Module 2:

Planning, Design, Appraisal and Implementation

Design of Rural Transport Infrastructure

Session 2.2

Part 1

Presentation 2.2a

The World Bank
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SSATP
theIDLgroup

The Training Modules

Module1. Policies and Strategies

This Module

Module 2. Planning, Design, Appraisal and Implementation

Module 3. Management and Financing

Module 4. Rural Mobility

Module 5. Social and Environmental Issues

Module 2. Planning, Design, Appraisal and Implementation

Session 2.1 Participatory rural planning process

This session

Session 2.2 Design of rural transport infrastructure

Session 2.3 Rural road economic appraisal methodology

Session 2.4 Labour-based works methodology

Session 2.5 Small scale contractor development

Session 2.6 Community Participation in Rural Transport Infrastructure

Session 2.7 Participatory Survey Techniques for Rural Transport

1. Introduction

Learning Objectives

This session enables participants to:

- Explain the rationale for Rural Transport Infrastructure (RTI) interventions
- Define key terms and concepts
- Describe the seven components for designing RTI interventions for basic access

Session Overview

- The case for Rural Transport Infrastructure (RTI)
- Concepts and Definitions
- Designing RTI for Basic Access

2. The case for Rural Transport Infrastructure (RTI)

- 3 billion people in developing countries live in rural areas
- Most live on < $2 / day
- Their lives are characterised
  - by isolation and exclusion
  - unreliable access to the most basic economic opportunities and social services
- Their transport needs
  - non-motorised means
  - on rugged paths, tracks and roads, which are
  - …. typically in poor condition
  - ….. often only passable in dry weather

Some basic data

Rural transport infrastructure (RTI) =

- rural roads, tracks, paths and footbridges
- network in developing countries:
  - *designated* (government responsibility) rural roads estimated at 5 - 6 million kilometres
  - *undesignated* roads, tracks, paths = expansive …
  - ... several times the designated network

Of the trips that take place over RTI:

- 80% are short distances < 5 kilometres
- made by non-motorised means, including walking, animals, bicycle, and porterage

Rationale: the case for RTI

- Excessively high standards of access often adopted
  - particularly when donor financing is involved
- Scarce resources mean that higher than necessary standards of access to limited populations lead to
  - costly long-term maintenance
  - denial of access to under-served populations
- 'Basic access approach' is advocated:

Priority is given to the provision of reliable, least-cost, all-season basic access to as many people as possible.

Concepts and Definitions

Card sorting exercise

Using the cards provided –
organise the definitions under the appropriate RTI headings.

3. Concepts and Definitions

- RTI Network
- Basic Access
- Basic Access Infrastructure
- Basic Access Intervention
- Features of RTI
  - physical
  - traffic characteristics
  - ownership
  - managing and financing

RTI Network

- lowest level of physical transport chain that connect rural population to farms, local markets, and services like schools & health centres
- potentially increases income and improves quality of life

Basic Access

- minimum level of service of the RTI network
- necessary building block for poverty reduction
- provision of basic services should be considered a basic human right, like health and basic education

Basic Access Infrastructure

- reliable access is need by the prevailing type of rural transport vehicles (motorised/non-motorised)
- reasonable delays at river crossings or temporary road closings during the rainy season must be tolerated
  - ➢reduce investment costs considerably
- maximum time for temporary closures is a political decision and an affordability issue

Basic Access Intervention

- the least-cost intervention (in terms of total life-cycle cost) for providing reliable, all-season passability by the prevailing means of transport
- all season passability for a pick-up truck, a small bus, or a truck, even if these are a small fraction of total traffic
- need appropriate RTI for the efficient and economical use of non-motorised (or intermediate) transport
- e.g. Bangladesh: non-motorised rickshaw-vans (for goods) and passenger rickshaws dominate traffic

Features of RTI

- includes the intra- and near-village transport network
- infrastructure that provides access to higher levels of the road network

Physical

- community RTI = tracks, paths and footbridges, and sometimes (partly) engineered roads
- should not exceed five km. in length

Features of RTI *continued*

Traffic characteristics

- mostly on foot
- sometimes intermediate means of transport (IMT) - bicycles and animal drawn carts
- sometimes use motorised transport
- average daily motorised four-wheeled traffic on the majority of the RTI network is below 50 vehicles per day (VPD)
- non-motorised traffic (NMT) can be a multiple of this number

Features of RTI *continued*

Ownership

- normally owned by local governments and communities
- community RTI is usually undesignated - not formally recognised in the transport network
- If no legal framework, community RTI belongs to community
- But! the capacity of communities to own and take care of RTI is limited usually to the intra- and near-village network and to short links to the main road network

Features of RTI *continued*

Managing and financing

- transfers from central government (from the Treasury, dedicated road funds, donor financing)
- should be leveraged to generate local resources in cash or in kind
- financial resources are usually extremely scarce, particularly for maintenance

4. Designing RTI for Basic Access

Key aspects

1. Drainage
2. Roughness
3. The (Trouble) Spot Improvement Approach
4. Staged construction – NOT recommended for RTI
5. Engineering design
6. Implementation methods
7. Maintenance

1. Drainage

The Rationale

- Most RTI in developing countries carries traffic of less than 50 motorised four-wheeled vehicles per day (VPD)
- But! also a substantial number of intermediate means of transport e.g. bicycles & animal-drawn carts

What is needed

- single-lane roads
- spot-improved earth or gravel roads
- low-cost drainage structures
  - fords and submersible single-lane bridges

Drainage is critical!

The case for the removal of surface water

- Crucial for success of basic access RTI
- The weather causes more damage than the traffic!
- Requires
  - a good camber of 5% - 8%
  - adequate side drains
  - carefully designed cross drainage structures
  - stone or concrete drifts, or splashes can substitute for culverts

Dealing with rivers

- Major river crossings
  - design to allow traffic passage at low flows
  - close at high flows
  - peak flows often only last for a short duration (less than three hours)
- If rivers cannot be crossed for long periods
  - provide high-level and relatively expensive crossings to achieve basic access standards
  - if these are not affordable, provide an all-season footbridge
    - to allow pedestrian and IMT crossings during the rainy season

2. Roughness

- Roughness and speed are not important design parameters for basic access RTI
- But there is a limit to roughness!
  - to avoid damage to vehicles
- Speeds should normally not exceed 30 kph
  - taking into account the varied use of basic access roads, by people, non-motorised, and motorised traffic

The most important criterion for the infrastructure is to be able to:

withstand the elements and traffic

without extensive damage.

3. The (Trouble) Spot Improvement Approach

What is spot improvement?

- The focus of interventions only on difficult sections of the RTI

Rationale

- Deteriorating network of roads, tracks, and paths
  - passable only in the dry season, with difficulty
  - not at all in the rainy season
- In these situations, the spot improvement approach
  - is appropriate for providing basic access
  - at a lower cost

Using the (Trouble) Spot Improvement Approach

- Road failure is most likely on steep hills, at water crossings, and in low-lying areas
- Solutions:
  - realignment, paving of steep sections, provision of simple but permanent water crossings, raising low-lying areas on embankments
- Interventions must be designed and engineered well
- Upgrading an existing track/ earth road to basic access standard needs interventions on 10% of the road length
  - greatly lowers costs of providing all-season passability
- Construction cost savings of 50 – 90 % compared with full improvement

Spot improvement interventions call for good judgement by the engineer!

- Ensure untreated sections have sufficient capacity for the prevailing conditions and transport types
- If the soils not strong enough to bear traffic, provide
  - camber and drainage, or
  - gravel surface should be provided throughout
- During design analyse each section to find the least-cost solution
- The spot improvement approach also applies to periodic maintenance
  - spot re-gravelling, instead of full gravelling, may be the right approach

But, there is resistance to spot improvement

- Especially in donor-financed interventions
- Constraints
  - political pressure
  - road agency and donor preference for high-standard, high-cost roads
- More recent successful projects based on the spot improvement approach
  - some donor-financed interventions working in close collaboration with the responsible road agencies

But! spot improvement approaches will **NOT WORK** in areas that have very poor soils or are prone to flooding.

Performance-based road management and maintenance contracts

- Potential to enhance spot improvement approach
- Only applied on major highways (until recently)
- World Bank-financed project in Chad
  - proposing to introduce such contracts on 450 km unpaved main road network

Performance criteria are:

A. passability at all times
B. a specified average speed
C. minimal riding comfort
D. road durability and preservation

These contracts should guarantee an approach whereby

- the contractor focuses on the critical spots of the network
- while assuring a minimal level of comfort for the road user

Kenya: The Roads 2000 Programme
a success story

- Maintenance implementation strategy
- A solution to the deteriorating unpaved road network of 53,000 km.
  - a limited number of trouble spots was the main cause of non-traffickable roads
  - traditional equipment-based maintenance approach could not provide the required services with the current funding levels
- Built on the successful experience of the labour-based Rural Access and Minor Roads Programmes

Three components of the Roads 2000 approach

1. Rehabilitation Phase

Bring roads back to minimum maintainable standard

2. Routine Maintenance

Establish labour-based maintenance system

3. Spot Improvement

Plan and carry out a follow-up programme of selected spot improvements

1. Rehabilitation Phase

- Labour units brought the road to a passable & maintainable level
  - cleared the vegetation & drainage system
  - reestablished the road camber

2. Routine Maintenance

- Small-scale contractors (group or single person contracts) established
  - to carry out routine maintenance on a permanent basis
  - on more heavily-trafficked roads (> 50vpd) - they were supported by tractor-towed graders

3. Spot Improvements

- Identified in the rehabilitation phase and implemented as funds and resources allowed

Spot improvements - typical works in the Kenya 2000 programme …

- installation of new culverts
  - on average one new line per km.
- rehabilitate
  - existing culverts (or replacement)
  - bridges and drifts
- spot re-gravelling
  - to a maximum of 4% of the road network length
- alternative surfacing
  - over limit distance
  - e.g. steep sections, approaches to structures
- full road reconstruction
  - over a limited distance

… for the Kenya 200 programme …

Costs for unpaved roads

- adjusted to year 2000 prices

- partial rehabilitation and spot improvement
  - $ 2,000 / km.
- labor-only routine maintenance
  - $240 / km. / year
- routine towed grading
  - $280 / km.

Experiences of Spot Improvement and Labour-Based Approaches in other countries

Group Discussion

What are the experiences of Spot Improvement and Labour-Based Approaches in other countries?

4. Staged construction

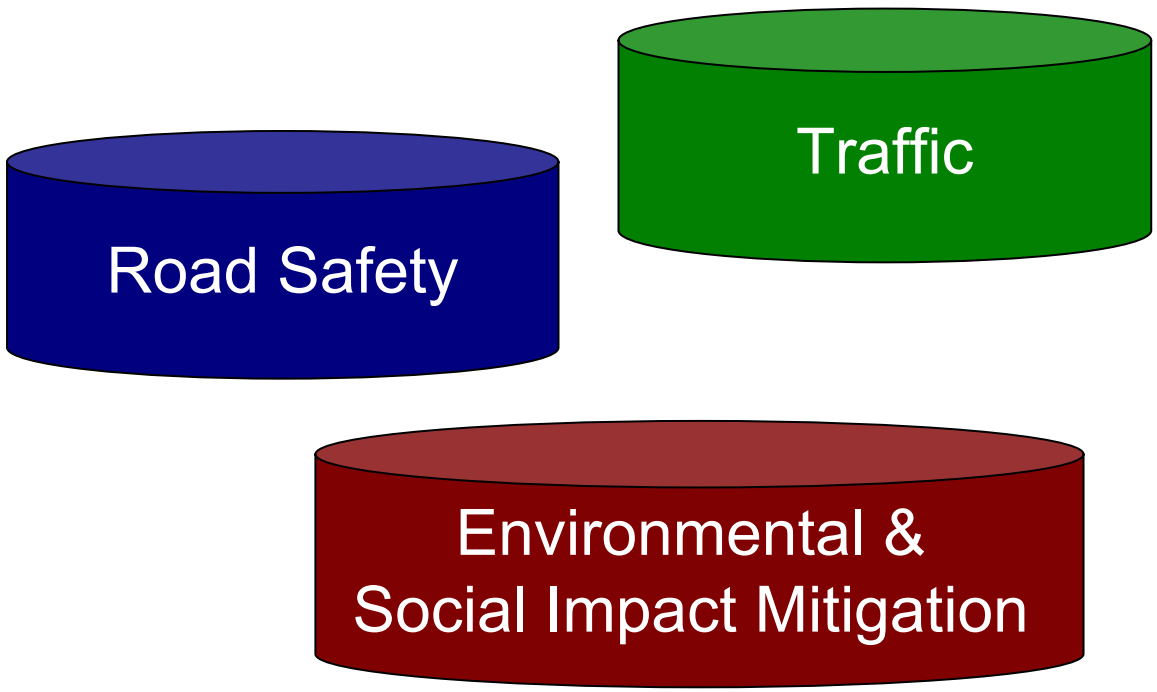
NOT RECOMMENED FOR RTI

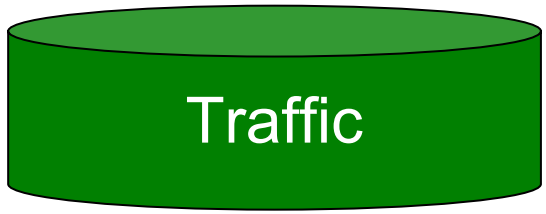
- Staged construction is
  - investment into structural elements of RTI …
  - ... for future upgrading needs due to traffic growth
- Long-term savings may be possible
  - trunk or provincial roads – if substantial traffic growth is expected
  - But! not for RTI, especially if initial traffic levels are very low
- If road agencies insist on such ‘advance’ investments
  - justify with economic analysis
  - analysis must take into account the additional short-term maintenance because of higher-than-necessary investments

5. Engineering design

- Basic access RTI must be properly designed
  - to resist the weather and traffic
  - produce a maintainable and sustainable asset

Considerations:





- RTI should be designed for size!
  - to allow the largest and heaviest users to pass safely without damaging the structures
  - e.g. 7 ton trucks, pick-up trucks, motorcycles, power tillers
  - also for non-motorised means of transport in some cases
- Avoid designs to a low standard suitable only for 4WD-drive vehicles
  - rarely used by local transporters or the local population
- A potential problem = large trucks
  - using the road to evacuate heavy natural products and resources e.g. crops, timber, minerals
  - likelihood of such traffic must be confirmed at project appraisal

Road Safety

- Safety concerns of *basic access RTI* are different than those for higher-level infrastructure
- Typical problems are
  - single-vehicle accidents
  - accidents between motorised and non-motorised vehicles, pedestrians and animals
- The challenge
  - to ensure that the speed of motorised traffic is low
  - …. not more than 30 kph, particularly within villages

- Single-lane roads with passing places – inherently dangerous?
  - are wider roads safer even when the traffic levels are low?

  No.
  - The risk of vehicle-to-vehicle collision increases slightly …
  - … even if the volumes increase from 10 vehicles/ day to 50 vehicles/ day
  - this level of traffic can be accommodated by passing places

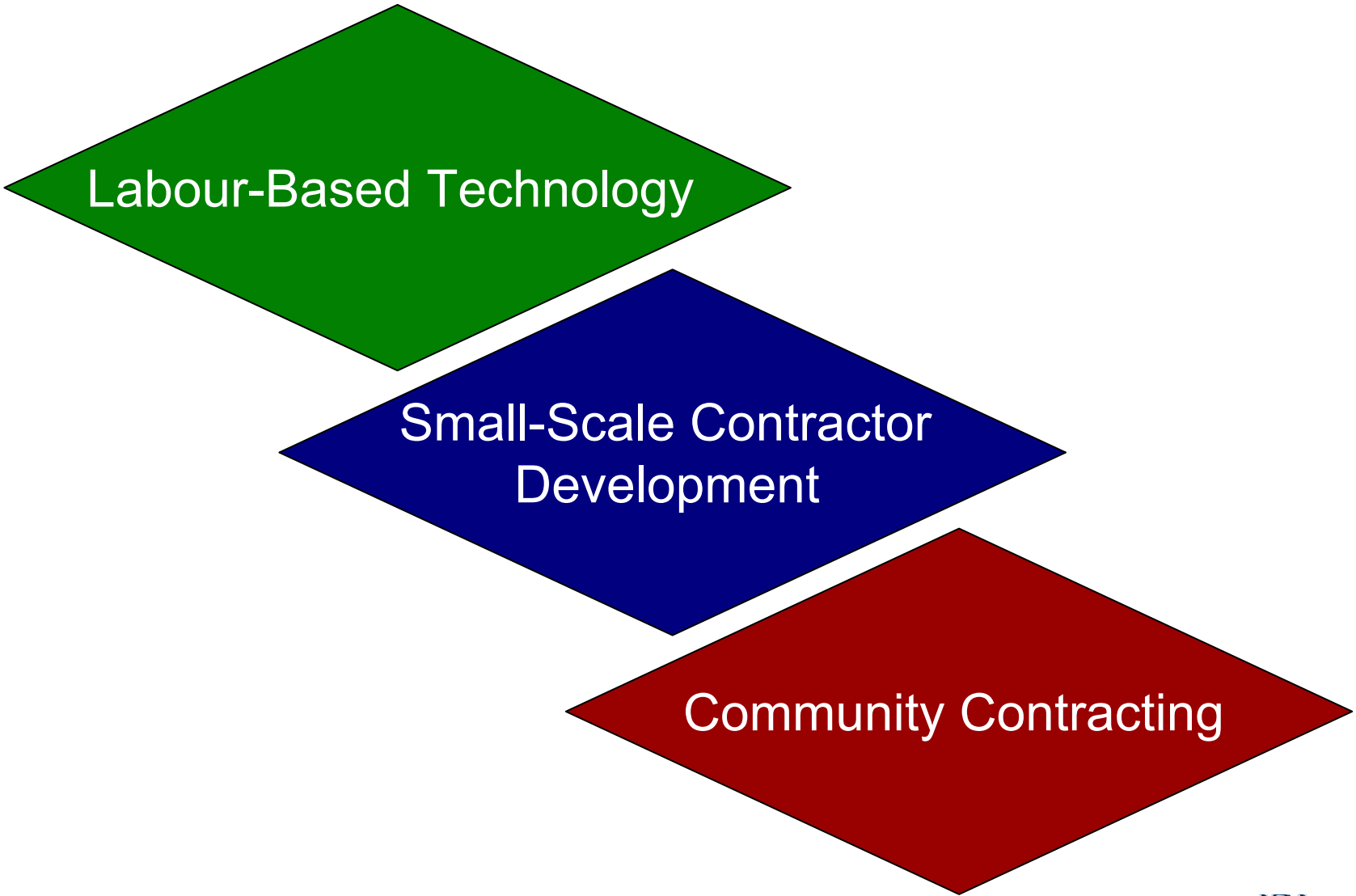
- If large volumes of pedestrian (NMT) are expected, construct:
  - a wider road shoulder or
  - separate pedestrian and NMT-ways (particularly within villages)

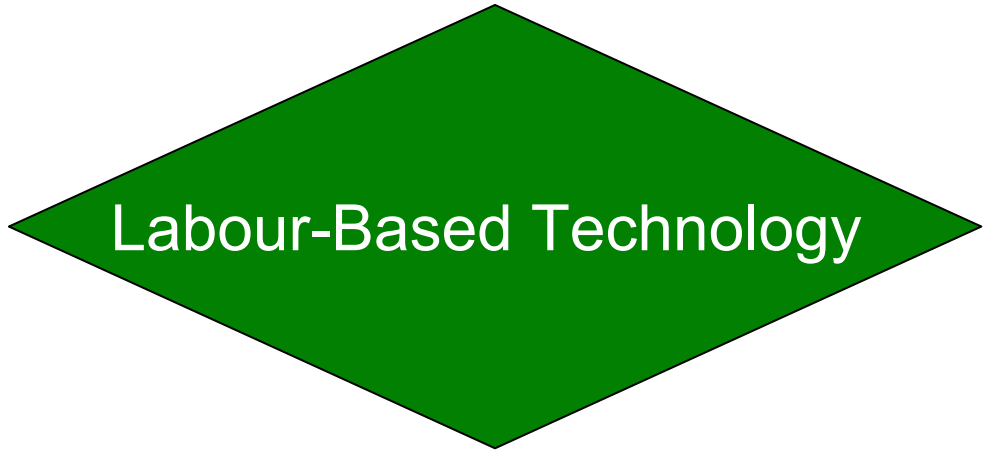
Environmental & Social Impact Mitigation

- Acquisition of productive agricultural land and housing to develop RTI
  - might necessitate resettlement
  - … likely to be minimal in the case of improvements to existing roads
- Dust from vehicles and erosion of RTI surfaces, drainage structures, and outlets
- Opening up of territory - previously inaccessible/ marginally accessible to immigration and resource harvesting

- The processes to identify and mitigate the potentially adverse impacts of RTI projects, while enhancing their positive effects =
  - environmental assessment (EA)
  - social assessment (SA)
- EA and SA must be
  - initiated at the beginning of the project cycle
  - continued throughout

6. Implementation methods





- Poverty alleviation
- Income - wages from work + procurement of materials and tools from local sources
  - RTI requires 2,000 to 12,000 person-days per kilometer for construction and
  - … 200 to 400 person-days per kilometer for maintenance
- Local empowerment through skills-transfer and creation of ownership
- Gender-specific impact
  - e.g. 'Destitute Women Programme' implemented in Bangladesh

Relevance of Labour-Based Technology*

Road construction & maintenance often described as

- equipment-based or labour-based
  - depending on the relative intensity of productive factor use

The term 'labour-based' describes

- projects where labour is substituted for equipment when it is cost-effective
- covers most road-related activities apart from compaction and heavy earthworks
- use of appropriate light equipment (mostly tractor-trailer)
  - which supports utilisation of labour in specific essential activities e.g. compaction and gravel haulage for surfacing

* Based on comparative studies in for example Ghana, Lesotho, Madagascar, Rwanda, Zimbabwe, Cambodia, Lao People's Democratic Republic (Lao PDR) and Thailand.

Labour-Based Technology …

- Economically & socially desirable
  - unemployment is high, jobs are scarce
  - average daily wage rate for agricultural sector workers less than $1 - $5 per day
  - equipment usually owned by a few large-scale contractors or government departments
  - maintenance and back-up services can be problematic and expensive, and real equipment costs are prohibitively high
  - lower unit cost of labour relative to capital

- ILO concluded that labour based construction and maintenance* …
  a) 10-30% less costly, in financial terms, than more equipment-intensive works
  b) reduced foreign exchange requirements by 50 to 60%
  c) created, for the same amount of investment, 2 to 5 times more employment

** Employment-Intensive Infrastructure Programmes: Labour Policies and Practices, 1998*

The viability of labour-based construction techniques depends on ….

- Government attitude
- Economic conditions
  - especially labour and capital markets
- Location of the project
- Road agency administrative and financial procedures
- Capacity for management and human resource development
- Provision of adequate training

Basic Access is ideal for labour-based methods

- Spot improvement interventions are
  - small-scale and varied
  - requiring attention to detail
  - often do not require heavy construction equipment
- Community RTI
  - gives people the opportunity to acquire the skills for the eventual infrastructure maintenance by labour-based methods
- Note: equipment (e.g. graders)
  - seldom available for subsequent maintenance activity for RTI
  - so should be planned for at design

Prerequisites for effective labour-based contract execution

- Labour availability
  - in sufficient numbers
  - with supervision experience
- Contractors must be small-scale
  - experienced in labour-based project execution
  - qualified
  - possess/ have access to appropriate equipment
  - willing to undergo training
    - if they have no direct experience in labour-based execution of works

Despite these advantages ……

It has been difficult to mainstream labour-based approaches.

- The difficulties encountered include
  - inflexible labour laws
  - availability of cheap second-hand heavy equipment
  - unsuitable procurement laws
  - lack of capacity to rapidly pay labour-based contractors

To mainstream labour-based approaches, these obstacles need to be overcome at the policy level.

Small-Scale Contractor Development

- Basic access interventions are
  - small-scale, varied, and scattered
  - ideal for execution by small-scale labour-based contractors and by community contracts

Such contracting requires

a) an appropriate policy environment
b) capacity building programmes for designing, managing, and execution of contracts
c) appropriate procurement procedures

Development of small-scale labour-based contractors needs …

An enabling environment

- regular workload for contractors
- rapid payment of bills
- access to credit facilities and equipment rental opportunities.

Management capacity of the contracting agency is key!

- To overcome capacity constraints at the local government level
  - government entities should join together to form joint-services committees or
  - hire consultants to assist in contract management
- Contractors' associations have an important role to play in the capacity building process as well

- The limited capacity of single small-scale contractors
  - requires employment of numerous contractors if major earthworks are involved
  - average capacity = about 1 km of earthworks per month and 0.5 km of gravelling per month
- Part of the capacity building process is
  - assistance to the contractors with appropriate equipment
  - in most cases tractor-towed equipment e.g. trailers, water bowsers, rollers and towed graders

- Major means of channelling grant funding to the rural poor
- Procurement by communities
  - or on behalf of, or from communities
- Communities are implementing agencies who take direct responsibility for their own development
- Role of government = facilitate and support
  - usually through the assistance of NGOs

Requirements for community contracting ...

- Participation from the community
  - in designing the various procedures, including procurement and disbursement
  - greatly assists accountability
- Simplified procurement procedures for community contracting
- Legal framework that gives communities legal status
  - without which they are unable to receive or manage funds

7. Maintenance of Basic Access RTI

Problem = insufficient/ non-existent maintenance

- Inadequate financial allocations to RTI maintenance
- Lack of capacity to execute maintenance
  - linked to institutional issues

The need for rehabilitation is a good indicator for the lack of maintenance capacity.

The fact is …..

- Earth & gravel roads and paths are
  - very vulnerable to the elements
  - often will not survive a single season without proper maintenance
- A road/ path is no better than its weakest link!
  - one failed drainage structure or section can be sufficient to disrupt access

A rule of thumb: expenditures for maintenance should be

- 50-80% of total expenditures for roads in a *growing* network
- 90-95% in a *mature* network

The argument goes like this ….

'… insufficient maintenance capacity means even higher initial standards are required …'

- This is a short-term view
  - higher standards e.g. bituminous surfacing, might extend the useful life of the RTI by a few years
  - **BUT!** a lack of maintenance on such a surface eventually causes even higher costs
  - ➢ … as total-cost analysis demonstrates

- Routine maintenance is required in all circumstances
  - lack of maintenance reduces the useful life of an 'over-designed' surface substantially

Maintaining an earth or gravel road is relatively costly

Rule of thumb

- Undiscounted maintenance costs over the typical life of RTI will equal the initial construction costs.
- E.g. a typical $5,000/km. basic access road may cost an average of $250 a year per km. to maintain over its assumed 20 year life.

Engineering tradeoffs with maintenance - periodic: routine: recurrent

Need for PERIODIC maintenance reduced by:

- Enhanced *routine* maintenance – to provide the required 'passability'
  - also reduces the need for further investments in the form of spot improvements
  - naturally occurring gravel used for periodic renewal of gravel layers no longer available in some countries
- Maintenance of a proper camber
- Protection of drainage structures

The costs of increasing the grading frequency on earth roads is lower than gravelling at low traffic levels.

Concluding Remarks

- Rural transport interventions must be an integral part of development strategies to combat poverty
- Greater impact if RTI interventions
  - are designed in a least-cost, network-based manner focussing on eliminating trouble spots
- The (trouble) spot improvement approach is the key to the least-cost design
  - cost savings of 50% – 90%
- Labour-based approaches are best suited for the implementation of RTI interventions