The Green Roads for Water Initiative aims to transform the way roads are built and maintained all over the world by incorporating water management and regreening in the design and construction of roads. The aim is to improve livelihoods and resilience of communities living around roads and doing away with negative impact such as erosion, flooding, sedimentation and dust, whereas at the same time improve the climate resilience of road infrastructure itself and reduce water related road damage.
For more information visit: **www.roadsforwater.org**

TECHNICAL PAPER 1

GREEN ROADS FOR WATER

IN COASTAL LOWLANDS AND FLOODPLAINS

Key Messages

- In coastal lowlands roads serve as flood protection infrastructure and vice versa: this requires cooperation between the responsible organizations in transport, water management and disaster risk reduction to optimize functions and co-benefits and come to joint specifications and better integrated concepts;
- In coastal lowlands roads also have a major impact on water management which is now often manifest in water logging;
- As roads are the main infrastructure in these low lying areas, they can also be used to control water levels for productive use;
- Roads have a major impact on flood plain – hydrology: they often dissect the flood plain in a wetter and drier section;
- Bridges may constrict the flood plain. whereas bridge sills may raise water and silt levels;
- Road building in flood plain requires special attention to keep flood plain conditions alive and prevent uncontrolled breaking of the roaded embankment.

MAIN TECHNIQUES

- Adequate drainage (with fish passage) through French mattresses and culverts will preserve the flood plain conditions
- Low embankment roads with loodways may facilitate controlled flooding into wetland areas or recharge zones
- Submergible roads that are inundated for part of the year can be built in flood plains
- Several techniques improve the contribution of roads to water management in coastal low lands: road alignment to compartimentalise high and low lands, adequate cross drainage to retain and release water, using gated culverts for water level control, making use of borrow pits for drainage and water storage.

- This is a model gated culvert along an internal polder road in Bangladesh which can be used to control water in different compartments of the polder and store water for irrigation in the dry season.
- Bridges can also be provided with vertical gates to control the water flow and retain water and store it where it is needed (or to prevent water from entering where it would cause damage to crops)

ROADS IN COASTAL LOWLANDS: ISSUES AND OPPORTUNITIES

Coastal areas represent 20 percent of the world's land, but they are home to more than half of the global population and an equal portion of economic activities. They offer a rich variety of ecosystems with a range of services, such as storm protection, water purification, nutrient recycling, fish spawning, and recreation (tourism). They also sustain food production (crops, fisheries, and aquaculture).

Due to their location, coastal systems are among the most productive but also one of the most threatened. They are at the forefront of climate change with sea level rise, storm surges, floods, and changing rainfall patterns, but there is also a larger picture of changing river regimes, sedimentation patterns in coastal deltas, and land subsidence. Roads have a significant influence on the development of coastal areas. Because they are often combined with permanent embankments, they may influence the duration and extent of inundations and the dynamics of flooding in coastal deltas. Roads also fragment the landscape and interrupt the natural flow of water and the movement, sediments, and nutrients important for biological diversity, fertile agriculture, and fisheries.

A resilient approach consists of managing the road infrastructure along with the surrounding landscape, adapting to the broad opportunities of the area rather than reclaiming and protecting as much land as possible, and accepting risks while building in mechanisms to deal with these risks.

There is a strong connection among roads, water management, and flood protection in low-lying coastal areas, but this connection isusually not systematically operationalized. This represents both a major missed opportunity and, in several cases, the creation of a substantial problem.

There is considerable scope for an integrated approach in which roads can become instruments for water management and flood resilience in coastal areas. There are three main opportunities: (i) roads contributing to improved agricultural water management; (ii) roads combined with flood embankments; and (iii) roads serving more systematically as temporary flood shelters and evacuation routes.

ROADS FOR IMPROVED WATER MANAGEMENT

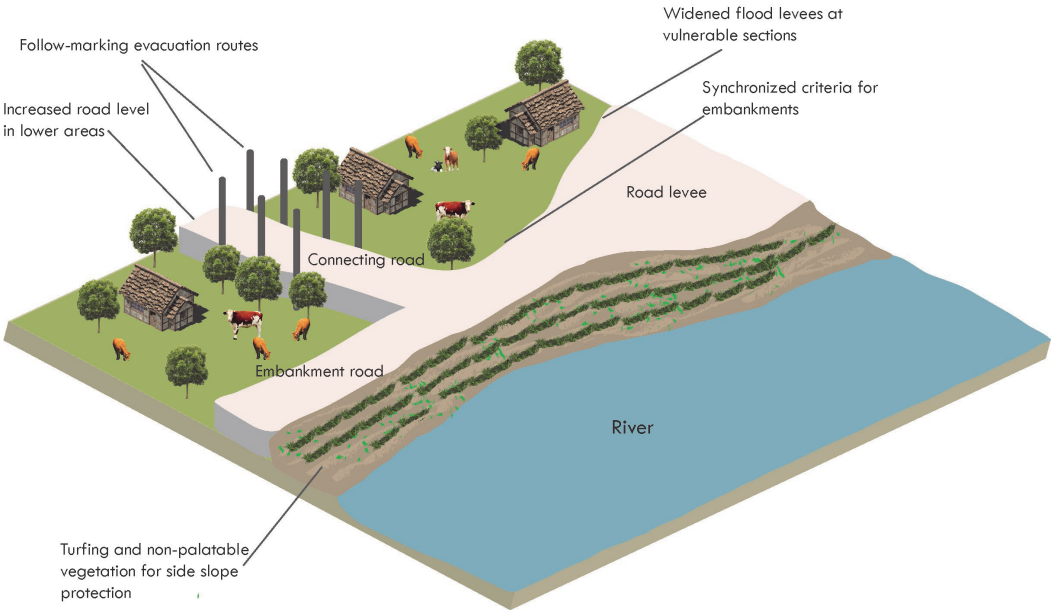
Roads, bridges, culverts, and gates in low-lying coastal areas strongly influence the flow of water, its distribution, and its levels. The network of internal roads, including small village roads and pathways, divides the areas into compartments, separating relatively higher and lower lands. Road infrastructure may impede drainage and create waterlogging, affecting land use and the soil's capacity to absorb rain during high rainfall events. Cross-drainage structures (bridges, [gated] culverts, and pipes) are often insufficient, too narrow, and obstruct water flows. Likewise, bridge sills may be too high, impede drainage, and cause waterlogging.

At the same time, although they are now not constructed on these principles, roads can be powerful instruments to better regulate water levels in the fields and contribute to improved agricultural production. If properly fine-tuned, roads in low-lying coastal areas can serve as infrastructure to create areas with relatively low and high water levels and thus allow more varied, multiple-cropping land use patterns. At present, road alignment is not often designed in accordance with the catchment's hydrology. As mentioned, water-crossing structures may have inadequate dimensions, or may be incorrectly located or absent. Neither are they systematically provided with gates that would provide a major opportunity to actively manage water levels and store and/or release (flood) water between different sections of the low-lying coastal areas. At the same time, erosion and subsidence quickly damage new roads designed without attention to required drainage. In summary, combining road development with water management brings multiple benefits: less waterlogging, less road damage, improved agricultural production, and improved overall livelihoods of rural communities.

ROADS COMBINED WITH FLOOD EMBANKMENTS

There is also a strong link between roads and flood embankments. Many of these embankments are also used as roads: the top of the embankment serves as a subgrade for the road pavement. There are also several examples of roads functioning as embankments of rivers, channels, and canals. There are sometimes mismatches between these transport and flood protection functions. This happens when a paved road is developed on an embankment that has not yet reached its safe and climate-proof level; because of the road, pavement cannot easily be increased. In some instances, the height of the embankment is reduced to create a wider road and improve transport functions.

In addition, when a road is developed it tends to compact the body of the embankment: this makes it stronger but also may cause subsidence of the embankment body. This threatens the essential flood protection functions of an embankment. The construction of bridges in the flood embankment may also weaken or strengthen the flood protection functions. The current issues can be turned around by dovetailing road and embankment development, which would make both stronger, and by designing embankments following criteria to accommodate a future road.



ROADS AS TEMPORARY FLOOD SHELTERS AND EVACUATION ROUTES

The third important nexus between roads or embankment roads and flood resilience is that roads act as shelters and as safe havens during times of inundation. Also, after floods recede, roads serve as places where affected people and livestock can temporarily settle and rehabilitate. There is a need to systematically develop these linkages with roads in areas at high risk of inundation providing evacuation routes and safe places for people and livestock.
For instance, a good practice is to create levees along vulnerable sections of the roads to protect roads and embankments, and create flood and post-flood shelters for humans and livestock.

ROADS IN FLOOD PLAINS: ISSUES AND OPPORTUNITIES

Floodplains are among the highest-potential areas for agriculture in the world, bringing together many different functions. Floodplains are vulnerable to relatively minor changes in hydrology: changes in the water supply upstream or changes in the morphology of the floodplains themselves can have a drastic impact.

The development of roads in low-lying floodplains presents a special challenge and opportunity: roads in these terrains have a major effect on the area's hydrology, both positive and negative. Roads, if built properly, will preserve and even enhance the different ecosystem services of the floodplains, but they may also undermine the floodplain, cause it to silt up, dry up, or be permanently inundated.

The opportunities for using roads to manage floodplains differ with the type of floodplain and its predominant use. In relatively dry floodplain areas, floodwater can, for instance, be stored in the upstream zone for use in the dry season. In wetter floodplains, the road will create wetter conditions in the upstream areas, affecting the local ecology and creating conditions conducive to the cultivation of submerged crops such as rice or sugarcane. It is also important to take into account the possible effects of road construction on land submergence and silt deposition: a road or bridge in a floodplain that blocks the movement of floodwater can cause land levels to rise.

If the overall strategy for road development in floodplains is clear, a number of points must be settled. During road development, the following need to be decided:

- Selecting the location and height of road embankment;
- Considering the use of controlled overflow sections;
- Providing adequate cross-drainage and subsurface
- flow capacity;
- Controlling the upstream water level with cross-drainage structure; and
- Ensuring fish passage.

GLOBAL RESILIENCE PARTNERSHIP

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