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 2

GREEN ROADS FOR WATER IN SEMI-ARID AREAS

Key Messages

- Road change the surface hydrology in semi-arid areas, now often causing extensive erosion, flooding and sedimentation with considerable damage to road bodies themselves too
- Because roads acts as barriers and drains for rain run-off, they can also be used for water harvesting at large scale
- There are several techniques to systematically divert or retain water in semi-arid areas by making use of the road infrastructure, such as flood water spreaders, flow dividers at culverts, road drifts or road embankment acting as storage reservoirs
- Road drainage should be connected to water storage and infiltration such as infiltration trenches, converted borrow puts or farm ponds

INTRODUCTION

Semiarid areas cover 15.2 percent of the world and are home to 1.07 billion people (14.1 percent of the global population). Semiarid areas are not only characterized by relatively low overall annual rainfall (typically less than 600 mm), but also by rain being concentrated in part of the year, usually in one or sometimes two rainy seasons. The retention of rainfall in semiarid areas is of vital importance: it assures the availability of water and moisture for productive and consumptive use in dry periods.

Road infrastructure itself can be used to harvest water and redistribute runoff to areas where it is beneficial. Roads either act as an embankment that guides water or as a drain that channels rainwater. This can be used in a systematic manner. The amount of water that can be harvested depends on the rainfall pattern, the catchment area as defined by the road, the rainfall patterns, and the land use and soil characteristics within the catchment area. The challenge is not only to capture the rainfall runoff, but also to store it for later use. Runoff in the landscape that is guided by road infrastructure can be stored in three different ways:

- In surface storage structures, such as pond and converted borrow pits;
- Spread over land areas and used to replenish soil moisture, e.g., for rainfed cultivation or for rangeland improvement, retained by bunds, terraces, and micro-basins; and
- Routed to recharge areas where it will replenish shallow aquifers. Water can be lifted and pumped up from shallow aquifers.

	Recommended practices	Surface storage	Soil moisture storage	Groundwater recharge
1	Floodwater spreaders along road surfaces		✓	
2	Flood diversions from culverts and road drainage		✓	✓
3	Infiltration structures fed from road drainage			✓
4	Cascading irrigation from road drainage		✓	
5	Surface storage fed from road drainage (borrow pits, ponds, and cisterns)	✓		✓
6	Road bodies used as dams for water storage	✓		
7	Raised road embankments with raised culverts	✓	✓	✓
8	Road crossings used as sand dams or as waterspreading structures		✓	✓

FLOOD WATER SPREADERS ALONG ROAD SURFACES

Runoff generated by the road surface can be diverted directly to farmland, recharge areas, or storage ponds using drainage techniques. A common technique is to have a series of floodwater spreaders alongside paved road surfaces. These will guide the runoff from the road surface to farmland immediately adjacent to the road and contribute to greater soil moisture. These spreaders consist of low (30 cm) curved structures made of local material that can be used for collection. They are inexpensive to build but need to be rebuilt annually.

FLOW DIVERSION FROM CULVERTS AND ROAD DRAINAGE

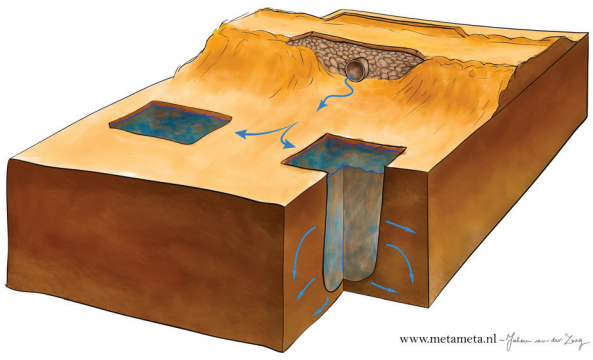
Road drainage systems concentrate runoff. Culverts are the embodiment of the changed drainage pattern that comes with road development. Because they concentrate runoff, there is always the risk of erosion downstream of the culverts. Gullies so created may even "creep" upstream and destroy the road body. Therefore, both to protect downstream land and to make beneficial use of water, runoff should be diverted from the culverts.

Different auxiliary structures may be constructed to gently divert flow from culverts to where water will be used or conserved. The structures may be constructed from different materials with different alignments, widths, and heights. V-shaped flood diverters are, in most circumstances, most appropriate, because they dissipate energy from the culvert runoff. If the flow from the culvert comes at low velocity, a diversion structure will be sufficient. The structures should also be placed at a reasonable distance of at least 3 m from the culvert outlets to avoid creating sedimentation inside the culvert.

INFILTRATION STRUCTURE FROM ROAD DRAINAGE

Water from road drains, either culverts or lead-out ditches (or mitered drains), can be guided directly to groundwater recharge structures. Most common are infiltration trenches, recharge wells, and infiltration ponds. Infiltration trenches consist of a chain of individual percolation ponds with water overflowing from one pond to the other. This keeps trenches in steep terrain from being scoured out, but instead allows water to overflow from one pond to the next in the trench. The infiltration trenches should be placed at a safe distance of at least 20 m from the road body on the downhill side to keep them from soaking the soil and affecting the road subgrade. Alternatively, the infiltration trench is led away from the road body.

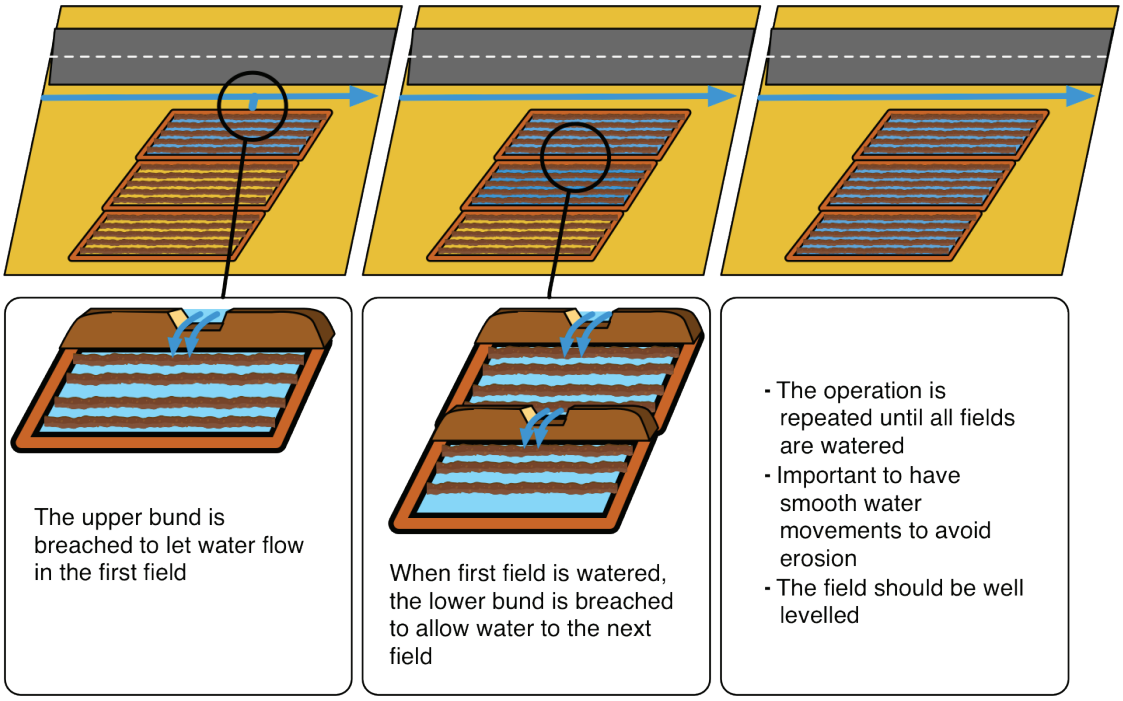
Alternatively, runoff can be guided to recharge wells or percolation ponds. These collect the water for recharge in the shallow aquifer. In some cases, these may be abandoned dugwells or out-of-use borrow pits. Importantly, these recharge structures penetrate a water-bearing layer with good transmissivity (ability to convey water) and spare storage capacity (not saturated). Such conditions are easily found in most semiarid areas.



CASCADING IRRIGATION FED FROM ROAD DRAINAGE

The water from road drainage may also be applied directly on the land. This can be done through a single leveled ditch at the top of the field that homogenously spills water to the field downstream, preferably by furrows. This prevents water coming from the road drainage system from immediately submerging the crop and causing damage. The field needs to have a very even, continuous gentle slope to avoid erosion and water ponding. A variation on this comes from relatively level humid areas where the single road ditch is also used in two ways: (i) during rainy periods as a drainage ditch collecting excess water, and (ii) during dry periods as the source of supplementary irrigation.

A more elaborate system is when a cascade of fields is served by the water collected from the road. The fields are divided into sub-basins. Water is allowed in the uppermost basin. Once filled, its retaining bund is breached to allow water to enter the next field downslope. This system is commonly used to grow rice in slightly undulating areas.



BENEFITS OF GREEN ROADS FOR WATER IN SEMI-ARID AREAS

The hydrological and socioeconomic impact of these technologies has been measured since 2015. Monitoring data have shown an increase of 1.2 to 2 m in groundwater levels during the dry period. Soil moisture next to the road has increased up to 100 percent in some cases and farm productivity has risen by 35 percent on average. Moreover, there is the added value of protecting the roads from erosion, flooding and sedimentation, and the drastically reduced damage to the landscape.

More techniques can be found in: **www.roadsforwater.org**

GLOBAL RESILIENCE PARTNERSHIP

META