ha) • Block Name • District Name • Updated by • Updated on • Remarks
Thana	• Thana name • District Name • Block Name
River	• River name • River type
Railway Network	• Railway type • Railway sub type • Traction • Railway length (km) • Updated by • Updated on • Remarks
Railway Station	• Railway station name • Updated by • Updated on • Remarks
Road Network	• Road Number • Lane • Road Start End Name • Road Type • Road Length (Km) • Updated by • Updated on • Remark
Proposed Strengthening Work for EKE	• Located at • Chainage
Road Constructed by WRD	• Located at • Chainage
Dhar	• Name
Project Area	• Name • Area • Remarks

3.3.2 *Engineering Information System*

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT

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Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1.	Design HFL & Formation Level-GFCC(2008)[#]	Design HFL and Embankment Formation level for Kosi river will be entered.	The output will be in form of graphs representing input parameters (HFL, formation level)
2.	Geotechnical (Soil) Investigation Survey	Soil investigation report corresponding to each bore hole location across Kosi river will be entered.	The output will be in report form for bore hole location selected.
3.	Borrow Area	Borrow area details corresponding to river will be entered	Output can be seen in window itself after selecting the desired borrow area location.
4.	Gauge-Discharge Frequency Analysis	Gauge and discharge records observed over time period will be entered for ascertaining frequency of discharge and water level in the time period considered	The output will be in form of tables & graphs representing the input parameters
5.	Silt Factor and Grain size	River bed material C/S and embankment RD (chainage)	Silt factor manning co-efficient at location with Latitude and Longitude
6.	Existing Cross Section of Embankment (2013)	Cross Section Survey data of Embankment at one km interval will be entered	The output will be in form of tables & graphs representing the input parameters
7.	Rainfall Data	Observed hourly rainfall data will be entered for each gauging station.	The output will be in form of tables & graphs as given below: • Observed hourly rainfall data of a particular day in Table & Graph (Hours vs. Hourly Rainfall & Cumulative Rainfall on that day) • Daily cumulative rainfall (Y-axis) vs. days (X-axis) • Monthly cumulative rainfall (Y-axis) vs. Months (X-axis) • Yearly cumulative (Y-axis) vs. year (X-axis)
8.	GDS Site Data	Observed daily data for water level, discharge and sediment corresponding to a gauging site will be entered	The output of daily observed water level, discharge and sediment at GDS sites will be in form of tables & graphs as given below: • Day (X-axis) vs. Sediment load (1-Y-axis) vs. discharge (2-Y-axis) • Month (X-axis) vs. Sediment load (1-Y-axis) vs. discharge (2-Y-axis) • Year (X-axis) vs. Sediment load (1-Y-axis) vs. discharge (2-Y-axis)
9.	GD Site Data	Observed hourly WL & discharge data for each gauging station will be entered in above interface	The output of observed hourly WL & Discharge of GD Sites will be in tables & graphs as given below: • Observed hourly WL/Discharge data (Y-axis) vs. hour (X-axis) • Daily WL/Discharge (Y-axis) vs. days (X-axis)

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Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
			• Monthly WL/Discharge (Y-axis) vs. Months (X-axis) • Yearly WL/Discharge (Y-axis) vs. year (X-axis)
10.	G Site Data	Observed daily water level for each gauging site will be entered	The output will be in form of tables & graphs as given below: • Forecasted WL (Y-axis) vs. days (X-axis)

3.3.3 Basin Information System

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1	River Section (Cross /Longitudinal)	River cross section of Kosi River for year 2013 are reproduced on GIS platform for easy reference and a Data Base Management has been prepared for easy extraction.	River cross sections can be viewed on GIS platform and clicking on any cross section of the interest, it will give River Cross Section in Table & Graph format.
2	Topographical Survey Data in CAD & DEM	Topographical Survey Data have been stored river wise & year wise.	The same can be downloaded in AutoCAD format as well as DEM format
3	River Morphology from NIH report	River morphology report will be entered	Viewer will see the river plan report for different years. It can be downloaded also.
4	Geo-referenced Satellite Images	Geo referenced Satellite images for different years of Kosi basin will be entered.	The output will be in tabular form with each satellite imagery in downloadable format for desired year.
5	Kosi Basin Area Characteristics	DEM data of Kosi basin will be entered	Viewer will see the details of Kosi basin like catchment area, terrain slope, hill shade etc. in GIS platform
6	Flooded area due to breach in EAB in 2008	Satellite imagery	Satellite imagery displaying the flooded area can be seen.

3.3.4 Asset Monitoring System

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1	During Non-Monsoon Period (routine measures)	All information of the health of the assets will be entered through Android Based Application on Tablet in three stages: • Post Flood Site Inspection • Status Update	Viewer can see health information of all assets on Web Based GIS application on single window. The information marked with Unacceptable category will be displayed with Red Color. After remedy of the cause it will turn into Green color if it has been repaired in acceptable condition. Viewer can also view the photographs taken during inspection at various stages.
2	During Monsoon Period (Emergency Measures)	All information of the health of the assets will be entered through Android Based Application on Tablet in three stages: • In Flood Site Inspection	Viewer can see health information of all assets on Web Based GIS application on single window. The information marked with Unacceptable category will be displayed with Red Color. After

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Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
		• Status Update • Current status of flood fighting report	remedy of the cause it will turn into Green color if it has been repaired in acceptable condition. Viewer can also view the photographs taken during inspection at various stages

3.3.5 *SOP Monitoring System*

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1	Status of Approval	Details of schemes for which approval is required can be entered and updated also.	Viewer can see status of approval (in report form) in tabular form.
2	Status of Tendering Process	Details of tenders for future construction works can be entered and updated also.	Viewer can see status of tenders I Tabular form having dates of work allocation, work started, and work completed. Also photos for different stages of construction can be seen.

3.3.6 *Store Material Information System*

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1	Flood Store	All data with regards to construction material quantity available at different store locations can be entered.	Viewer can see the quantity of construction materials available at desired store locations in tabular form.
2	Site Store	All data with regards to material quantity available at different site locations can be entered.	Viewer can see the construction material available at site locations in tabular form.
3	Mechanical Store	All data with regards to quantity of machinery available at different store locations can be entered.	Viewer can see the machinery available at desired store location in tabular form.

3.3.7 *Analysis, Planning & Design Tool*

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1	**Analysis of Flood Protection Works**		
	a) Analysis for Raising and Strengthening of Embankments	Data for existing and design embankment top for Kosi basin will be entered.	Viewer will see the existing and design embankment cross section in graph form. Also in case of embankment damage, quantity of material fill required for constructing existing embankment up to design embankment top will be calculated.
	b) Swapping Tool (for Annual River Migration Analysis)	Satellite imageries showing river plan for different years will be entered.	Viewer can analyze the course of river in GIS platform by overlapping imageries of the river for different years.
	c) Buffering Tool (for New Bank Protection Works / New Flood Effected Area	Viewer will enter distance as desired for buffer analysis.	Viewer can analyse the river behavior approaching to bank/embankment.
	d) River Morphology	River morphology report available for Kosi basin rivers will be uploaded.	Viewer will see the report year wise which can be downloaded.
2	**Help Tools**		
	a) Planning of new flood	Material pertaining to planning of	Viewer will see the reports which

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Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
	protection works	new flood protection is uploaded	can be downloaded.
	b) Scheme preparation (Design Templates)	Design guidelines corresponding to embankment assets will be uploaded.	Viewer will see the design templates for various assets of embankment. These can be downloaded also.
	c) Design guide lines for Flood Protection Works by: Sri K.N.Lal	Guidelines by Sri K.N. Lal are uploaded.	Viewer will see the report. It can be downloaded also.
3	**Training Material**		
	a) Analysis and Design of Dams	Material in report form is uploaded	Viewer will see the report. It can be downloaded also.
	b) Design Flood Estimation	Material in report form is uploaded	Viewer will see the report. It can be downloaded also.
	c) Design of Weir, Barrages and Canals	Material in report form is uploaded	Viewer will see the report. It can be downloaded also.

3.3.8 *Documents*

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1	Document Management System	Useful documents/standard designs/codes will be uploaded	Viewer will see the document list in tabular form which can be downloaded.

3.3.9 *Community Participation System*

Sl. No.	Name of the Sub-module	Design Concept of INPUT	Design Concept of OUTPUT
1	ICP	Information regarding damage to embankment and assets during floods, pre-flood and post floods can be entered along with photographs	Viewer can view the report in tabular form along with photographs depicting the location of damage. Also status of information (closed/not closed) can be seen
2	Feed back - Guest	Information regarding damage to embankment and assets during floods, pre-flood and post-flood periods can be entered along with photographs	Viewer can view the report in tabular form along with photographs depicting the location of damage. Also status of information (closed/not closed) can be seen

4. REPORTING PROTOCOLS & FORMATS

4.1 INTRODUCTION

A **Report** is a specific form of writing that is organized around concisely identifying and examining issues, events, or findings that have happened in a physical sense, such as events that have occurred within an organization. A report is written for a clear purpose and to a particular audience. Specific information and evidence are presented, analyzed and applied to a particular problem or issue. The information is presented in a clearly structured format making use of sections and headings so that the information is easy to locate and follow.

A **Protocol** is commonly described as a set of rules. A protocol is a *RULE* which describes how an activity should be performed. In governmental fields of endeavor, protocols are often unwritten guidelines. **Protocols** specify the proper and generally accepted behavior in matters. The **Reporting Protocol** is an easy-to-follow Users' Manual that outlines the principles, concepts, calculations methodologies and procedures required for effective participation. The **Reporting Protocol** provides the framework for effective participation and is designed to minimize the reporting burden and maximize the benefits.

In **K-EAMS** application, there are three types of reporting which are listed below.
- Identified Community Reporting
- Guest Reporting
- Field Officer Reporting during Site Inspection

4.2 PROTOCOL FOR DATA ENTRY AND THEIR FREQENCY

Data Control System - for Entering Data		Authorized User	Frequency	Messages to be sent
Module Name	**Sub-Module**			
Spatial Data	Remote Sensing	FMISC_admin	As per required	No SMS required
	GIS			
	Map Server			
Module Name	**Sub-Module**			
Real Time & Forecast Data	Observed Hourly Rainfall Data	SE (flood monitoring)	Hourly	No SMS required
	Observed Daily Rainfall Data		Daily	No SMS required
	Observer Hourly WL & Discharge of All Gauging Sites		Hourly	If WL above Danger level, SMS will be sent to concerned CE, SE, EE of WRD
	Observed Daily WL & Discharge of All Gauging Sites		Daily	If WL above Danger level, SMS will be sent to concerned CE, SE, EE of WRD
	Observed Daily Sediment Load Data		Daily	
	3-Day Forecast WL		Daily	If WL above Danger level, SMS will be sent to concerned CE, SE, EE of WRD
Maintenance History	Maintenance History (Asset Wise)	FMISC_admin	Annually	No SMS required
	Maintenance History (River Wise)			No SMS required

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Data Control System - for Entering Data		Authorized User	Frequency	Messages to be sent
SOP	Scheme Approval	Chief Engineer's Office	Annually	Date of Fixing Meeting will be sent to all members of Committee. Please give the name of committee members
	Tender Status - Upload New Tender Detail		As per SOP	No SMS required
	Tender Status - Update Tender	Concerned Executive Engineer	As per SOP	In case of Deley, SMS will be sent to concerned EE, SE & CE of WRD
Module Name	**Sub-Module**			
Engineering Data	Design HFL, Design & Existing Formation Level	Concerned Division	Annually	No SMS required
	L Section of Kosi River			No SMS required
	River Cross Section in The Basin			No SMS required
	River Cross Section at Gauging Sites	Concerned Chief Engineer		No SMS required
	Embankment Cross Section	Concerned Chief Engineer		No SMS required
	Soil Investigation			No SMS required
	TOPO Survey Data (AutoCAD for Kosi River)			No SMS required
	TOPO Survey Data (AutoCAD for Kamla River)	FMISC / MIS		No SMS required
	TOPO Survey Data (DEM)			No SMS required
	River Morphological Reports			No SMS required
	Geo Referenced Satellite Imageries			No SMS required
	Silt Factor and grain size			No SMS required
Asset Information Data like actual changes in data		FMISC / MIS	Annually	No SMS required
Document Information		Concerned Chief Engineer	Annually	No SMS required
Meta Data		FMISC / MIS	Annually	No SMS required
Module Name	**Sub-Module**			
Review on Community Observation	Review on Community Observation	As per SOP	Daily	Community feedback to be send to concerned EE for review
		Action taken by sms through administrator As per SOP	Daily	In case of Emergency, Unacceptable and Minimally Acceptable, send SMS to SE (Flood Monitoring), CE,SE & EE

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Data Control System - for Entering Data		Authorized User	Frequency	Messages to be sent
Site Inspection	Asset Monitoring	Concerned EE through his CE	Daily	In case of Emergency, Unacceptable and Minimally Acceptable, send SMS to SE (Flood Monitoring), CE,SE & EE
Module Name	**Sub-Module**			
Store & Flood Fighting Data	Store Information	Concerned EE through his CE	flood period - Weekly / remaining period - monthly	No SMS required
	Daily Flood Fighting			No SMS required
Module Name	**Table Name**			
Dynamic Linking	For Observed Hourly Rainfall Data	Admin	Hourly	No SMS required
	For Observed Hourly WL & Discharge of All Gauging Sites			No SMS required
	For Daily Forecast WL at Gauging Sites		Daily	No SMS required
	For Daily Forecast WL along Embankment			No SMS required
	Inundation Entry		Annually	No SMS required
Module Name	**Sub-Module**			
Master Table	Master Data of River	Admin	Annually	No SMS required
	Master Data of Rainfall Station			
	Master Data of Station			
	Master Data of Zone			
	Master Data of Circle			
	Master Data of Division			
	Master Data of Sub Division			
	Master Data of Section			
	Master Data of District			
	Master Data of Block			
	Master Data of Village			
	Master Data of Check Item			
	Master Data of Check Item Details			
	Master Data of Event			
	Master Data of Unit			
	Master Data of Contact Us			
	Master Data of Modules			
	Master Data of Tender			
	SMS Mobile Number			
	Master Data of Material			
	Master Data of Store			
	Mapping of Store and Material			

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4.3   IDENTIFIED COMMUNITY REPORTING

Community participation in various activities for flood management can be organized effectively through following three principles:

- Community's Needs,
- Effectiveness and Efficiency, and
- Practicable Implementation.

As per current practices followed in Kosi basin, when an important message / news regarding embankment functioning has to be conveyed to the concerned department/officials, only telephonic/ mobile communication is available, thus affecting the decision or planning process for flood fighting. Moreover, current practices have drawbacks as defined below:

- The informer has no record of valuable information sent,
- The informer does not get status of his information, and
- There is no common platform for informer and officials /department.
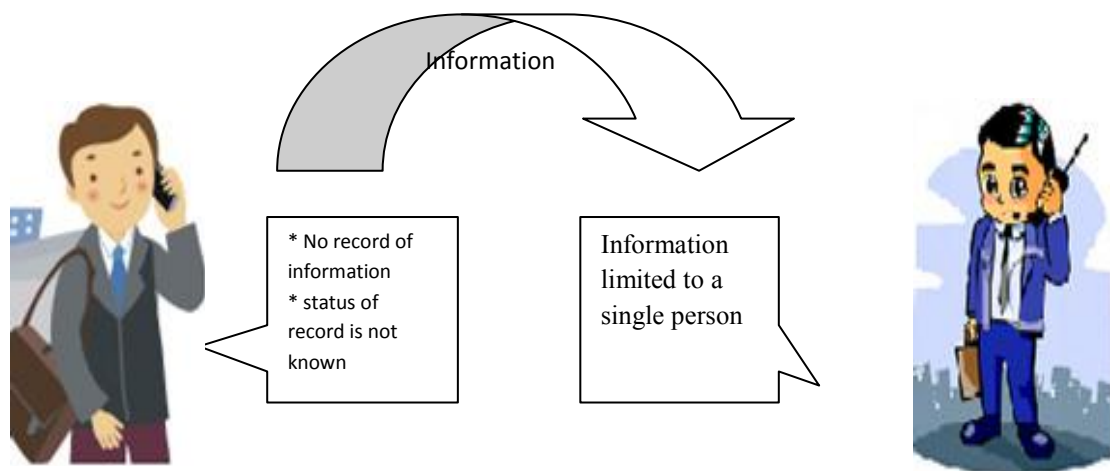
Figure 4-1: Current Practice

In current scenario of community participation, villagers report only in case of overtopping, breaching and piping, whereas they can report on almost entire embankment failure. The participation of community in flood fighting involves training them when and how to report through user friendly technology. Apart from training the community on reporting flood situations, they should be made aware of dimension of problem, ways of tackling them and their own role in them.

The process and requisites for organizing community participation are as follows:

- Process design,
- Identify the stakeholders' related community activities,
- Draft shared visions reflecting community's needs and concerns,
- Launch a public awareness campaign to keep the community informed and ensure,
- Community participation in decision-making, implementation and review,
- Identify information required and develop data collection methodology,
- Risk Assessment (to be presented in the form of maps, tables and graphs),
- Understand floods through historical records or hearing from people who experienced floods, as an existing local knowledge,
- Create a database inventory determining,
- Current land-use practices,

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- Potential future land-use patterns,
- Patterns of human settlement,
- Location of resources (natural and artificial),
- Map the natural courses of the river,
- Undertake hazard assessment from a multi-hazard perspective,
- Check to ensure that the risks identified are the same as those perceived by all stakeholders,
- Facilitate the risk assessment at the community level,
- Problem analysis,
- Conduct vulnerability and capacity assessment to determine the community at risks,
- Identify the human factors that contribute to flooding,
- Identify the flood plain areas in terms of their risk level with respect to different magnitudes of floods,
- Setting goals,
- Determine objectives based on risk assessment results and vision,
- Decide the scope of community activities. Goals are largely set by regional development objectives and driven by the need to reduce flood risks, secure livelihoods, sustain economic development and preserve environmental quality,
- Draft action plan,
- Evaluate various possible measures to address flood risks within the given scope such as land-use planning, building codes, zoning, conservation, drainage improvement, etc.,
- Develop an action plan listing specific activities, roles and responsibilities of key stakeholders,
- Set the timeline and the expected results,
- Carry out economic analysis and financing arrangements,
- Set monitoring, evaluation and review procedures,
- Widely disseminate the draft plan, particularly to all those who are directly effected,
- Implementation,
- Approval of the plan in the community,
- Formation of community activities - The grassroots flood management/response organizations (community based organizations, groups or volunteers) are the key to mobilize the community at large,
- Implementation of short, medium, and long-term community activities towards floods, and
- Monitoring and evaluation - continuous improvement of participation, documentation and dissemination of good practices for replication.

Proposal in K-EAMS

Following two services will be designed for community participation:

- Web-Site Interface, and
- SMS interface

After giving training on above two technologies, community can be helpful in following ways:

During pre-floods: They can report in advance for:

- Works completed and pending,
- Vulnerable spur locations and embankment stretches, if any,
- Repairs to be carried out for embankment slope, protection works, approach roads, structures etc. if not completed before onset of monsoon,
- Outcropped vegetation on Embankment or spur,
- Animal burrowing, if found in embankment,

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- Cattle grazing, and
- Critical locations where piping was dominant in previous year floods.

During floods, They can report possibly for:

- Locations with increasing danger water levels,
- Overtopped or breached locations, and
- Any change in river course etc.

Post floods, They can report for:

- Overtopped locations requiring further raising of Embankment,
- Any new observation on a particular location regarding piping, visible shifts in river course, breaching etc.,
- Locations requiring new bank/slope protection works, launching apron or strengthening of existing protection works,
- Repairs to be carried out for damaged embankment slopes, protection works, approach roads etc., and
- Any digging of drainage channel, if required.
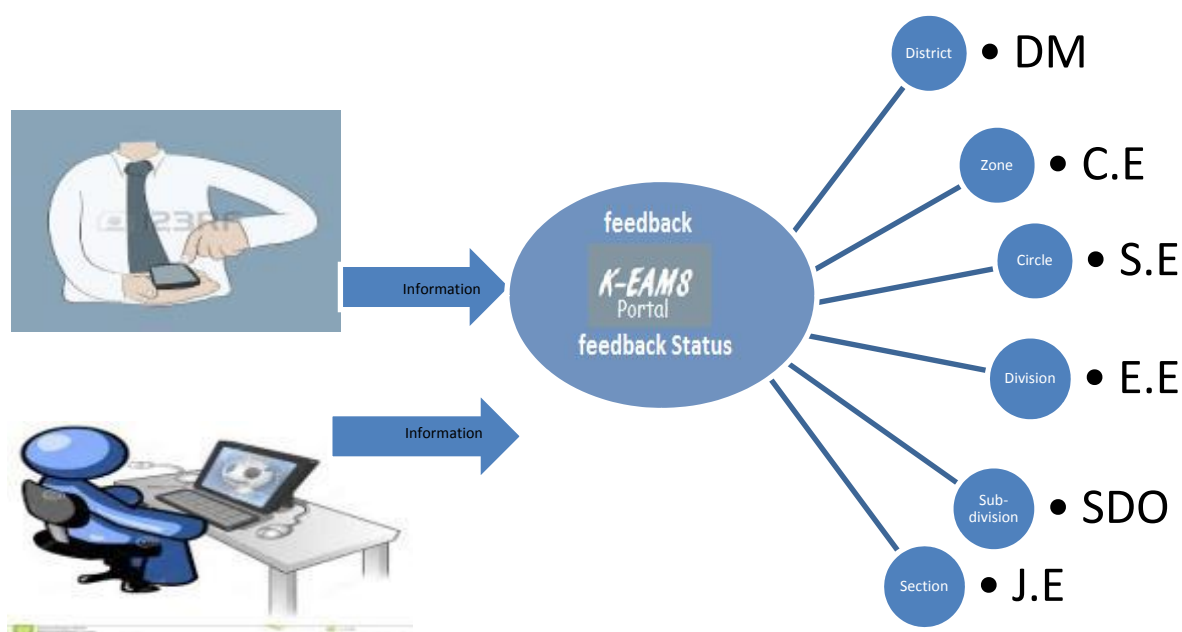
Figure 4-2: Proposal of current technology

WEBSITE INTERFACE (On line mode of communication)

In Authorized Community Participant group (Figure 4-3) we have included *Mukhia* and *Sarpanch* of every village along the embankments under Kosi basin area of Bihar.

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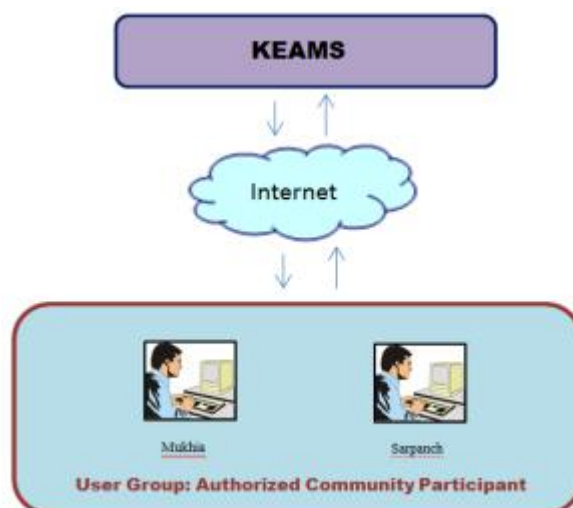
Figure 4-3: User Group of Authorized Community Participant at a glance

After geting trained, authorized community participants can feed the observed problems regarding embankment assets on K-EAMS application. He/she has to enter the following details :

- Asset
- Problems observed
- Nearest Village
- Approximate Chainage
- Remarks
- Upload Photo, if any
- Observation Date
- Name
- Mobile Number

To register the problem observed, he/she has to follow the steps mentioned below:

- You will see the **Login** button on Home Page as you connect to the site.
- Click on **Login**, you have to select your **Identity** to enter into the system.
- Click inside the **Username** text box and type your Username.
- Click inside the **Password** text box and type your password.
- Click on **Login** button to submit your login details.
- You will be able to Log In successfully.
- You will get observation details form here. You have to select Category of Defect Observed, Date of Defect Observed, Select Asset Related to Defect and Nearest Village from drop down.
- Enter Detail of Defect (if any) and Location (Mile stone or other land mark)
- By clicking on **Browse** button, you can upload any photo if you have.
- You have to enter Name, Mobile number and E-mail ID and click on **Submit** button.
- All details will be saved in database and will be displayed into form.
- If you want to send another observation click on **Another Observation** button.

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Figure 4-4: Login Gateway

Figure 4-5: Observation Details Form Fill UP by Identified Community Participant (Contd. 1)

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Figure 4-6: Observation Details Form Fill UP by Identified Community Participant (Contd. 2)

Figure 4-7: Observation Details Form Fill UP by Identified Community Participant (Contd. 3)

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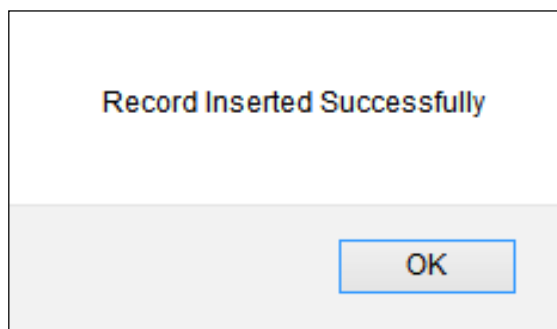
Figure 4-8: Observation Details Form Fill UP by Identified Community Participant (Contd. 4)
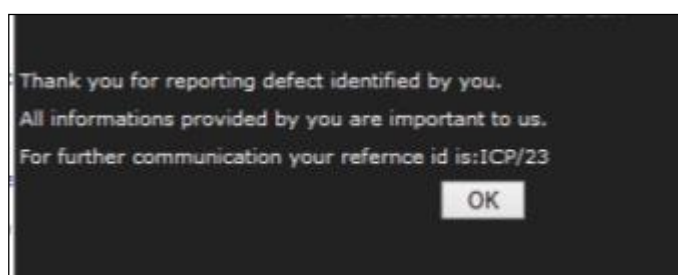
Figure 4-9: Observation Details Form Fill UP by Identified Community Participant (Contd. 5)

Figure 4-10: Observation details display in form type

All the observation details have been saved in database, where administrator will analyse all the observations recorded in K-EAMS application and after cross check, he will authenticate them and forward it to concerned persons. If from the particular area, cluster of problems are recorded frequently, an Alert will be generated and concerned persons will have to solve it immediately.

SMS INTERFACE (off line mode of communication/ without internet)

In current practice, the community makes telephonic call to give urgent information on emergency. The drawbacks of the current practice are as follows:

- It is chargeable to contact the concerned officials /department,

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- The receiver might miss the call for some reason and the situation might get worse due to unavailability of needed information,
- The receiver's (concerned official) mobile might be off or not reachable due to network related issues,
- The informer being a poor person might not be having balance in mobile to make outgoing calls,
- Via telephonic call, the information is limited to a single person, and
- It is difficult for community to communicate with the concerned officials/department via telephonic call.

In **K-EAMS,** the community will get a simple 5 digit Toll-Free number and the community can easily notify of the current emergency prevailing in his locality /nearby village. The community will get instant confirmation message and confirmation receipt of his message from the concerned officials. A spam filter has also been used to filter the fake messages like abused messages etc. After filtering, only genuine messages will be instantly stored in the K-EAMS database. Administrator will cross check all the messages and after authentication, messages will be instantly delivered to the concerned officials' mobiles, notifying the emergency situation. The concerned officials can then inspect & take appropriate steps .The concerned official can give his feedback. If from the particular area, cluster of problems are recorded frequently, an Alert will be generated and concerned persons have to solve it immediately.

Figure 4-11: The overview of the proposed "Tool Free SMS" concept

It will fetch following advantage over prevailing methodology:

- Free messages will be sent to the concerned department/official,
- Instant confirmation message will confirm the receipt of emergency information,
- The message will be reflected under "Community Participation System" module of K-EAMS,
- The Community will get SMS for the given information

4.4   GUEST REPORTING

Guest reporting is same as identified community reporting. The main difference is that identified community are the registered users of K-EAMS application and guest are general users. Therefore, community participants will have to firstly login in K-EAMS application to report while guest can report generally.

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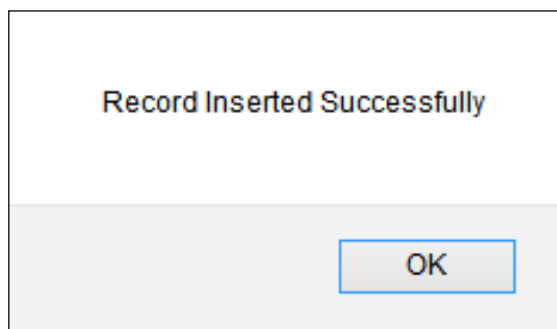
Interfaces for guest reporting are shown below:

Figure 4-12: Observation Details Form filled up by Guest (Contd. 1)

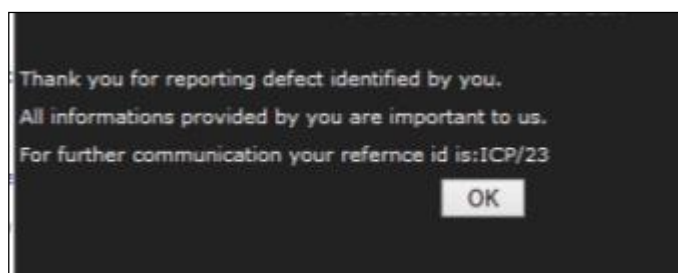**Figure 4-13: Observation Details Form filled up by Guest (Contd. 2)**

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Figure 4-14: Observation Details Form filled up by Guest (Contd. 3)

Figure 4-15: Observation Details Form filled up by Guest (Contd. 4)

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Figure 4-16: Observation Details Form filled up by Guest (Contd. 5)

Figure 4-17: Observation Details Form filled up by Guest (Contd. 6)

Figure 4-18: Observation Details Form filled up by Guest

All the observation details would be saved in database, where administrator will analyse all the observations recorded in K-EAMS application and after cross check will authenticate them and forward it to concerned person. If from the particular area, cluster problems are recorded frequently, an Alert will be generated and concerned persons have to solve out it immediately.

4.5   FIELD OFFICER REPORTING DURING SITE INSPECTION

Field officers will do their reporting with the help of **Android Based Application on Tablets.** Tablet based information will be available for Field Inspectors during their site inspections during monsoon and non-monsoon periods. Through this android application, Field Inspector will support K-EAMS in sharing information of the latest vulnerable occurrence related to Embankment Assets

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which would, later or in near future, help Water Resource Department to take appropriate decision for the protection of embankment, mankind and their assets.

Figure 4-19: Android Tablet based Inspection Module

Site inspection performed by the field officer is of two types.
- During non-monsoon period
- During monsoon-period

DURING NON-MONSOON PERIOD

For non-monsoon period, field officer will do the site inspection three times.
- Post-flood site inspection
- Status Update

DURING MONSOON PERIOD

For monsoon period, field officer will do the site inspection three times.
- In-flood site inspection
- Status Update

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The process of all site inspections is same. Inspections have to be done from time to time to see the updates or progress of the work. An example of post-flood site inspection during non-monsoon period is shown as below. Following are the steps which will be followed by Field Inspector through android tablet based application.

Click on Post Flood Site Inspection Application will detect all the known information automatically i.e. Division, Sub-Division, Section, Embankment, latitude-longitude. Enter details for selected asset, other selected asset and defected item from drop down list. Enter approx. chainage

Figure 4-20: Interface showing details for entry form of post flood site inspection (contd. 3)

Select evaluation criteria (A-Acceptable, M-Minimally Acceptable, U- Urgent E-Emergency) . Enter remark and attach photo.

Figure 4-21: Interface showing details for entry form of post flood site inspection (contd. 4)

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Click on save button for OFF line mode (No Internet Connection), else click on submit button for ON line mode (Internet Connection available).

Figure 4-22: Interface showing details for save button

Figure 4-23: Interface showing details for list view of saved details

As the field officer avails the internet connection, he/she can send the details to K-EAMS server by clicking on **send** button.

Figure 4-24: Interface showing details for sending save details

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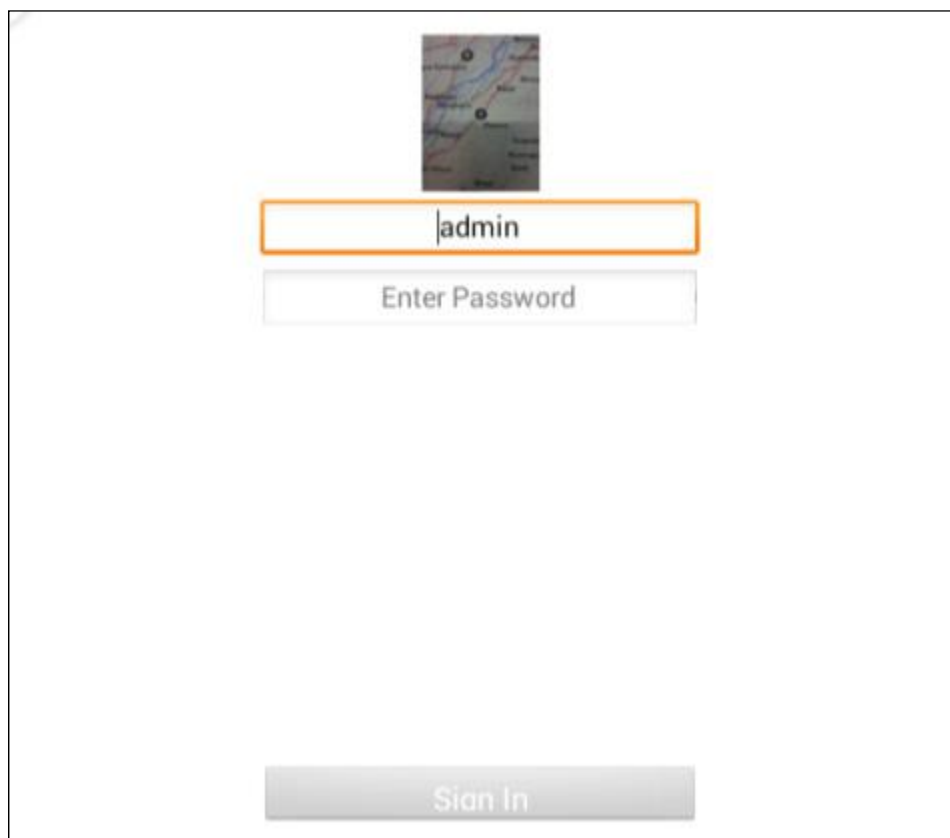
Figure 4-25: Interface showing details for login gateway
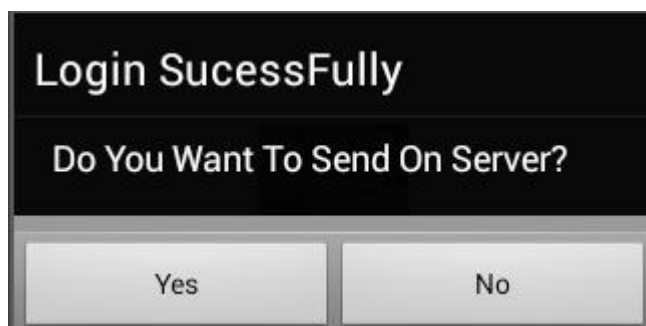
Figure 4-26: Interface showing details for successful login
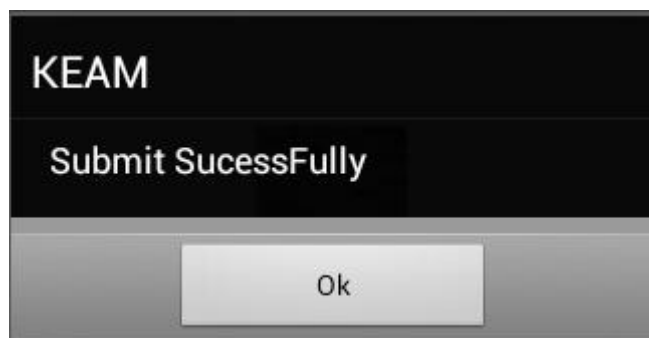
Figure 4-27: Interface showing details for details submitted successfully

Advantage of report recorded from the android tablet is that it is Geo-Tech image/information which will automatically get displayed with exact latitude-longitude points on map. As the field

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inspector sends his report through android application to K-EAMS application, it will come to the server and will get filtered automatically by spam filter. Filtration is necessary to avoid or to discard fake information. After filtration, if site inspector has ticked on **"U"** condition **i.e. Emergency/Unacceptable**, it will automatically get displayed on real time Alerts. Before that administrator will cross check all the information and will authenticate them. After authentication all the reports will be forwarded to concerned persons to take action.

5. SYSTEM ARCHITECTURE &TECHNOLOGY

5.1 FUNCTIONAL DATA FLOW
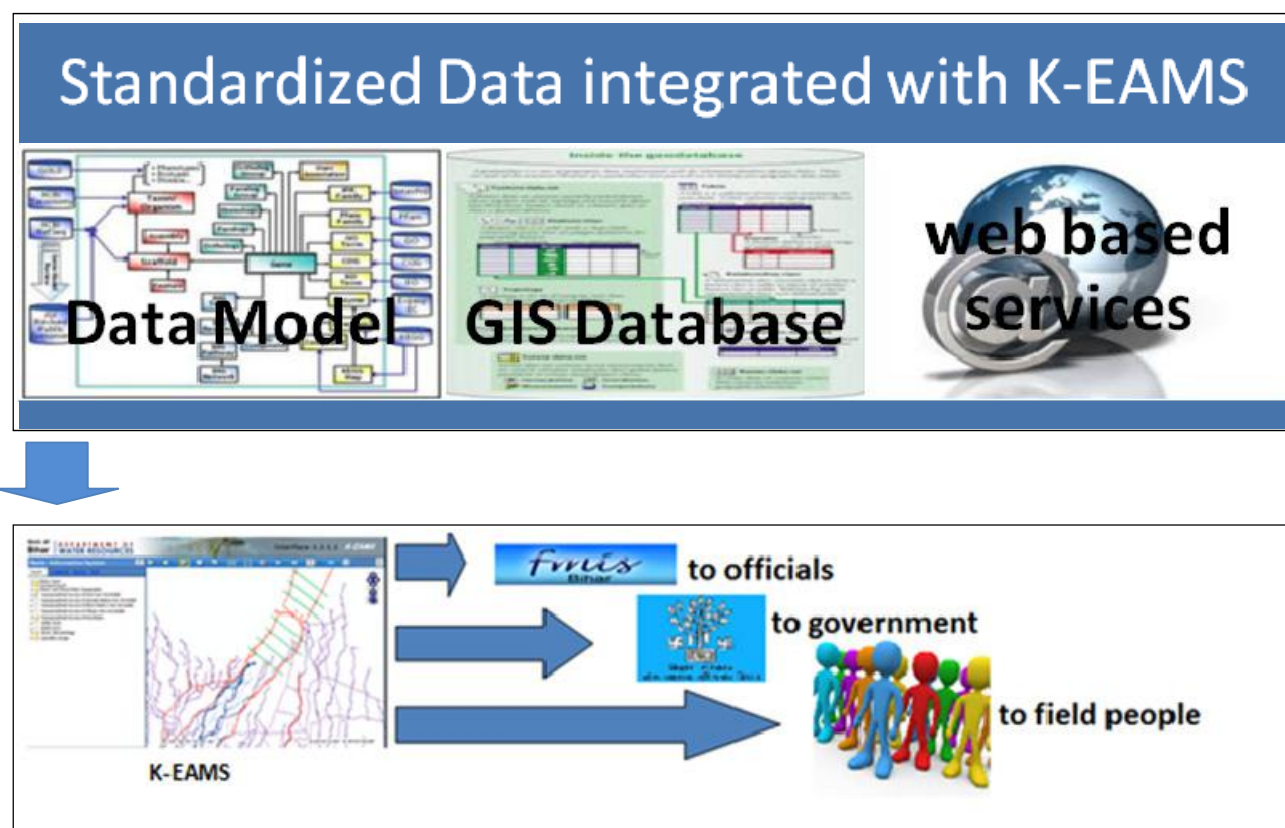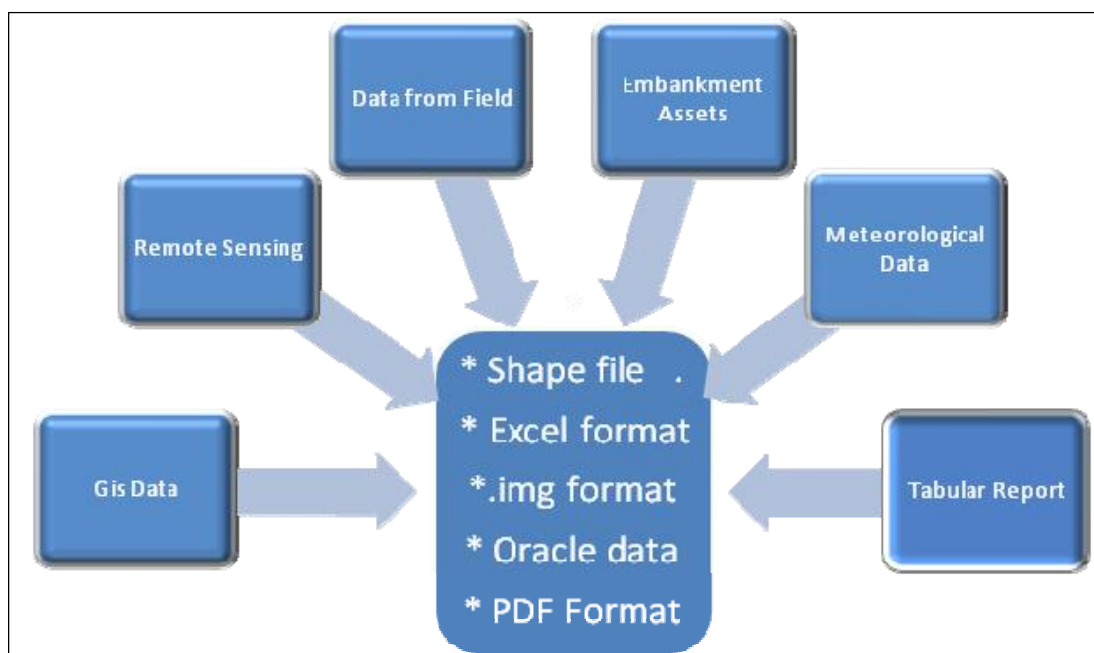
Figure 5-1: Function Data Flow:

The functional data flow starts from standardization of GIS data, remote sensing data, field data, embankment data, meteorological data, tabular report to shape file, excel format, image format,

Oracle data, pdf format. The formatted data is then passed to data model, GIS database and is finally shown in form of result / output via K-EAMS modules.

The output/result is visible to FMIS, WRD and other concerned Departments of Govt. of Bihar and field functionaries.

The development framework consists of the following components which are considered core to the application:

- Presentation Layer (HTML, ASP, JavaScript / Silverlight API)
- Business Layer including components of C# and ArcGIS Server.
- Persistence Layer consists of databases (attribute database and geo-database)
- Server (ArcGIS Server and Oracle 11g)
- Interface to External systems
- Community Participation Portal

5.2   PRESENTATION LAYER

In general, Presentation Layer is responsible for display or the delivery and formatting of information.

In K-EAMS, Presentation Layer or the user interface is proposed to develop using HTML, ASP.NET, J Query, JavaScript and Ajax.

JavaScript / Silver Light API for Arc GIS Server has been used to create GIS interface for K-EAMS.

5.3   BUSINESS LAYER DESIGN

In K-EAMS, Business Layer has been developed using C#. The following points elaborate the use of C# :

- C# language is the latest object-oriented language that is aimed at enabling programmers to quickly build a wide range of applications for the Microsoft .NET platform.
- K EAMS of using C# and the .NET platform is to shorten development time by freeing the developer from worrying about several low level plumbing issues such as memory management.
- C# code is compiled to an Intermediate Language (IL) which then runs in the Common Language Runtime (CLR)
- K-EAMS provides simple navigational tools on all forms, with links to other data entry items.
- Following business logics has been used:
  - o Interaction between user-interface and attribute database server.
  - o Interaction with external system such as HIS and Flood Forecasting Model
  - o Interaction with GPRS/SMS portal to get community input data.
  - o Interaction with map services (ArcGIS Server) for map rendering based on user-defined criteria.
  - o Reports engine is used to generate custom reports based on user request.
  - o JAVASCRIPT / Silver Light API for Arc GIS Server along with C# is used to upload and process survey data in Microsoft Excel format to the server.
  - o ActionScript is used to interact with ArcGIS Server.

5.4   PERSISTENCE LAYER (DATABASE)

A geo-database is a database optimized to store and query data that represents objects defined in a geometric space. It is also used to store attribute data. Oracle 11g has been used as database for geo-data and attributes data.

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5.5   WEB SERVER:

Internet Information Services (IIS) has been used as web server. IIS web server is a product of Microsoft and .NET is also a product of Microsoft .Hence, IIS is compatible with and .Net Reporting tools like HTML reporting, other reporting tools of VS-2013 (RDLC, Crytal Report can also be integrated for the best graphical edge). Web server interacts with ArcGIS Server for hosting various services from its directories.

5.6   MAP CONTENT ADMINISTRATION

ArcGIS 10.2 server has been used as map server. Map server is compatible with web server to render map from geo-database as well as satellite imageries. This feature of ArcGIS has been used extensively to overlay time series river morphology data as well as rasterised inundation maps.
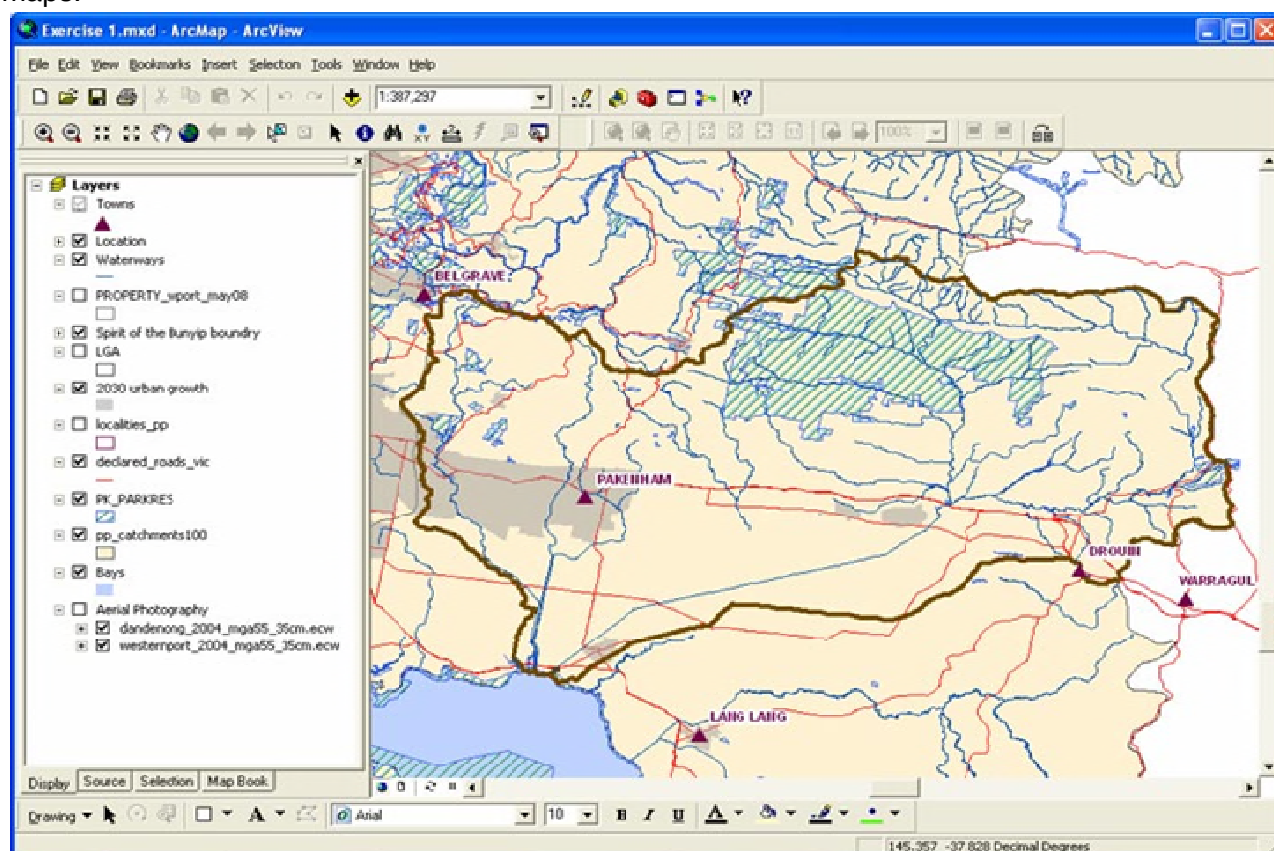

Figure 5-2: Map Content administration by ArcGIS

5.7   REPORT DESIGNER

Visual studio 2013 has some built-in reporting facilities, which have been examined for its integration. However, RDLC / Crystal Report can also be integrated for the best graphical edge.

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5.8   SOFTWARE LICENSING REQUIREMENTS:

The following software need to be purchased:

S. No	Detail	Software (latest versions preferred)	Purpose
1	Map Server	Arc GIS Server Advanced Enterprise (ver.10.2) (Minimum & Recommended) with ArcGIS Image Extension	To publish map / data and manage services
2	Operating System for Map Server	Microsoft Windows Server – 2008 (Minimum), 2012 (Recommended) Standard edition – for Servers	To host Web Server, Map Server and Database Server
3	GIS Workstation	ArcGIS Desktop (ver.10.2) Advanced (Minimum & Recommended) with Spatial Analyst and 3D Analyst extension	To prepare spatial and non-spatial data
4	Operating System for Workstation	Windows 7 (minimum), Windows 8.1 (Recommended) (64 Bit) – for work station	For workstation
5	DATABASE	ORACLE 11G R2 (64 Bit)	To host K-EAMS database
6	AutoCAD	Version 2007 (Minimum), 2015 (Recommended)	To view engineering data on AutoCAD
7	Web Development Tool	Microsoft Visual Studio 13 (Minimum & Recommended)	To host Web Server and develop web application tool
8	OFFICE Tools	Microsoft Office 2010 (Minimum), 2013 (Recommended)	To prepare KEAMS document

5.9   HARDWARE AND NETWORKING REQUIREMENTS WITH CONFIGURATION

Sl. No.	Hardware Requirements	Reason	Minimum Configuration	Recommended Configuration
1	Workstation	For developing GIS data (spatial and non-spatial)	• Xeon® Processor 5600 Series • Dual high-end ATI or NVIDIA® graphics cards with 1 GB RAM. • 8 GB RAM • 1 TB Hard Disk • DVD drive	• Xeon® Processor 5600 Series and above • Dual high-end ATI or NVIDIA® graphics cards with 4 GB RAM. • 16 GB RAM • 10 TB Hard Disk • DVD drive

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Sl. No.	Hardware Requirements	Reason	Minimum Configuration	Recommended Configuration
2	Server-I	For Arc GIS Server to publish map/data.	• 16 GB RAM (4x4 Dual ranked RDIMMs), 10 MB Cache • Quad Core Intel Xeon E52643 3.30 GHz Processor. • 2x300 GB 15000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 1for OS • 3x900 GB 10000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 5 • DVD drive	• Same as minimum requirement
3	Server-II	For Oracle 11g to house the database and IIS for hosting K-EAMS.	• 16 GB RAM (4x4 Dual ranked RDIMMs), 10 MB Cache, • Quad Core Intel Xeon E52643 3.30 GHz Processor. • 2x300 GB 15000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 1for OS • 3x900 GB 10000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 5 • DVD drive	• Same as minimum requirement
4	Desktop PC's at Client Site	For accessing K-EAMS	• Intel Pentium Dual Core (2.2 GHz, 2MB Cache) • 2GB DDR2 RAM • 1 GB Graphics Card (Recommended)	• Intel Core i3 • 4GB DDR2 RAM • 2 GB Graphics Card and higher

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Sl. No.	Hardware Requirements	Reason	Minimum Configuration	Recommended Configuration
5	Tablet	For Field Inspector	- OS - Android OS, v4.2.2 (Jelly Bean) - CPU 1.2 GHz Cortex-A7 or above - MEMORY- 8/16 GB , 1 GB RAM - SCREEN -7 inch - Camera - 2mp or above with Geo-tagging - WLAN - Wi-Fi 802.11 dual-band, Wi-Fi Direct, DLNA, Wi-Fi hotspot - GPS Enabled 3G connectivity or above	- OS - Android OS, v4.4 (KitKat and above) 1.5 Ghz Qualcomm Snapdragon S4 Pro Quad Core Processor - MEMORY- 32 GB , 2 GB RAM - SCREEN -10 inch - Camera - 5mp or above with Geo-tagging - WLAN - Wi-Fi 802.11 dual-band, Wi-Fi Direct, DLNA, Wi-Fi hotspot - GPS Enabled 3G connectivity or above
6	LAN / VPN	Dedicated LAN / VPN connection between the FMISC, WRD and the Data Centre will also have to be established to allow administrators from head office to administer the server.	- Dedicated internet services with a bandwidth of minimum 10 mbps (up and down –link) at Server end. - Internet service with 2MBps bandwidth at client end.	Same as minimum requirement
7	SMS gateway	A SMS gateway from any service provider be obtained to route the public SMS sent to a definite number to be redirected to the designated database server	- DND activated SMS services - Traditional SMS activated services - Instant delivery SMS facility - Unlimited SMS facility enabled	Same as minimum requirement

6. NON-FUNCTIONAL SYSTEM REQUIREMENT

6.1 SECURITY

The data related to Embankments are highly sensitive in nature and thus need to be protected. Further, cyber-crime has become too prominent these days. Therefore, high security has to be integrated in the system to meet the security threats evaluation.

- **Database level High Security (hidden security):**
  - Use of triggers in database will keep a smart track on all ongoing alternation (update, delete etc.) at both application level and database level as well.
    - Trigger on delete- will keep track of date of deletion, time of deletion, IP used, User ID used etc.
- **By denying unauthorized access:**
- **Encryption Technology:**
  - Highly sensitive data can be encrypted and kept database for providing high security. This will reduce the leak of sensitive data on database level, even if anyone tries to fetch important data from database of via application, he will get encrypted.
- **Identification:**
  - In identification process of K-EAMS, a network element recognizes a valid user's identity
- **Authentication:**
  - In Authentication process of K-EAMS, a method is used by the server to verify the clients' identity. This feature provides methods to authenticate clients via a set of standardized and reusable methods that require little or no modification. The methods available to developers are:
    - None – This method does nothing.
    - Windows Authentication – Attempts to authenticate the user.
- **Authorization**: Authentication is concerned with verifying the user using one of the aforementioned mechanisms. The purpose of authorization is to provide an easy method to apply access controls to Web applications. K-EAMS Authorization can be performed in two different ways:
    - Users – A user or list of users can be specified that are explicitly allowed or denied from using the application
    - Roles – A role or list of roles can be specified that are explicitly allowed or denied from using
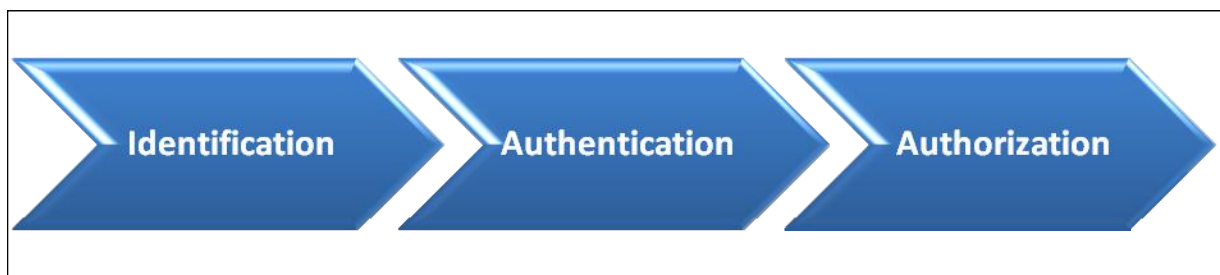
Figure 6-1: Data Security Steps in KEAMS.

- **IIS Authentication –** Uses authentication methods provided by the IIS Web Server
  - Authorization refers to who is allowed to access specific application resources.
- Cryptography
  - Cryptography is an important feature incorporated into the .NET framework because it provides programmers with the ability to securely transmit sensitive data.
  - The .NET framework implements a stream-based encryption layer, which allows data streams to be routed through encryption objects to produce encrypted output streams.
  - The .NET framework handles automatic generation of asymmetric key pairs and symmetric shared secrets applied to CryptoStream objects.
- **CAPTCHA** is a type of challenge-response test used to determine whether or not the user is human.

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Figure 6-2: Security Verification.

- Highly sensitive data can be encrypted and kept database for providing high security. This will reduce the leak of sensitive data on database level, even if anyone tries to fetch important data from database of via application, he will get encrypted.

6.2 PERFORMANCE REQUIREMENT

- **Immediate delays:**
  - o Checking the fact that the system must perform as what every user expects .So in every action-response of the system, there are no immediate delays.
- **Response time**
  - o The maximum response time for the submission of a job will be 1 minute.
- **Capacity**
  - o The maximum number of jobs schedulable is limited only by the capacity of the nodes to fulfill the jobs' deadlines; there is no upper limit inherent in the Libra scheduler as such.
- **Deadline sensitivity**
  - o Assuming submitted statistics for jobs are accurate, the Libra scheduler will ensure that all jobs are completed with a 10% error allowance.
- **Cost sensitivity**
  - o Under all circumstances, the maximum cost payable as submitted by the user will be the maximum cost charged to the user.
- **Maintenance Requirement**

Maintenance support will be provided which will ensure the following activities;
- Troubleshooting of the errors faced by the users at a least possible time.
- Correction of errors that were not caught before.

It is required that the system administrator will record the error logs and provide the same to the designated maintenance staff on a regular basis. The maintenance team will respond to solutions within least possible time. An update / hot fix will be provided in a least possible time with specific documentation.

It is to be noted that day to day monitoring of the software, database administration will be the responsibility of the system administrator at the client's end.

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6.3   DEPENDENCY ON OTHER APPLICATION

The K-EAMS will be dependent in the following application:

- JavaScript API for Arc GIS Server

- Google API

6.4   BACKUP

K-EAMS will give facility of following backups

Automatic daily backup: EAMS will automatically take backup of the database at a fixed time for data safety.

ON demand Backup: Any time backup can be taken via K-EAMS module of the needed module and can be restored by using following concepts
- **Physical online or hot backups:** K-EAMS database backup can be backed up while the database is up and running.
- **Physical offline or cold backups:** The database must be shut down and a copy must be made of all essential data files and other components of the database.

6.5   DISASTER RECOVERY
- Potential Threats to be considered and mitigated against could include Natural Threats: Fire Floods and Flash Floods, Hurricane/Storm, Earthquake
- Considering the above threats, we have planned to the following
- Offsite backup: to store full backup sets offsite, this will help in recovery time.
- Log Shipping/ Replication:-
    o By Log Shipping transaction log backup will be automatically sent from primary database to standby database for Failover (Failover means replacing primary database with standby database when primary database is unavailable).
    o Log Shipping uses standby server that is not used during regular operations. A standby server is useful to help recover data if a disaster occurs. We can only use log shipping at the database level. When a standby server is restoring transaction logs, the database is in exclusive mode and it is unusable. The latency on the standby server is based on how frequently the transaction log backups are taken at the primary server and then applied at the standby server. It has low maintenance cost with fast recovery of data. By Log Shipping, all activities can be recovered such as tables, views.

6.6   PLATFORM COMPATIBILITY

ArcGIS Server Manager supported browsers
- Firefox 10 or higher
- Google Chrome 10 or higher
- Internet Explorer 8 and above for ArcGIS 10.2.1

Note: It is recommended that Manager is used either in Firefox, Chrome, or Internet Explorer 9, 10 or 11 browser for the best possible experience. Using Internet Explorer 8 may result in a lower-quality display of Manager.

- ArcGIS Server requires a 64-bit operating system; 32-bit operating systems are not supported.
- Python 2.7 (64 bit) is installed with ArcGIS for Server.

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- Windows 8.1, 8, Windows 7, Vista, and XP: These operating systems are supported for basic testing and application development use only. They are not recommended for deployment in a production environment.
- Microsoft Windows Server 2003, 2003 R2, Vista and XP are no longer supported starting at ArcGIS 10.2.2.

6.7 SAFETY REQUIREMENTS

Consistency:
- Checking the fact that all clients must be attachable to one server, so there would be appropriate control of the test statistics and information.
- Also in case of a potential loss of connection between the client and the server, the client's test progress so far is lost. When the client finishes its test (by pressing the finish button) then its progress is sent to the server and it would be logged. In case of a potential server breakdown, only the so far finished tests are saved to the log file.

Object Oriented:

This program uses object oriented mechanisms to protect its data. Currently, there is no security scheme of this program. Thus the log files that are being created are readable using a simple text reader.

Data Transfer:
- K-EAMS shall use secure sockets in all transactions that include any confidential customer information.
- K-EAMS shall automatically log out all customers after a period of inactivity.
- K-EAMS shall confirm all transactions with the customer's web browser.
- K-EAMS shall not leave any cookies on the customer's computer containing the user's password.
- K-EAMS shall not leave any cookies on the customer's computer containing any of the user's confidential information.

Data Storage:
- The system's back-end servers shall only be accessible to authenticated administrators.
- The system's back-end databases shall be encrypted.

7. DESIGN CONSTRAINTS

7.1 SOFTWARE DESIGN CONSTRAINTS

- The software will rely on the Microsoft .Net Framework (http://www.microsoft.com/net/overview.aspx). It is assumed that any system running this software will have the Microsoft .Net 4.0 or greater correctly installed.
- ArcGIS Desktop is required for administrating.
- The data of the K-EAMS should be regularly updated. This will provide the latest and the most updated information /data for the flood disaster management team. It will benefit the users to coordinate and provide the latest data to K-EAMS where data will be updated and intrigued to K-EAMS.
- High Licensing Fee for Arc GIS Server
- High Licensing fee/renewal fee of Oracle 11G
- For high graphical reports, crystal report for visual studio 2013 might be needed.
- It will require in detail training.
- There is almost no scope of open source resources in K-EAMS
- Licensing might be required for bulk use of Google API

7.2 HARDWARE CONSTRAINTS

There are a few constraints for the K-EAM computer hardware.

- The tablet /mobile availability is a requisite in K-EAMS.
- Dependency on servers:
  - Arc GIS Server
  - Oracle Database server.
- The best performance the GIS servers should be minimum
  - 16 GB RAM (4x4 Dual ranked RDIMMs), 10 MB Cache, Quad Core Intel Xeon E52643 3.30 GHz Processor.
  - 2x300 GB 15000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 1for OS
  - 3x900 GB 10000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 5
  - DVD drive
  - Windows server 2012 Standard edition
- For the best performance the Database servers should be minimum
  - 16 GB RAM (4x4 Dual ranked RDIMMs), 10 MB Cache, Quad Core Intel Xeon E52643 3.30 GHz Processor.
  - 2x300 GB 15000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 1for OS
  - 6x900 GB 10000 rpm Serial Attached SCSI(SAS) 6 Gbps 2.5 inch Hot Plug Disk Drivers With RAID 10
  - DVD drive
  - Windows server 2012 Release 2 , Enterprise edition & data Centre 64-bit (AMD64/EM64T)
- Internet connectivity of at least 2Mbps Speed and higher at Client End and Server End
- For field inspection for data upload, Tablets are needed on field level with minimum following configuration.
  - OS – Android 4.0 or above
  - 1 Gb RAM
  - 7 inch screen
  - 2mp+ Camera
  - 3G connectivity
- For using mobile tablets at field level, availability of 3G and above connectivity is a requisite.
- A 3G and above enabled SIM card is required for Android based tablet.

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7.3   USER INTERFACE CONSTRAINTS

- There should be no restriction imposed by K-EAMS on users. Only policy decisions (permissions, access, privileges, etc.) should prevent any user from accessing any part of K-EAMS from local or remote station.
- Similar functionality should be presented to the users using similar user interfaces. However, user interface should clearly reflect access modes and operations level.
- The user must have in depth knowledge of either Hindi or English, for using the software efficiently.

7.4   OVERVIEW OF DABASE INTERACTION WITH SYSTEM

Following are the purpose of database system to solve the related problems:
- Data redundancy and inconsistency
  o Data redundancy: - Data redundancy is a condition created within a database or data storage technology in which the same piece of data is held in two separate places.
  o Inconsistency: –Data inconsistency exists when different and conflicting versions of the same data appear in different places. Data inconsistency creates unreliability.
- Difficulty in accessing data - Need to write a new program to carry out each new task.
- Data isolation- Data are scattered in various files and files may be in different format.
- Integrity problems - Data integrity refers to the overall completeness, accuracy and consistency of data. Marks should be between 0 and 100.
- Atomicity of updates - Complete the process or undo the entire process.
- Concurrent access by multiple users - Multiple users access concurrently.
- Security related issues – e.g. Password related problem.