



# *Sustainability*

*or*

*“It takes a village to raise a sensor network”*

**Technology and Global Development**

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# Learning goals:

- Look carefully at a fairly good example of using a participatory research and development approach to ICTD
- In doing so, help you to see a model for how a complete project can be planned and managed
- Leave simple pumps, and look at a design with cool technical elements.
- Summarize a framework for thinking about sustainability

# Case study: COMMON- Sense Net

- Problem?
- Geography?
- Technology?

# Partnerships

- Who were the partners?
- What role did they play?

# Participatory assessment

- How did they go about it?

# Participatory assessment

- Field survey
- 10 months
- 3 villages
- Goal: identify and categorize the information needs of the rural population living in semi-arid regions
- Chose "family" as the basic unit of study

# Survey phase 1

- Goal: classify families by livelihood into groups
- Method: for each neighborhood or caste
  - Identify set of knowledgeable individuals
  - Hold discussions with them



# Survey phase 2

- Goal: Prioritized list of issues by group
- Method: with each like-livelihood group
  - Hold group meetings
  - Follow up with semi-structured interviews
  - Identify relevant information issues
  - Prioritized issues with farmers (by consensus)
  - Repeat several times per group (iteration)



# Survey phase 3

- Goal: Gather *information* details of priority issues
- Method:
  - Meetings with interested individuals

# Results of iterative participative assessment

- Identified a diverse set of info needs
  - Weather prediction
  - Market conditions on a particular day
  - Legal advice on land-holding rights
- Highest priorities across groups
  - Crop yield
  - Pest and disease control
  - Bore wells' water level

# ICT?

- Are these priorities ICT issues?
  - Crop yield
  - Pest and disease control
  - Bore wells' water level
- How do the researchers interpret them?

# Creative (in the good sense) mapping of ICT to needs

- The highest priorities are not obvious information issues
- The researchers reinterpret:
  - The problem of crop yield -> a problem of \*predicting\* crop yield, so as to make good farming decisions.
  - And making decisions is an \*information\* problem, which defines the problem in the researchers' domain.
- If the researches were botanists, crop yield would suggest much different approaches than a sensor net.

# Interpreting data

- You can't expect the participative research to say:
  - ”We need a web site that will display graphs of environmental conditions in our field, and suggest informed strategies for what to grow and how.”
- Your expertise is providing that creative interpretation.



# Corresponding Caveat

- Toolhead et al:
  - "Our iterative survey process indicated a priority need for screws, therefore our proposed implementation using a hammer is justified."
- Iterative, participatory vetting is a safeguard

# Resulting technical solution

- What was the technological system?
  - What were the components?
    - How did they communicate?
  - What was the use process?



# Resulting technical solution

- Decision support system for making farming decisions
  - Based on existing crop simulation models (where available)
  - The models define the required data inputs
  - Sensor network to provide required data to the models

# Use case once sensor net deployed:

- Data gathered repetitively
- Data saved to database
- Database uploaded regularly by "crop modeling specialist" who
  1. tune the model coefficients
  2. validate the model with new set of data
  3. modify model as improved data becomes available.

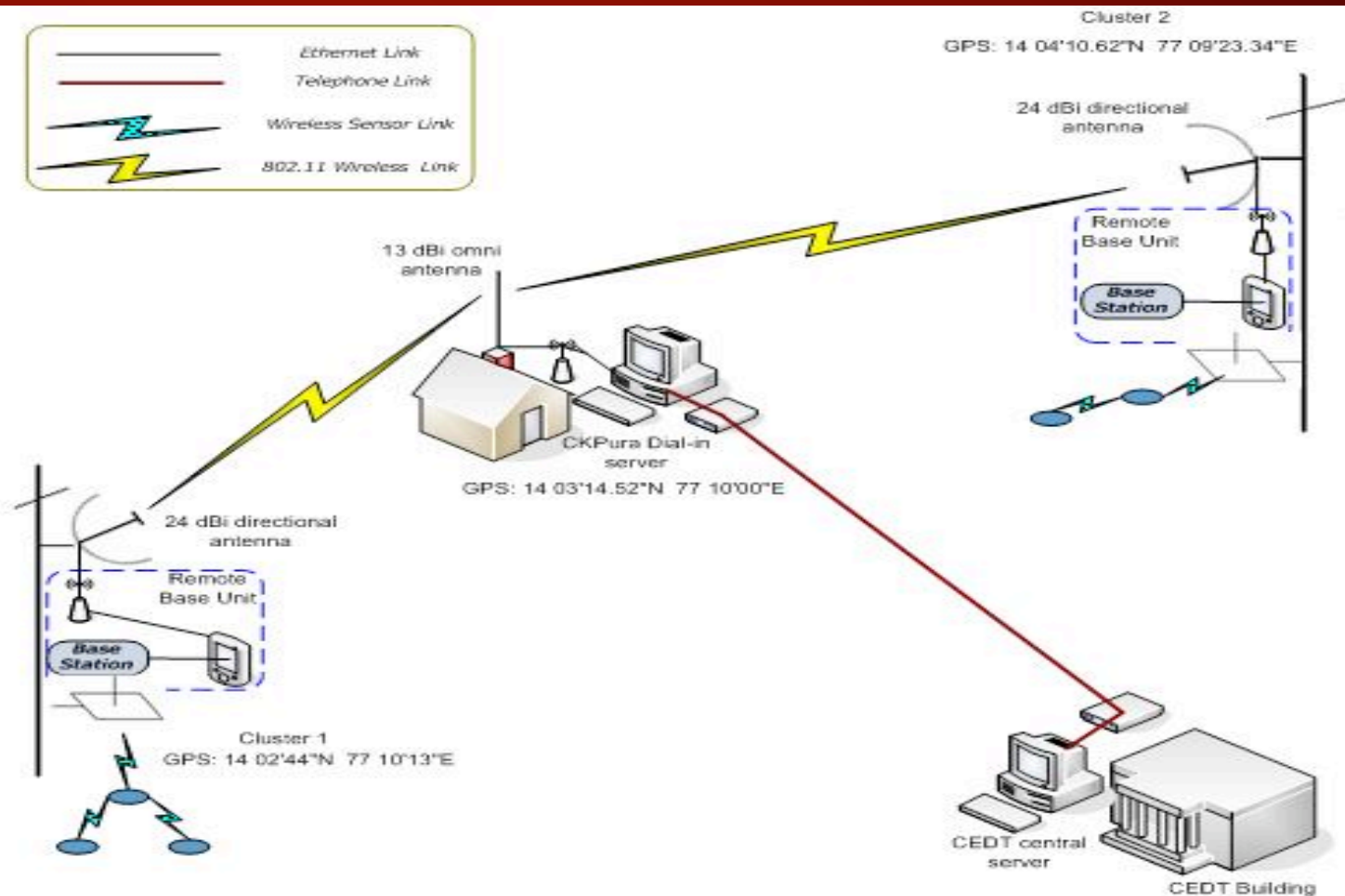
(Concern to keep in mind: Does not sound like a sustainable role within the farmer community.)

# Alerts

- Alerts generated by the system.
- The system operator alerts the farmer.

(Question to keep in mind: What skill does the system operator need?)

# Technical system design



Source: <http://www.common-sense.net.in>

# Sensing subsystem

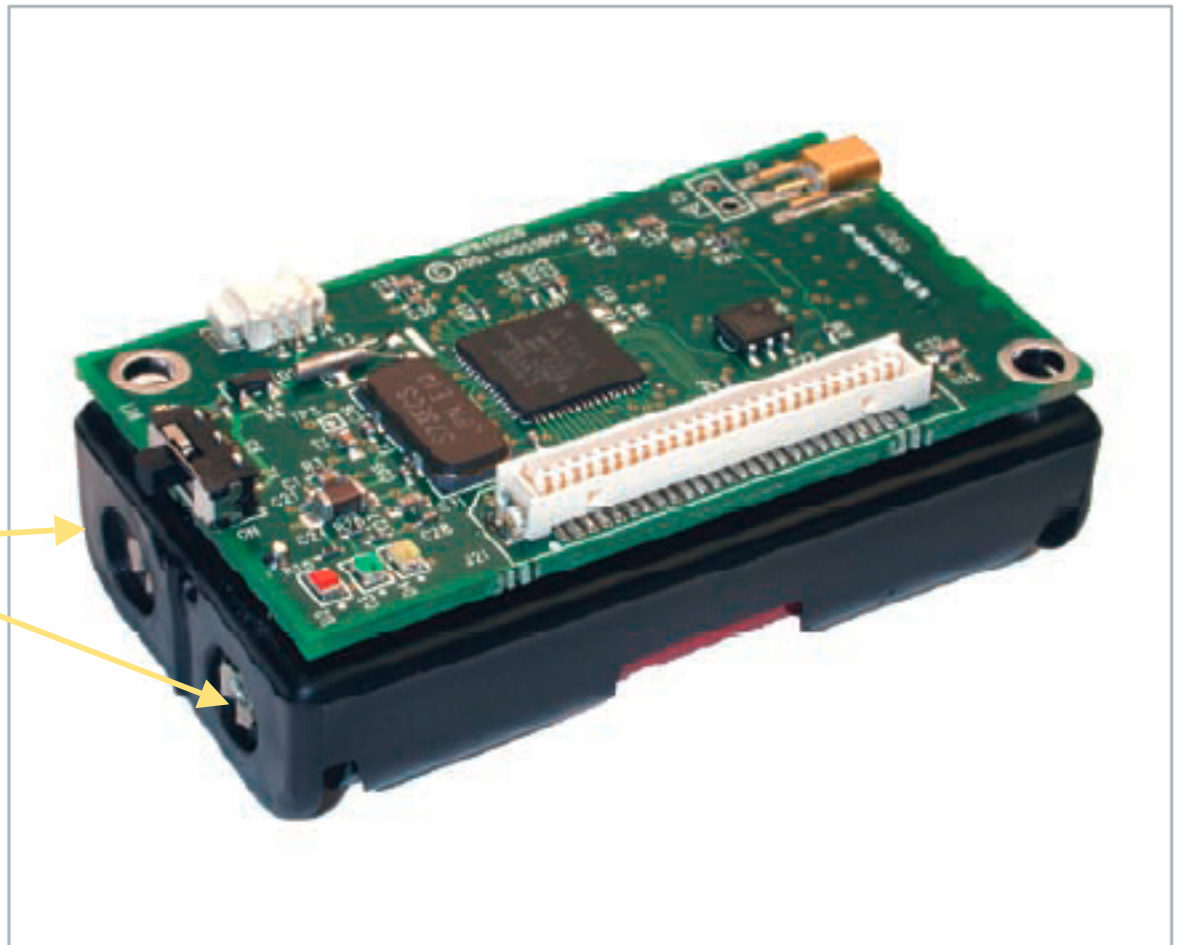
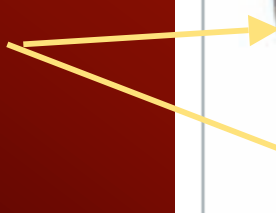
- Meteorological and soil sensors
- Connected to a mote
  - A specialized teeny computer
  - With 802.11 connectivity,
  - Powered by a pair of alkaline batteries

# Mica2 mote

Crossbow

Image scale?

2 AA batteries



Source: <http://www.xbow.com>

# Data collection system

- Motes do minimal processing
- Send back data to a central processor.
- Motes can talk to motes,
  - creating an ad-hoc network
  - for multi-hop routing of data



# Data transit

- The network was very sparse
- The sensor nodes weak
- So they had bridges
  - ruggedized PC
  - and access point
  - on electric poles

# Data logging / network management

- sends commands to sensor network
- logs data

# Data processing subsystem

- Future - apply predictive models to data

# Data Access subsystem

- Web interface to display raw and process data.
- Farmers can access graphs and spread-sheets local village center
- <http://www.commonssenet.in>

# Some Problems:

- What technical problems did they hit?

# Some Problems:

- Power:
  - 2 month battery life
- Hardware:
  - corruption in flash memory
- Software:
  - mote freeze
- Network:
  - WiFi link unreliability

# Participatory iterative design

- They state they did participatory iterative design
  - definition of the problem
  - proposal of a technology-based solution
  - develop system and test in the local cultural and social context
- Where was it was done well?
- Where could they have improved on it?



# Hybrids

- How did they use “cultural hybrids”?

# Hybrids

- They explicitly used "hybrids"
- In particular, a person who was:
  - a local farmer
  - who is also an agronomist,
  - and who is familiar with information systems
    - from having worked with them for a decade.

# Capacity Building

- In another paper<sup>1</sup>, the same researchers consider the capacity building aspects of their project
- They consider 3 levels of ICT-based human capacities  
adapted from Osterwalder<sup>2</sup>
  1. Ability to use and understand applications
  2. Ability to develop and maintain applications
  3. Ability do provide and maintain infrastructure

1. J. Panchard and A. Osterwalder, "ICTs and capacity building through apprenticeship and participatory methods applied to an ICT-based agricultural water management system," in Social Implications of Computers in developing Countries. IFIP WG 9.4, 2005.
2. Osterwalder, A. (2004). ICT in developing countries - a cross-sectoral snapshot. The Electronic Journal of Information Systems in Developing Countries EJISDC.



# Level 1 - User

- To what extent does the project help developing an ICT infrastructure for farmers in terms of developing capacities to provide and maintain and ICT infrastructure for water management.

# Level 2 - Developer

- To what extent does the project help develop locally relevant ICT-based agricultural water management applications, notably in terms of developing capacities to create and maintain these applications.

# Level 3 - Infrastructure

- To what extent does the project help the farmers develop their capacities to understand and use the ICT-based water management system? Is there spill-over in terms of developing more general ICT-usage capacities.

# Answers?

- They don't have answers yet.
- Their expected outcomes are not well formed.
- But I think it is looking in the right direction.



# Alternative questions

- Individual learning
  - What level of apprenticing or training is needed?
  - For who?
- Organizational learning
  - What new processes or ongoing programs will be necessary in the local center?
- Community learning
  - What new institutions will need to be built to support the region?
  - What new local business opportunities does this present
- Governmental learning
  - Should new policies be put in place to support this?

# Sustainability

- They concede that this was a research project intended to investigate experimental technology, and it will not lead immediately to a "profitable" application.
- They don't address what the benefit to the community who participated in the research with them was, and if it was made clear that the community would likely not get sustained value from the project.
- They identify sustainability issues at several levels.

# Technical system sustainability

- Ability of the sensor network to function without need of skilled maintenance.
- I would argue the the degree the complete technical system (not just the sensor network) can function without such need.

# Technical Scalability

- Given the difficulty of operating reliably networks of a few tens of nodes, it is still unclear today how well sensor networks will scale in the future.
- They contend they don't have an answer as to whether this will scale.

# Economic sustainability

- "One has to demonstrate that the investment necessary per year (one time sensor purchase, changes of batteries, possible service charge for the forecast) can be recovered by the improvement of yield and the increased income that results."
- Or an alternative business model.
- As yet unanswered.

# Planning for Sustainability

- Sustainability can be planned for at 3 levels

## 1. Capacity building

- Do individuals, organizations, communities, governments have the knowledge, processes, and policies to keep the complete system going?

## 2. Motivation & incentives

- Are individuals, organizations, communities, and governments motivated or otherwise have incentives to keep the complete system going?

## 3. Technical

- Is the technology robust so that its use and maintenance does not overwhelm 1 and 2?



# Motivation & Incentives

- People, organizations, businesses, and governments have to have appropriate motivation to sustain it
- Personal motivation or incentives (\$)
- Financial sustainability within a market
  - See techno-economics, coming soon
- Mission alignment within an organization
- Political support within a government



# Technical sustainability

- The chosen technology has to be as easy to sustain as possible
- Includes:
  - Robustness of solution
  - Availability of support units
  - Availability of talent in the job market