Name of Technology	**Artificial Groundwater Aquifer Recharge**
Sector	**Water Resources**
Sub-Sector	**Water Supply**
Introduction	Artificial recharge of groundwater aquifer is important for the storage of surplus surface water due to excess stormwater runoff underground to serve growing populations demand for more water under a warming and drier climate as projected for The Gambia. The recharge is also useful in mitigating or controlling saltwater intrusion into coastal aquifers.
Technology characteristics	The main purpose of artificial aquifer recharge technology is to store excess water for later use, while improving water quality (decreasing the salinity level) by recharging the aquifer with better water. The artificial recharge techniques in common use include the following: • Infiltration Basins and Canals of a particular volume are used to recharge a corresponding volume of an aquifer. Canals may be more efficient than the infiltration basins because high circulation velocities in the canals precluded the settling of fine material and result in higher infiltration rates. • Water Traps are earthen dams of variable height that are constructed of locally available materials and are used to increase infiltration in streambeds. Their storage capacities fluctuate between 250 and 400 m^3 and, given proper maintenance, they have an estimated life span of 20 to 25 years. • Cutwaters are excavations of variable dimensions, used as reservoirs, built in low-lying areas. The primary objective of this cutwater technology is the harvesting of surface waters. Cutwaters used for artificial recharge are built on top of permeable strata but those used for surface water storage are built on impermeable substrates. • Drainage Wells or "suckwells" are used to dispose of drainage waters. Their depth is determined by the well digger and is based on reaching an adequate fissure or "suck" in the rock. The wells are constructed either square or circular in shape and are provided with guard walls of concrete above the ground surface and drainage ports or underground pipes or culverts to conduct runoff into the wells. • Septic Tanks and Effluent Disposal Wells serve as other technologies for artificial groundwater recharge but basically consist of effluents from soakaways in septic tanks; • Sinkhole Injection technologies utilize treated and excess surface runoff in karstic limestone aquifers, which are commonly associated with seawater intrusion and are highly saline. The recharged water is monitored through a series of monitoring and production wells. Monitoring is carried out to measure changes in groundwater levels and water quality (salinity levels). Most of the freshwater supply for animal and human consumption in The Gambia, especially in the western half of the country comes from groundwater and the major source

	of recharge is rainfall. Current rainfall variability and its projected decrease under climate change will not allow for a sufficient level of aquifer recharge by natural means. Thus, the technologies discussed in this factsheet will provide for the artificial enhancement of the natural recharge.
Costs, including	
Cost to implement adaptation options	• Capital cost of basins and canals is estimated at $31,300. The production cost is $0.20/m^3. • The water traps are estimated at between $133 and $167. • The capital cost of a 5,700 m^3 cutwater, equipped with a 14 m extraction well, is estimated at $6,325. • The initial capital cost of the sinkhole injection system is estimated at less than $15,000.
Operations and maintenance	• Infiltration basins and canals require minimal maintenance, consisting mostly of using a bulldozer to remove accumulated sediments and to rehabilitate the system; • Water traps require maintenance during the first few years of operation, until the natural vegetation grows again in the area; • Maintenance of cutwaters include removal of large loads of sediment deposited in cutwaters during dry periods; the operation and maintenance cost is estimated at $248 per year. The production costs are estimated to be about $0.30/m^3 for the first five years of operation, $0.17/m^3 for the next five years (five to ten years of operation), and $0.15/m^3 for the following five years (ten to fifteen years of operation). • Maintenance of suckwells is labor-intensive and generally involves the removal of silt, which accumulates at die bottom of the well and may plug the "suck", rendering it useless. Owing to increased labor costs and declines in profitability at most sites, suckwells may not be viable. • In sinkhole injection, operations are simple. The earth canals need to be kept clear to ensure maximum delivery of water. The settling basin has to be cleaned of accumulated sediment and vegetative growths once every four to five months. Vandalism, resulting in damage to sluice gates, sinkholes, and monitor wells, is also a problem in the maintenance of the system. Maintenance costs are low, under $3,500/year.
Potential financing and markets:	There are opportunities to use private well digging companies in construction of the structures used for groundwater aquifer recharge. The Horticulture Unit of the Department of Agriculture can facilitate access to finance for installation of the technologies on the Kombo Peninsular where abstraction of water is close to tipping point and the aquifers need to be recharged.
Potential development impacts, benefits	Groundwater recharge produces a number of economic, social and environmental co-benefits.
Economic	Aquifer recharge increases freshwater availability for agricultural activities particularly in horticulture which is practiced by women during the dry season. Use income is generated from these activities.
Social	Income generated from horticultural activities is used to pay for school fees and for medical attention. Women also use some of the money to buy clothes to attend social gatherings.
Environmental	In general, most wells influenced by artificial recharge have shown declines in salinity levels. Recharge methods are environmentally attractive and create a number of other environmental co-benefits. During the construction of water traps, disturbances of soil and vegetation cover may cause environmental damage to the project area. There is a potential for contamination of the groundwater from injected surface water runoff, especially from agricultural fields and roads surfaces. In most cases, the surface water runoff is not pre-treated before injection. Recharge can degrade the aquifer unless quality control of the injected water is adequate.
Status	Aquifer recharge is not practiced in The Gambia at operational level. However, there are potentials for the rivers to recharge the underlying groundwater aquifer during the three-month rainy season period. Cutwaters can be used in rangelands, degraded lands, forests, and national parks and sinkholes can be used in residential areas to encourage infiltration of rain water into the ground and aquifers.
Advantages and disadvantages of aquifer recharge	Replenishment and storage of rain and runoff water in underground aquifers of The Gambia using the technologies discussed in this factsheet have the following advantages and disadvantages. Advantages include: • Most of the technologies are simple, appropriate and will generally be well understood by both the technicians and the general population; • A lot of the rainwater that falls and runoff to the sea during the wet season will be captured, stored and available for use in the dry season, when demand is highest. • The recharge will significantly increase the sustainable yield of the two aquifers of

	the country. • Utilization of the technologies support the management of surface water runoff and thus reduces erosion, loss of top soil and sedimentation problems in farms and fish spawning grounds. Disadvantages include: • Recharge with effluents may not be culturally acceptable especially when the groundwater stored is used for agriculture and livestock watering; • In the absence of financial incentives, laws, or other regulations to encourage landowners to maintain drainage wells adequately, the wells may fall into disrepair and ultimately become sources of groundwater contamination; • Where significant volumes of water are not available to inject into the aquifer, groundwater recharge may not be economically feasible.
Acceptability to local stakeholders and Feasibility of implementation	The Gambia being located in the Sahelian zone of West Africa requires replenishment and storage of water through artificial recharge of her groundwater aquifers. Implementation of the technologies is feasible and will be acceptable to the stakeholders. There would, however be reservation in the utilization of the water if effluents from soakaways of septic tanks are used as source of recharge.
Endorsement by experts	Experts in The Gambia have long term expertise in implementing community water supply systems using borehole and wells. Private contractors that construct these water points can easily be capacitated to be involved in the construction and implementation of the aquifer research technologies discussed in this factsheet. The experts will benefit from capacity building on experimental studies to quantify the recharge provided by different technologies and will easily endorse the adoption and implementation of the technologies.
Timeframe	As these technologies have been implemented in many parts of the world there would be little feasibility and piloting in The Gambia. Adoption and implementation may take about 3 to 5 years.
Institutional capacity	The Hydrogeological Division of the Department of Water Resources, Soil and Water Management Unit of the Department of Agriculture and the Horticultural Unit of the Department of Agriculture will need institutional capacity building, including human capital to adopt and implement the technologies for aquifer research. Experts will need capacity building in the assessment and monitoring of the volume aquifer and to determine the level at which recharged is required. The experts would also need capacity building in determining the most viable technologies for aquifer recharge.
Adequacy for current climate	The technologies reported in this factsheet are adequate for current climate. The technologies may need to be adjusted to collect more water under the projected climate change.
Size of beneficiaries group	Aquifer recharge is applicable at the watershed level. However, priority must be given to the coastal area of the North Bank Region and the Kombo Peninsular (Greater Banjul and the Kombo Districts of West Coast Region).