# LifeNet & Reliable Connectivity

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# Motivation & Ad Hoc Networks

# Some Scenarios:

Disaster-relief operations

On-field media

Exploration

Maritime industry

Mountaineering & expeditions

Remote rural areas

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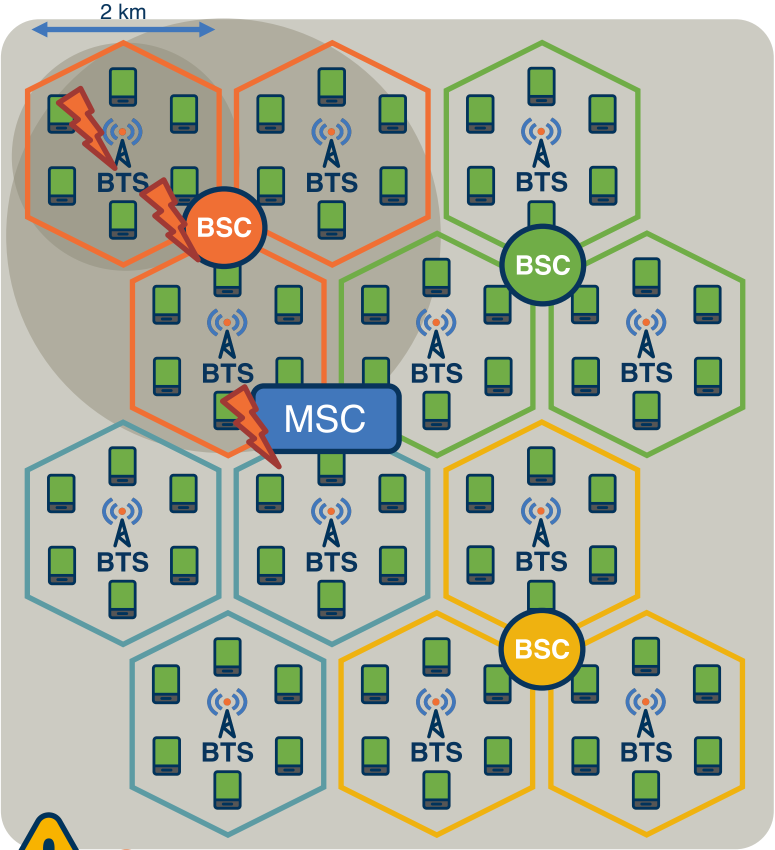
# Key Characteristics

## Transience

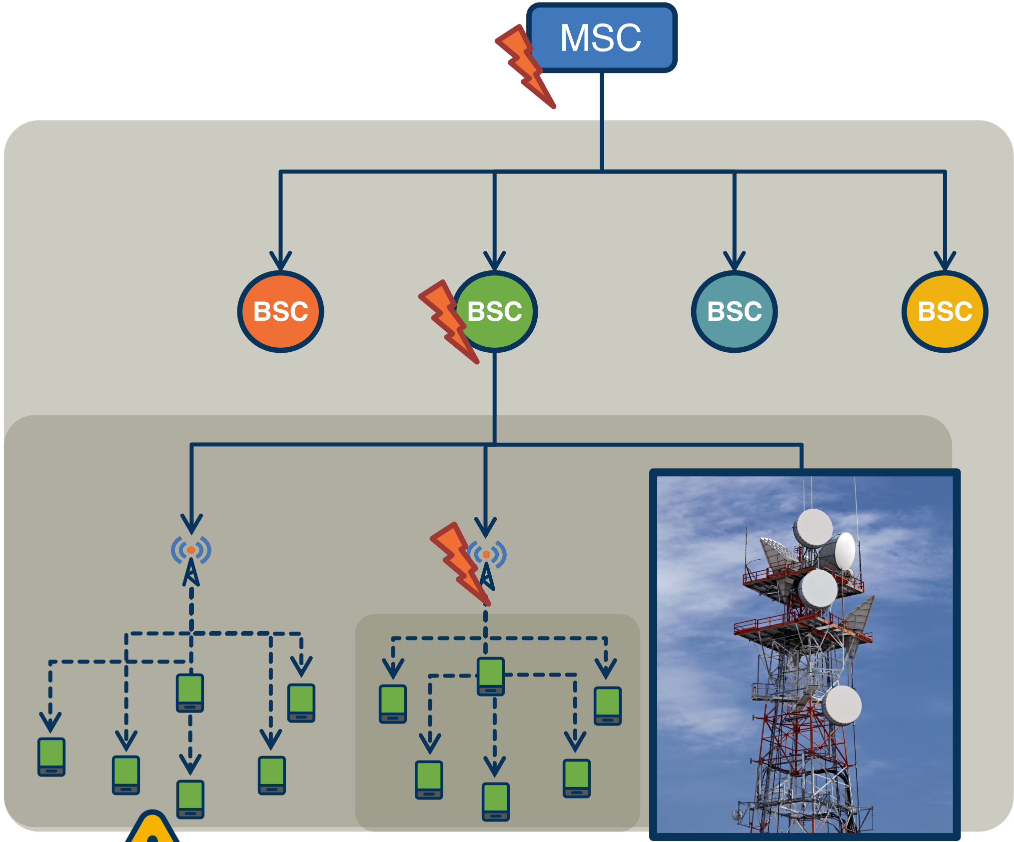
Moving users, changing network topology, changing physical obstructions, failing nodes, new nodes joining the network at random

## Lack of Infrastructure

Use of infrastructure such as huge towers and power supply backups is not feasible

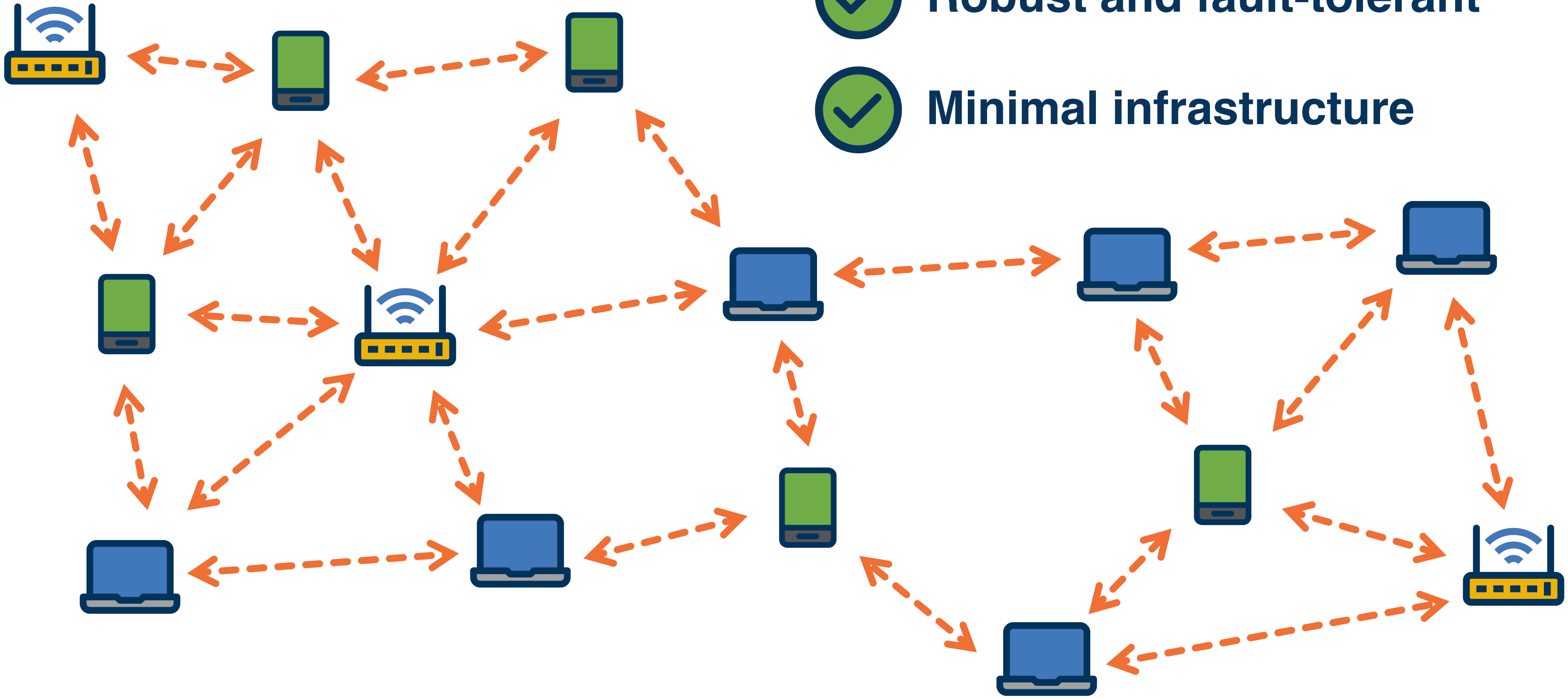



Single-point failure system!




Infrastructure at the last hop!

# Why Can't Traditional Solutions Be Applied?



- Robust and fault-tolerant
- Minimal infrastructure

# Desirable Approach: Ad Hoc Networks

# Prior Literature on Ad Hoc Networks

## Early Routing Protocols

- DSDV
- DSR
- AODV
- ZRP
- TORA
- OLSR

**Poor-routing metrics**

Results were **simulation-based**

Results **not repeated when implemented**

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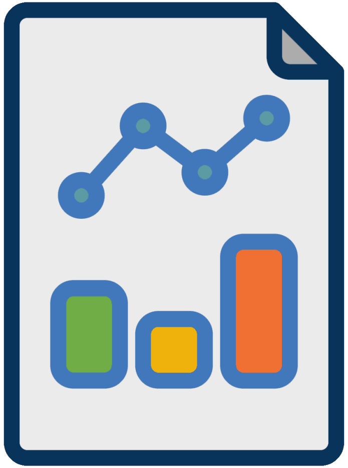

## Modeling and Evaluation Insights

- Per-node capacity is **O(1/√n)**
- Ad hoc networks **can be scaled** if locality of traffic is maintained
- **Hop count** is not a useful metric
- **Neighbor abstraction** is a poor approximation of reality
- **Addition of nodes** can improve node performance
- Metrics that reflect **end-to-end properties are key**

# Prior Literature on Ad Hoc Networks

# Prior Literature on Ad Hoc Networks

## Refined Implementations

- RoofNet: ETX metric, SrcRR, ExOR routing protocols (MIT)
- Multiradio multihop routing (MSR)
- TDMA-based MAC (IITB)

**Usability constraints** as they were **designed for throughput**

**Throughput not enough** for **high-bandwidth applications**

## Situation:

**Current Ad Hoc Networks** have usability constraints, such as static topologies and dependence of specific platforms and their throughput is insufficient for high-bandwidth applications

**Traditional Wireless Networks** cannot handle transience because their designs are single point failure systems, and they require infrastructure

**Transience**

**Lack of Infrastructure**

Can a **change in approach to ad hoc networking** address the problem in a **better way**?

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# Design Principles & Contributions

# 1. Focus on High Reliability and Usability at the Expense of Throughput


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# 2. Use of Commodity Systems

**High Scalability**

Networking software is a **complex inter-dependent system**

Networking hardware is **optimized for low-level commodity software**

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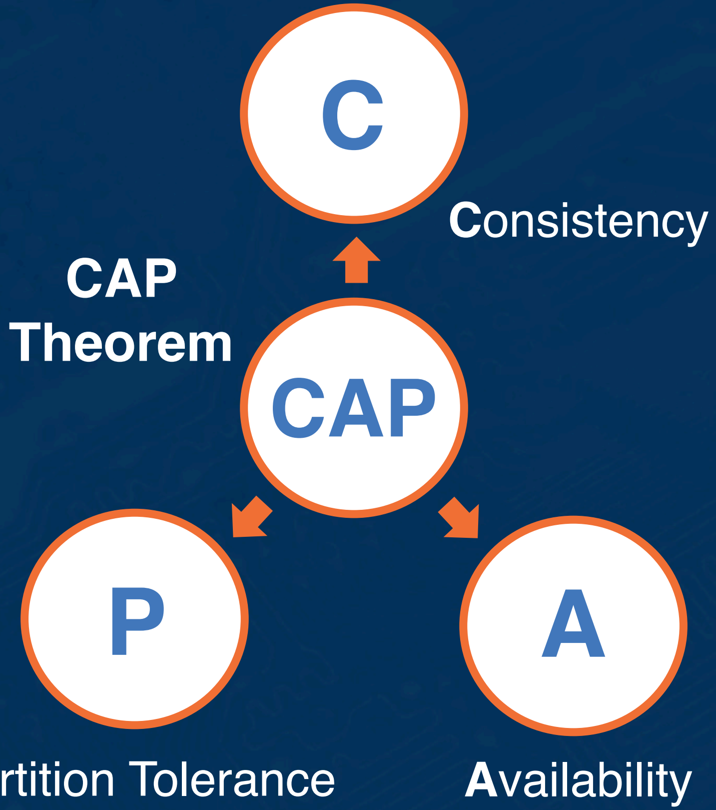
# 3. Availability Under Eventual Consistency

**A**tomicity
**C**onsistency
**I**solation
**D**urability

**ACID Approach**

**B**asically
**A**vailable
**S**oft state
**E**ventually consistent

**BASE Approach**



A new routing metric **Reachability**

A new routing protocol **Flexible Routing**

**Why is reachability useful?**

- Effects are naturally captured by transience
- Easy to compute and maintain
- Enables a compact network representation at individual nodes sufficient for routing

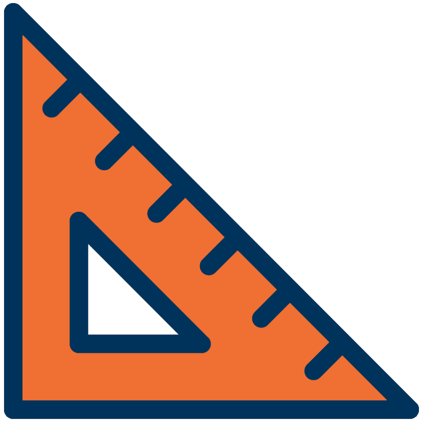
**Flexible Routing**

- Uses reachability as routing metric
- Proactive routing
- Multipath routing
- Trades throughput for reliability

**EDT**

# Primary Contributions

# The Reachability Metric



**Reliance on end-to-end measurements**

- Particularly true for **multihop communication**
- Because **network conditions at each of the hops are important**
- Should get **appropriately captured** in the **value of the routing metric**

## Desirable Properties of a Routing Metric

**Capture availability**

- Should **capture the aspect of availability** for **empowering the routing protocol** to make **availability-aware routing decisions**.
- Flexible routing protocol is a **multipath routing protocol**, so the metric **should capture their effect** as well.

# Desirable Properties of a Routing Metric

**Easy & bandwidth-efficient to calculate and maintain**

- **Calculation of the routing metric values at individual nodes** is control overhead
- Becomes **critical** under transience to **achieve the desirable trade-off between the accuracy and efficiency** of calculating and maintaining the metric values

# Desirable Properties of a Routing Metric

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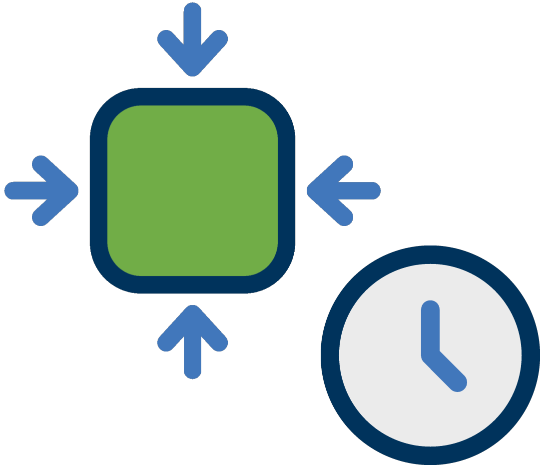

Compact & eventually consistent network representation

This becomes particularly important as the network scales!

# Desirable Properties of a Routing Metric

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# Intuition:

Aims to capture the **effects of transience in a single numerical value**

Measures the **end-to-end multipath probability** that a packet transmitted at a source node reaches the destination node

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# Definition:

**Reachability(A,B,T,L) of node B from node A** is defined as the **expected number of packet copies** received by **B** for **every packet originated** at **A** and **diffused in the network** for **at most L hops** in **time interval T.**

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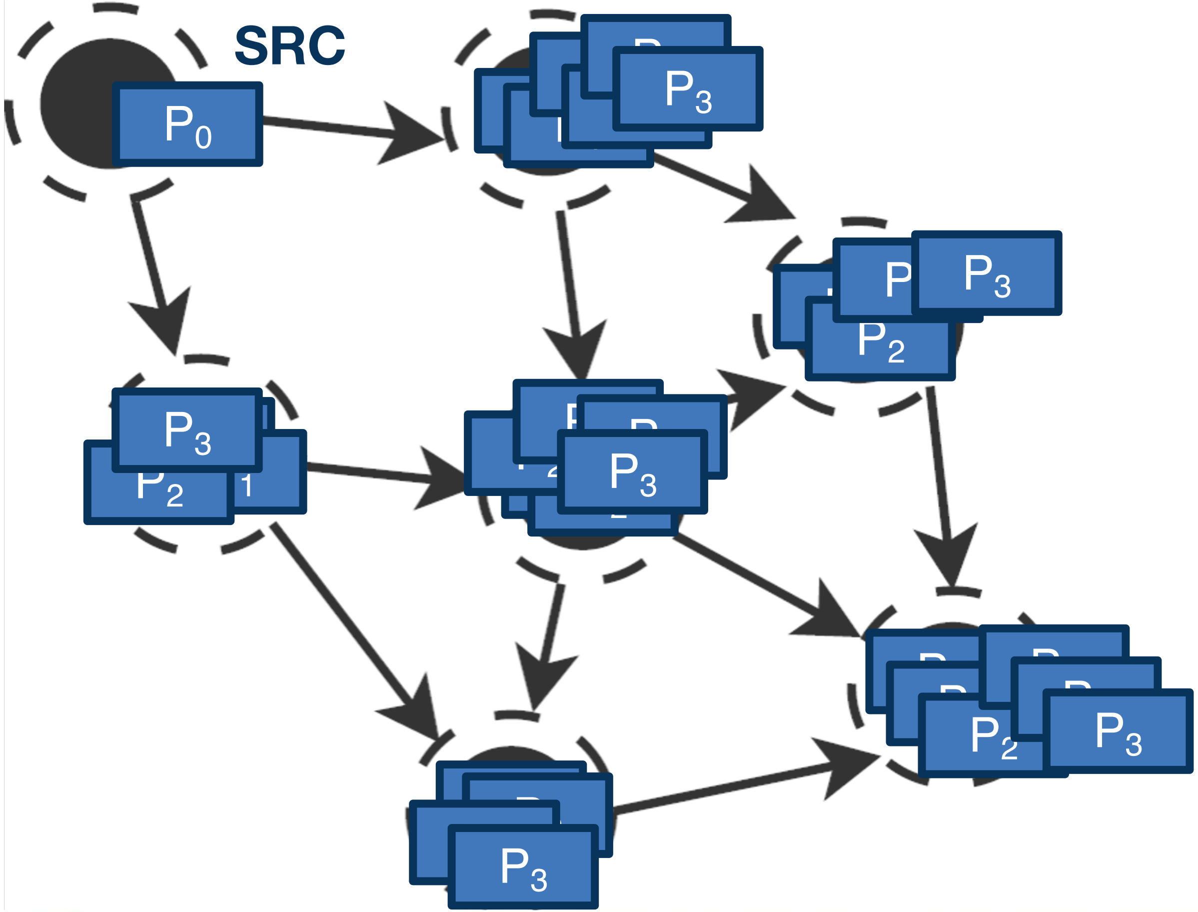


# Measurement Algorithm

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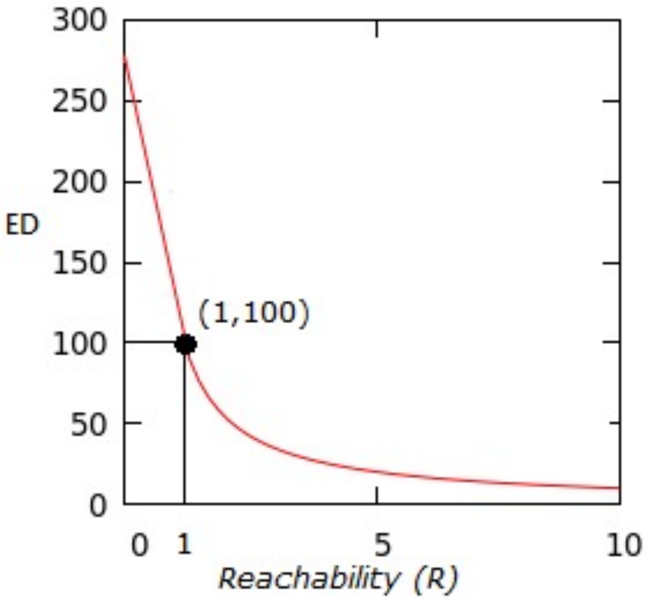
# Reachability

= (Number of packet copies received) / (Number of packets transmitted)

- For convenience, reachability is **mapped to a one-byte value**, which is **roughly its inverse** and called ‘**Effective Distance**’

```
IF (R > 1)
{
        ED = (100/R)
}
ELSE
{
        ED = 255 – (155*R)
}
```




## Mapping Reachability to Distance

# Experimental Evaluation

Reachability captures the effect of **mobility**

Reachability captures the effect of **node failures**

Reachability captures the **increased availability as the network scales**

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# Situational Analysis of Odisha Floods

# Team


Brahmani and Baitarani River Basins
Mahanadi River Basin
Cuttack
Bhubaneswar
Kendrapara
Paradeep
Jajpur
Dhenkanal
Brahmani River
Chandaka Forest
Bhitarkanika National Park

# Location

Disruption of Power Supply

Destruction of Roads

Destroyed Public Buildings

Broken Embankments

# Field Situation

# Operational Survey

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# Impacts of Floods on Infrastructure:

Most of the villages were completely submerged in water during peak floods

Findings

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# Impacts of Floods on Infrastructure:

- **Power supply was cutoff** for more than a week in most places. In some places, it was cutoff for **more than two weeks**.
- **Cellular networks were non-functional** for more than two weeks in the entire flood-affected zone.
- **Power supply intermittent** even after several days passed.

## Findings

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# Impacts of Floods on Infrastructure:

Concrete or tar roads were broken in some places rendering the flood affected areas inaccessible to vehicles

Findings

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# Impacts of Floods on Infrastructure:

**In many cases embankments were completely destroyed.** Embankments were the only road to many villages, destruction of which, made them completely inaccessible.

# Impacts of Floods on Infrastructure:

Many mud houses were uprooted or destroyed completely.



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# Impacts of Floods on Infrastructure:

Public buildings such as schools were severely damaged or partially destroyed.



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