ROADS CROSSINGS AS SAND DAMS

KENYAN EXPERIENCE

PRESENTATION

1. Introduction
2. Identify arid and semi arid counties of Kenya
3. Water harvesting methods from roads
4. The economic importance of non vented drifts as water harvesting structures
5. Design consideration
6. Typical costs per metre run of drifts
7. Failure mechanisms
8. Conclusion & Recommendations

Arid Counties of Kenya

There are nine arid counties in Kenya with a total combined population of 4,620,199 or 12% of the population of Kenya

These counties are Turkana, Wajir, Mandera, Marsabit, Isiolo, Garissa, Samburu, Baringo, Tana River

The semi arid Counties: Kitui, Makueni, Meru, Embu, Tharaka-Nithi, West Pokot, Narok, Kajiado,Laikipia, Kilifi, Kwale, Lamu, Taita Taveta, Laikipia.

The semi arid counties have an approximate population of 9,424,648 or (24%) of the population of Kenya.

The arid and semi arid counties are ranked some of the poorest in the country.

(**Source:** Adapted from Vision 2030 Development Strategy for Northern Kenya and other Arid Lands (2011)

A map of arid and semi arid counties of Kenya

More than half of the Kenyan republic is arid or semi arid

Water harvesting for people and agriculture

Due to the unreliable rainfall there is need to harvest water for the people and agriculture in order to become more resilient to the harsh climatic conditions.

During the rain seasons a lot of water is collected into the road side ditches and discharged through culverts into seasonal rivers and finally to the Indian ocean.

The rivers dry up quickly and leave the people without water for animal and domestic use

The crops dry up leaving the people with hunger and poverty.

Semi-arid areas in Kenya

Characterised by many expansive(large) sandy or rocky seasonal rivers and lack of water by the local communities.

The rivers range in span from 5 -300 metres

The rivers typically flow for just a few days or even hours each year

The rivers also cut across rural roads posing a big challenge for roads crossings.

During the dry season the sandy river beds become too loose for loaded vehicles to cross and in the rainy seasons they become floody cutting off road transport.

The rocky river beds are also too rough to drive through.

Due to the large sizes of the rivers, bridges are expensive and uneconomical to construct while the traditional culvert river crossings are vulnerable to being washed away by the floods due to sedimentation and debris.

In order to provide cheap and affordable road river crossing, the KeRRa Makueni Regional office adopted non vented drifts to cater for road transport as wells as providing water for people

Example: Kyuasini Non Vented drift (80m x 5m) constructed on rock bed (Makueni county)

Wet sandy river bed in Muangini river–Makueni County(200m span) – loaded vehicles sink – drift construction ensures access.

Expansive river crossing in Rocky River bed in Thwake river Makueni County- 170m span (rocky surface very rough and uncomfortable to drive- drift construction ensures smooth riding surface)

A vented culvert river crossing - not preferred

1) requires regular maintenance to remove sediments flotsam

(2) capacity of the culverts is greatly reduced resulting in wash away and cut off road

(3) and: does not retain water!

Non vented drift (sand dam)

In order to solve the problem which is pertinent in Makueni County of Kenya and in many other semi arid regions in Africa it resulted in a serious thought to develop and design a **Non vented drift(without culverts) or sand dam** to act as both road crossing and water retaining structure to provide the surrounding communities who live within a radius of 3-5 km from the structure with water all year round and enhance road connectivity.

Kyuasini non vented drift (80m x 5m) constructed on rock bed-Makueni county

A road crossing as well as a water retaining structure-2012

Mukuyuni drift in Makueni county in kenya - 120m span (Constructed on sandy river bed as both a road crossing and a water retaining structure)-2012

THE BENEFITS OF NON VENTED DRIFTS(SAND DAMS)

1. Provide connectivity in rural roads enhancing trade

Drifts create all weather road crossing enhancing trade and reducing travel time.

Below: isuuni river crossing in makueni county acting as an all weather road crossing-constructed in 2013(60m span)

2. Provide adequate source and sustainable supply of safe and clean water to homesteads and domestic animals

During the rainy season, the sand behind the retention walls will fill with water and sand resulting from surface run off and ground water recharge within the catchment of the river.

Below: Kako drift- a source of piped water for kako and kyaluma villages in makueni county in kenya

3. Increase food production through initiating small plots under small scale irrigation

Drift construction results in a sustainable source of water, the community can organize themselves through a project management committee to set up small irrigation plots ranging from 0.25-0.5acres.

Below: A Small irrigation schemes in Muangini drift in Makueni County (a source of sustained food in rural areas)

4. A sustained source of clean river sand for development projects

The non vented drift retains a lot of sand in the upstream side. With organised sand harvesting, additional income can be generated by the surrounding community and shared between the individual house hold.

Below: Retained sand in the river bed due to drift construction in Muangini drift.(1 KM upstream) from the crossing-(Controlled sale of sand to building sites generate income for the rural community)

5. Increase individual house hold income through brick making

With expected explosion for need for housing and commercial buildings individual households can make bricks for sale to earn income. This will result in creation of employment in rural areas.

Right pic: Brick making activity in isuuni river drift – Makueni county-(A source of income for the rural community)

6. Increased forest cover

Non vented drifts ensure sustained water which shall be used for setting up tree nurseries. The community will plant trees in the river belt and also in their individual households. This increases forest cover, sale of tree seedlings to other areas, controlled sale of timber & fire wood for income

Right pic: Afforestation as a result of presence of water in the river due to drift construction along Muangini drift river banks-(Improved ecosystem and source of income – timber/wood sale)

7. Socio-economic: dramatic fall in water related diseases and better school enrolment

With the drift in place and clean water stored in the sand, communities observe a dramatic fall in water related diseases such as malaria and diarrhoea

This results in an increase in school attendance for school going children and a significant increase in household income and food production since children and parents will have better health to work in their farms and other related income generating activities.

8. Community owned and managed Projects

Community ownership and management is key to the successful operation to any drift project. It is important to involve members of the community during planning, implementation and commissioning of the project.

Education on the monetary value associated with the drift is very key in order to realise full benefits of the project.

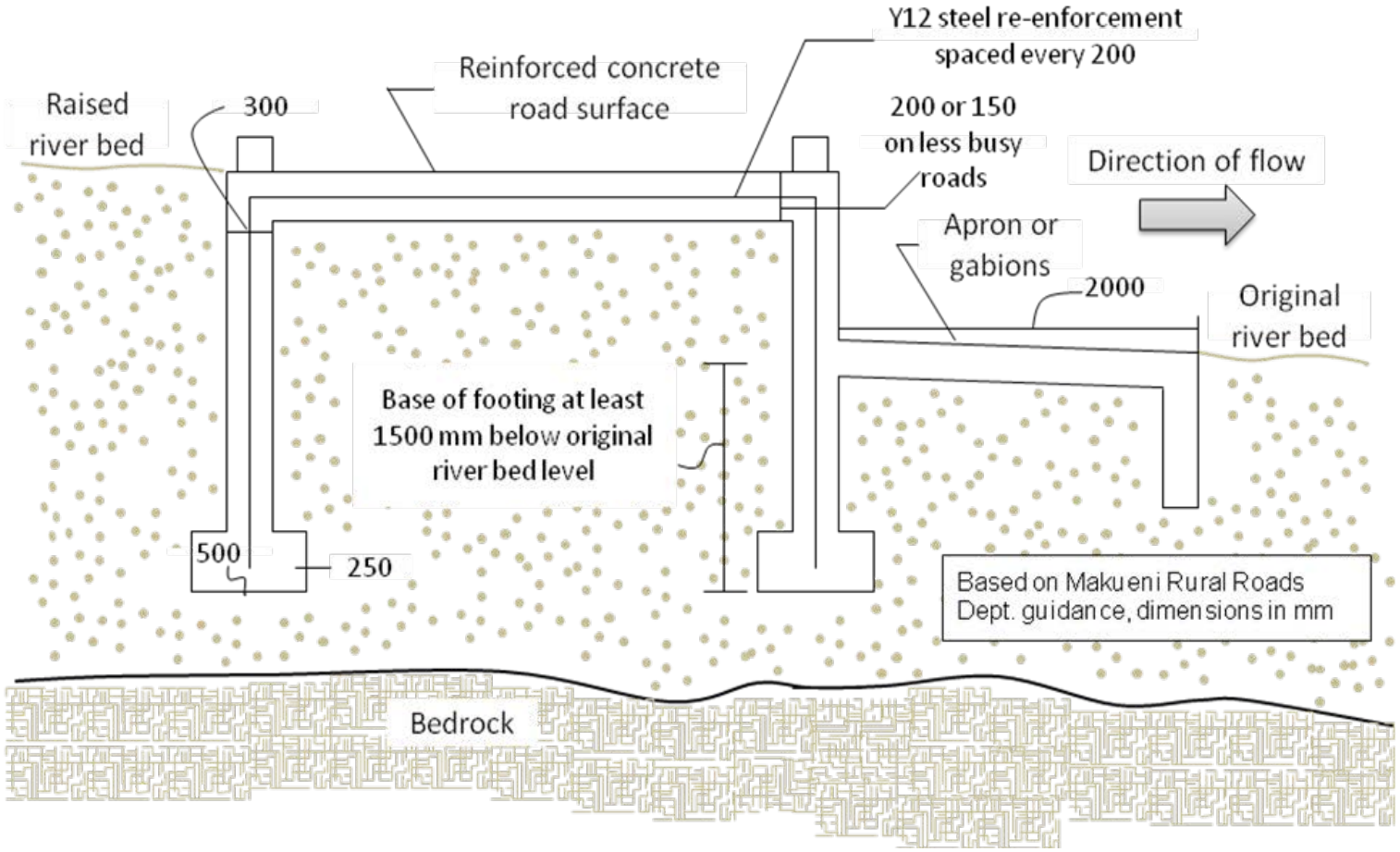
9. Low cost and maintenance

Non vented drifts are constructed of masonary and reinforced concrete walls using locally available materials and cheap labour from the local communities. They are long lasting with life span of over 100 years

Below: Mukuyuni drift in Makueni county 120m span(constructed to good standard hence long lasting requiring very low maintenance) -2013

DESIGN OF NON VENTED DRIFTS

Figure 5: Cross-section of raised drift crossing in Makueni County



Key factors to consider while designing non vented drifts

1. Site location

The site should be properly selected in order to economise on the cost of material and labour.

2. Hydrological survey

The designer should pay special attention to the amount of rainfall experienced in the area, the flood water within the catchment area and historical extent of flood levels information from the local community within the project area.

3. River bed condition

The designer should identify the river bed as either sandy or rock in order to come up with the most desirable type of structure.

Construction method

- Drifts are constructed using labour based methods by either direct labour or through small scale contractors
- They are constructed of reinforced concrete with twisted steel bars of size Y12 single layer.
- Concrete class used is 25/20 (1:1.5:3) well mixed with concrete mixer.
- Water should be highly controlled to ensure the cement is not washed away during vibration by good design mix and use of good quality formwork
- Well compacted hard core should be placed to a depth of 0.5 -1.5m to give adequate support to the top slab to avoid collapse under loaded traffic and create resistance to wash away by the flood water.
- Gabion boxes of size 2mx1mx1m should be placed at the foot of the foundation down stream of the structure to avoid undermining
- The structure should be extended beyond the experienced flood level to ensure there is no end approach failure when the floods are high.
- Middle curvature should be introduced to ensure the flood water concentrate at the middle of the river

Drift construction process in progress

150m span Thwake drift construction in Makueni county 2014

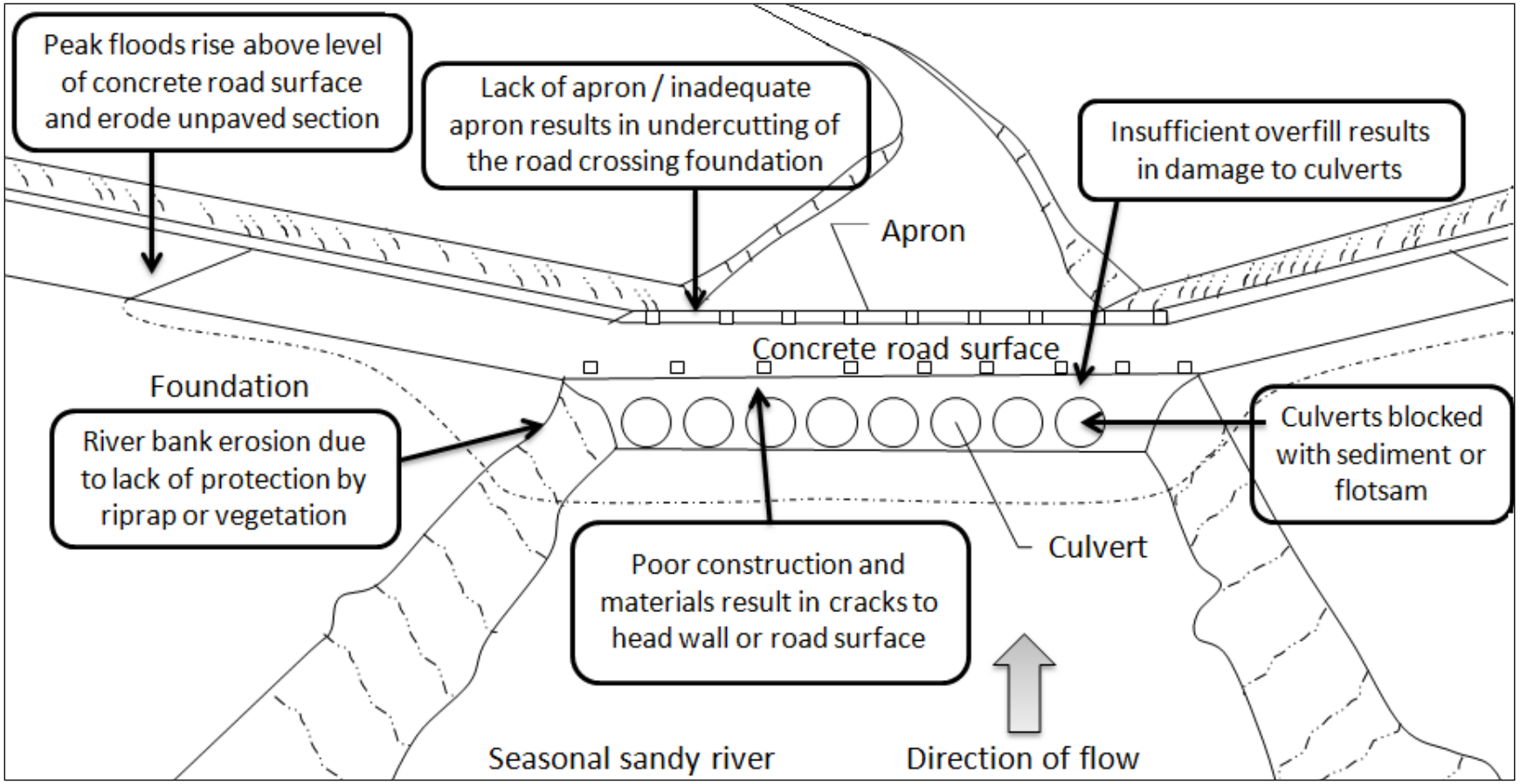
Drift construction process cont....

Reinforcement steel bars fixing

Estimated costs for non vented drifts based on the size and site location

Per metre length in Makueni county 2014	US dollar per metre
Drift type 1: Large drift, foundations excavated maximum depth 1.5 m and elevated 0.3 metre above the existing sandy river bed.	1530
Drift type 2: Large drift, constructed on bedrock, elevated 0.5-1.2 m above the existing river beds	940
Drift type 3: Small drift, constructed on normal ordinary river channels. Little or no elevation above the existing river bed level. Depth 0.5 -1.0 m	590
Type 4 : Small drift (Road slabs), constructed on bedrock or swampy plains . Little or no elevation above the existing river bed level maximum depth 0.5m	415

Drift failure mechanism



Drift failure mechanism cont...

There are several failure mechanisms through which incorrectly designed drift can fail

1. **End approach failure**: end failure approach occurs when the flood cuts of the drift approaches rendering the road impassable. This occurs when the river discharge has not been properly been studied. This failure is avoided by making the drift span long enough by extending the structure ends beyond the expected flood levels.
2. **Under scouring**: the foundations of the drift are undermined and the fill hardcore is washed away. This causes the slab not to be adequately supported and hence the structure collapses under traffic loading. To avoid this failure gabion mattress is introduced at the foot of the foundation at the downstream side of the structure.

Drift failure mechanism cont...

3. **Unsuitable fill material**: the material used as fill to support the top slab should be strong enough to hold the traffic loading and give the structure firmness/strength to resist movement by heavy floods
4. **Top slab failure**: occurs due to poor construction methods and lack of quality control

The top slab, walls and foundations should be constructed of high class concrete (minimum concrete class 25/20) well mixed and vibrated to ensure good strength to resist failure by traffic loading.

The slab thickness should be 150 - 200mm in low traffic volume roads. The reinforcement steel should be Y12 spaced at 200mm centre to centre single layer.

5. **Lack of Robustness**: the foundations, walls and top slab should be tied together by reinforcement steel to ensure rigidity of the structure so that flood water does not penetrate into the structure neither does it carry the structure away

Conclusion and recommendations (I)

- Since the benefits associated with non vented drifts in semi arid areas are many, it is recommended that the structures be adopted as river crossing structures in low volume traffic rural roads as opposed to more expensive bridges and traditional vented culvert drifts which are prone to wash away by heavy floods.
- This technology needs to be adopted by all counties in arid and semi arid regions of Kenya such as Makueni, Kitui, Machakos,Tharaka Nithi,Kajiado,Narok,Turkana,Samburu, Marsabit,Wajir and Garrissa
- The Rural Roads Authorities who are the lead managers of rural roads, needs to partner with other stakeholders such as the County Governments, Ministry responsible for water department, Ministry of agriculture and provincial administration in order to identify all possible low volume traffic river crossings to develop them and educate the communities living in the vicinity of the river crossings so as to maximally utilize the benefits associated with the non vented drifts.

Conclusion and recommendations (II)

- The local communities living in the proximity of the river banks should be involved during planning , implementation and maintenance of the structures so as to fully use the potential of the non vented drifts.
- The Kenya national government should develop policies on water harvesting from roads and develop a design manuals so as to bring the concept of water harvesting to full scale
- The full scale use of multiple non vented drifts at all road crossings in a given seasonal river will result in improved livelihood of the communities living along the river belts in the rural areas of Kenya and many other arid regions of Africa.

KENYA RURAL ROADS AUTHORITY

Prepared by:

Eng. Benson M. Masila

MANAGER(ROADS)

KENYA RURAL ROADS AUTHORITY

Supported by:

GLOBAL RESILIENCE PARTNERSHIP
CONVENED BY THE ROCKEFELLER FOUNDATION AND USAID

NWO

Developed by:

Mekelle University

META

ROAD TRANSPORT AUTHORITY

Utrecht University

IDS Institute of Development Studies

Bureau of Agriculture and Rural Development, Amhara Regional State

Bureau of Construction, Road and Transport, Tigray Regional State

ASAL Consultants Ltd.

HESPI