

Strategies on
reducing flood runoff
in urban
environmental
sciences essay



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Abstract

The increase in the number of impervious surfaces in urban areas has encouraged the increase in flood runoff; consequently increasing the potential damage to urban catchment due to pressure exerted by excess water beyond its capacity. Strategies for flood runoff reduction were discussed under two categories: Engineering schemes and abatement schemes. The engineering scheme focuses on the use of engineering structures to reduce flood runoff while Abatement schemes employ natural processes to reduce flood runoff. Advantages and disadvantages of both strategies were discussed and some examples cited.

Introduction

Flood runoff is the total volume of water flowing out from the catchment during a flooding event (FEMA, 2012). In other words, it is the excess water that flows out of an urban catchment when the intensity of rainfall is greater than the evaporation rate and infiltration capacity of the soil or when rainfall falls on impervious surfaces, such as roadways and other paved areas, not capable of infiltration. The excess water thus results in increased peak discharge, volume and frequency of floods (Konrad, 2013). Floods can be dated as far back as human existence, but urban floods can be linked to the start of development, construction of built-up areas and migration from rural to urban environments. The concentration of urban runoff generated mainly depends on the proportion of vegetated surfaces and impervious surfaces in an urban area (Marco and Cayuela, 1994). Flood runoff in urban areas became a concern when it was observed that it accounted for most of the adverse effects observed in rivers, lakes and other receiving waters

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downstream or within urban areas. This thus leads to the acceleration of the erosion of river banks, destruction of river habitats, more rapid eutrophication rates in lakes, and deterioration in receiving water quality. It was also observed that discharge of a large storm event may shock the receiving water body many times greater than an ordinary sanitary effluent load (Loehr, 1974, Bedient et al., 1978, WEF and ASCE, 1998 and Lee and Bang, 2000); Hence the need to protect lives and property and the environment against the effects of floods. According to Smith (1979) it is almost impossible to ensure total protection against flood especially with limited funding, but it is possible to reduce the effects of flood runoff and minimize the damages it can cause by simply altering the frequency and magnitude of flood events. Viavattene and Ellis (2011) suggested that in the UK, 40% of urban flood damages and accompanying economic losses are attributable to surface water pluvial flooding, with 25% of the total national properties at high flood risk in England being located in the greater London area. Just like North America, the National UK flood policy is shifting from fixing flood defences towards 'living with water' and 'making space for water' within the urban land-use fabric. The art of controlling and regulating urban runoff is called " stormwater management." And it is typically conducted on a street by street, even a building by building, basis (FEMA, 2012).

Strategies for flood runoff reduction

Strategies for reduction can be implemented based on three approaches:

Reduce excess water going into catchment, control the water levels within a catchment and keep water levels in catchments from inundating surrounding areas. Strategies can be implemented through engineering schemes and/or

abatement policies (Ward, 1978; Smith and Tobin, 1979; Smith and Ward, 1998). The Engineering scheme is a more 'intensive' approach usually deployed either within the river channel or at the most vulnerable parts of the flood plain or the coast; relying on capital works and control structures. While the abatement scheme is a more 'extensive' approach which works outside the river channel and over large sections of low lying coasts or a drainage basin. It works with the aim of reducing the magnitude of flood runoff using the environmental interdependence between land and water (Smith and Ward, 1998). Both schemes can be used individually or together, but a mix of both strategies is recommended.

Engineering strategies

Engineering strategies reduce urban flood runoff by containing or diverting flood runoff within or around urban catchments. Sometimes these strategies provide additional advantages by improving navigation along water courses but it has also been criticized for causing adverse environmental and ecological impacts (Smith and Ward, 1998). Examples of some engineering strategies include embankment and levees, channelization, dams, flood relief channels, intercepting or cut-off channels, flood storage reservoirs, washland schemes. Channelization is the widening or deepening of river channels in order to increase its carrying capacity to contain flood peaks and increase drainage of runoff on land. According to Brooker (1985) and Brookes (1988) a quarter of rivers in England and Wales have been subjected to channelization for easier navigation and land drainage. When compared to dams and levees, it provides less environmental disturbance (Smith and Ward, 1998), it makes streams more suitable for navigation especially for

larger vessels and confines water to a certain area of a stream and controls flood runoff by accommodating more discharges (huntercollege, 2013).

According to Brooker (1985) straightening and shortening river channels can have ecological effects on aquatic plants and animals. Swales (1980) discovered differences in fish population in channelized section of a lowland tributary in river Severn supporting juveniles and small species.

Channelization has also led to the loss of wetlands, increase in soil erosion and increase in flooding downstream (huntercollege, 2013). In a study carried out by Pilcher et al (2004), they compared fish populations of adjacent stretches of natural and channelised river of River Lee (Hertfordshire, UK) and River Stort (Essex, UK). They compared the fish species richness, ichthyomass and fish density in order to identify the influence of channelisation on fish community structure. They discovered that they obtained lower values for fishes in the channelised section compared to the natural sections, which they suggested is probably from reduced habitat heterogeneity, which includes reduced inconsistency in discharge rates, general channel uniformity, absence or insufficiency of in-stream structures (branches, logs, vegetation). They also added that in natural section of the rivers Lee and Stort, fish in general were distributed throughout the site, whereas in some channelised sections fish were captured in large, isolated shoals, often containing a high number of smaller specimens. Flood storage reservoirs are constructed to retain the runoff from an urban catchment for later release (Griffin et al, 1979). Sometimes before release, water is treated to improve local water quality because runoff tends to carry pollutants along the way. Some examples of flood storage reservoirs in the UK include; Medbourne Brook at Medbourne, Willow Brook at Weldon, <https://assignbuster.com/strategies-on-reducing-flood-runoff-in-urban-environmental-sciences-essay/>

Jordan at Litte Bowden. They provide wetlands and the aesthetics that comes with it as well as recharge the water table. The challenge with storage reservoirs involves the high cost of construction, large area of land requirement, silt accumulation, as well as the need for good management and design planning in terms of its capacity and operation vis-à-vis water management (Ologunorisa, 2009). Such as the case in Northampton at the caravan site in Billing Aquadrome Northampton in March 2007. The site was minutes away from disaster as the town needed to evacuate over 1000 people to save them from the flooding that was about to occur. Excess runoff of about 2-3days was diverted by the sluice gates into the flood reservoir, but when the reservoir got full, the gates had to be open and this increased the discharge along the widened river channel and increased flow was pinched where the drainage scheme ends and flooded the Billing Aquadrome residential Park. This failure of the drainage scheme was attributed to unpredictable and unreliable rainfall events which overwhelmed the flood reservoir and money allocated to river channel widening was misappropriated and drainage works were never completed. Channels enlargements may cause silting of river channels which would necessitate proper maintenance; it can also give rise to a false sense of safety above the design capacities. Flood relief channels, such as the River lee flood relief channel, requires adequate water management and solving this therefore entails a broad understanding of hydrological characteristics of the region (Ologunorisa, 2009). Washland schemes are very useful for small flood runoff, but they require a large area of flat land for storage just like flood storage reservoirs. Unpredictable and unreliable events can impair the benefits of washlands (Ologunorisa, 2009).

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Abatement strategies

Abatement strategies don't depend on engineering to reduce flood runoffs; instead it depends on environmental processes between land and water bodies. Abatement subscribes to the idea that " prevention is better than cure" (Ward, 1978) with the basic aim of reducing flood runoff peaks downstream by a series of land use changes upstream. (Smith and Tobin, 1979). Storm water management focuses on the reduction of flood runoff as well as the treatment of the water collected. For the purpose of this write-up, the focus on the strategies used to reduce flood runoff and not its treatment. The USEPA refers to these strategies as " Best Management Practice" (BMP). Some examples include Green Parking lots, Rain gardens, Sustainable Urban Drainage Systems, Parks, Rain water harvesting, Infiltration trenches, Rain barrels and cisterns, water detention basins, permeable pavements and pavers, grassed swales, and green roofs. Due to the fact that most urban surfaces are impervious and encourage surface runoff, these strategies encourage the reduction of impervious surfaces and thereby increasing infiltration. Parks which can be likened to afforestation in urban areas would involve planting of trees and grasses in designated spots which would encourage interception of water by leaves, evapotranspiration, infiltration, thereby reducing runoff, recharging ground water and providing aesthetic value to the area. (USEPA, 2012). Parks enhance the aesthetic quality of an area, provide a location for recreation and improve the environment but they demand a lot of space in order to be effective and could be expensive and time consuming to establish as it would require monitoring as well. Green Parking lots, unlike the regular parking lots are designed using pervious concrete or permeable pavers to encourage infiltration and reduce runoff. <https://assignbuster.com/strategies-on-reducing-flood-runoff-in-urban-environmental-sciences-essay/>

They are quite useful but can demand a lot of space and tend to be expensive to implement and can lead to negative downstream effects.

Permeable pavers is the use of concrete block pavers to cover the soil, these blocks create voids on the corners of the pavers while permeable pavement is manufactured without fine materials, asphalt or concrete surfaces and instead incorporates void spaces that allow for storage and infiltration thereby promoting groundwater recharge (USEPA, 2012). Infiltration trenches are ditches filled with rocks with no outlets. These trenches collect runoff during and after a storm event and release runoff into the soil by infiltration and into ground water (USEPA, 2012). Both strategies also look beautiful around urban area and improve the quality of groundwater but they occupy very little space of land and may not be very effective when used alone. Grassed swales are hydraulic conveyance channels that are covered with shallow grass. It helps to increase infiltration and then slow runoff. The choice of suitable grassed swales depends on land use, type of soil, slope, impermeability of the contributing watershed, and extents and slope of the grassed swale system. Grassed swales is better used in natural, low-lying areas and cannot be used to manage runoff from drainage areas that are more than 4 hectares in size, with slopes greater than 5 percent (USEPA, 2012). Green roofs involve having plants on rooftops. They are made with an impermeable membrane placed on the roof and overlaid with a lightweight planting mix which has a high infiltration rate and then covered with plants that are tolerant of drought, heat, and intermittent inundations from rainfall. Green roofs help reduce the frequency and volume of runoff and can also help reduce the effects of atmospheric pollution, sequester carbon, mitigate the urban heat island and create a beautiful environment (Czerniel <https://assignbuster.com/strategies-on-reducing-flood-runoff-in-urban-environmental-sciences-essay/>)

Berndtsson, 2010; Dunnett and Kingsbury, 2004, Getter and Rowe, 2006, Mentens et al., 2006, Oberndorfer et al., 2007 and Rowe and Getter, 2010). They have also encouraged the reduction in the cost of roof replacement and maintenance and elongated the life cycles. (USEPA, 2012). According to Todd (2011) a regular urban area has roads and parking occupying about three times as much land as residential structures. Implying the non-availability of adequate space for implementation, but when combined with other strategies such as permeable concrete, it may yield better results. Rainwater harvesting (RHW) is a system that will reduce the amount of rainwater entering the catchment (Kim et al, 2012). The water collected can be used for domestic puposes (Rowe, 2011), for flushing toilets, garden watering and other external uses that do not require water of drinking quality. (welshwater, 2013). RWH serves to cope with current water shortages, urban stream degradation and flooding (Zhu et al., 2004; Van Roon, 2007; Fletcher et al., 2008). According to Villarreal and Dixon, (2005) roofs represent approximately half of the total sealed surface in cities they contribute to the most important urban storm water runoff flow. RHW when used alongside conservation practices can be used to improve the production of neem (Gupta, 1994). There are a lot of studies carried out on RHW (Gupta, 1994; Chao-hsien and Yao-lung, 2004; Zhu et al., 2004; Villarreal and Dixon, 2005; Dwivedi and Bhadauria, 2009; Glendenning et al, 2012; Ashbolt et al, 2013). In the study carried out by Ashbolt et al, (2013) they wanted to find out if storm water harvesting in the urban catchments of south east Queensland, Australia would restore runoff flows to predevelopment levels. They used a storm water management model to investigate the effect of a range of future increases in urban impervious areas on stream hydrology as well as the <https://assignbuster.com/strategies-on-reducing-flood-runoff-in-urban-environmental-sciences-essay/>

potential of harvesting storm water to return the catchments to predevelopment flow conditions. Storm water harvesting was modeled and they found that increases in urban impermeable areas resulted in increases in the rise and fall for storm events in the catchment. However, capturing the runoff according resulted in a reduction in flow but this was insufficient to meet predevelopment conditions.

Conclusion

Engineering schemes do not necessarily reduce the quantity of flood runoff going into the catchment; they control or contain the flood runoff thereby preventing it from creating more hazards. While abatement strategies actually reduce runoff by infiltration and the effects it may cause downstream. Abatement strategies also result in other related benefits such as erosion control, improved agricultural output, improved landscape quality, and additional recreational facilities (Ward, 1978) but most of them require huge amount of space to be effective and may be quite cost demanding.

References

- Bedient, P. ; Harned, D.; Characklis. W. (1978) Stormwater analysis and prediction in Huston. J Environ Eng Div ASCE, 104 (1978), pp. 1087–1100
- Berndtsson. C. J. (2010). Green roof performance towards management of runoff water quantity and quality: a review. Ecological Engineering, 36 (2010), pp. 351–360.
- Brooker, M. P. (1985) Impact of river channelization: The ecological effect of channelization. The Geographical Journal. Vol 151 (1). Pp 63-69.
- Brookes, A. (1988) Channelised Rivers: Perspectives for Environmental Management. Wiley, Chichester.
- Chao-hsien, L and Yao-lung, L. (2004). Optimum Storage Volume of Rooftop Rain Water Harvesting <https://assignbuster.com/strategies-on-reducing-flood-runoff-in-urban-environmental-sciences-essay/>

Systems for Domestic Use 1. JAWRA J of the American Water Res Ass, 2004, Vol. 40(4), pp. 901-912. D. B. Rowe, K. L. Getter. (2010). Green roofs and roof gardens, in: J. Aitkenhead-Peterson, A. Volder (Eds.), Urban Ecosystems Ecology. Agron. Monogr. 55 American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, WI (2010), pp. 391-412. Dwivedi, A. K. ; Bhadauria. S. S. (2009). Domestic rooftop water harvesting (DRWH)- A case study. J of Eng and App Sci., 2009, Vol. 4(6), p. 31. Federal Emergency Management Agency FEMA (2012). Types of Floods and Floodplains. Available: <http://training.fema.gov/EMIWeb/edu/docs/fmc/Chapter%202%20-%20Types%20of%20Floods%20and%20Floodplains.pdf>. Accessed 25th April 2013. Fletcher, T. D.; Deletic, A.; Mitchell, V. G.; Hatt. B. E. (2008) Reuse of urban runoff in Australia: a review of recent advances and remaining challenges. J of Env Quality, 37, pp. S116-S127. Getter, K. L. and Rowe D. B. (2006). The role of green roofs in sustainable development. Hort Science, 41 (5), pp. 1276-1285. Glendenning, C. J. ; Van Ogtrop, F. F. ; Mishra, A. K. ; Vervoort, R. W. (2012). Balancing watershed and local scale impacts of rain water harvesting in India—A review. Agricultural Water Management, 2012, Vol. 107, pp. 1-13. Griffin D. M, Randall, C. and Grizzard, T. J. (1979). Efficient Design of Stormwater Holding Basins Used For Water Quality Protection. Water Research Vol. 14, pp. 1549 to 1554. Gupta, G. N. (1994) Influence of rain water harvesting and conservation practices on growth and biomass production of *Azadirachta indica* in the Indian desert. Forest Ecology and Management. Vol 70, Iss 1-3, , Pp 329-339. Huntercollege (2013). Department of Geography. Available: <http://www.geography.hunter.cuny.edu/~tbw/ncc/Notes/chapter.12.outline.111111.html>. Accessed 26th April, <https://assignbuster.com/strategies-on-reducing-flood-runoff-in-urban-environmental-sciences-essay/>

2013. Kim, H. Han, M. and Lee, J. Y. (2012). The application of an analytical probabilistic model for estimating the rainfall-runoff reductions achieved using a rainwater harvesting system. *Sci Total Environ.* 1; 424: 213-8.

Kingsbury, N and Dunnett, N (2004) *Planting Green Roofs and Living Walls.* Timber Press, Inc., Portland, OR

Konrad C. P. (2013) *Effects of Urban Development on Floods.* U. S. GEOLOGICAL SURVEY Fact Sheet 076-03. Available: <http://pubs.usgs.gov/fs/fs07603/>. Accessed 25th April 2013.

Lee, J. H.; Bang, K. W. (2000) Characterization of urban storm water runoff. *Water Res*, 34 (2000), pp. 1773–1780

Loehr, R. C. (1974). Characteristics and comparative magnitude of non-point sources. *J Water Pollut Control Fed*, 46 (1974), pp. 1849–1872

Marco, J. B. and Cayuela, A. (1994). Urban flooding: the flood-planned city concept. *Coping with floods, NATO ASI Series. Applied Sciences.* Vol 257.

Mentens, J.; Raes, D.; and Hermy, M. (2006) Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? *Landscape and Urban Planning*, 77 (2006), pp. 217–226

Oberndorfer, E.; Lundholm, J. Bass, B.; Connelly, M Coffman, R. Doshi, H. Dunnett, N. Gaffin, S. Köhler, M. Lui, K.; Rowe, B. (2007). Green roofs as urban ecosystems: ecological structures, functions, and services. *BioScience*, 57 (10) (2007), pp. 823–833.

Ologunorisa, T. E. (2009). Strategies for Mitigation of Flood Risk in the Niger Delta, Nigeria. *J. Appl. Sci. Environ. Manage.* June, 2009 Vol. 13(2) 17- 22.

Pilcher, M. W.; Copp, G. H.; Szomolai, V. (2004), A comparison of adjacent natural and channelized stretches of a lowland river. *Biologia, Bratislava*, 59/5: 669—673.

Rowe, M. P. (2011). Rain Water Harvesting In Bermuda. *J. American water res. ass.* Vol. 47,(6).

Scottish Environment Protection Agency (2013). *Sustainable Urban Drainage Systems (SUDS).* Available: <http://www.sepa.org>.
<https://assignbuster.com/strategies-on-reducing-flood-runoff-in-urban-environmental-sciences-essay/>

uk/water/water_regulation/regimes/pollution_control/suds.aspx. Accessed 30th April, 2013. Smith, K. and Ward, R. (1998). Floods: Physical processes and human impacts. John Wiley and sons. England. Smith, K. and Tobin, G. A. (1979). Human Adjustments to flood hazard. Longman Group. NewYork. USA. Swales (1980) Investigations into the effects of river channel works on the ecology of fish population. PhD Thesis. Liverpool University. Todd, L. (2011) Environmental Reviews and Case Studies: Why and How to Reduce the Amount of Land Paved for Roads and Parking Facilities. Environmental Practice, , Vol. 13(1), pp. 38-46. USEPA (2012) Stormwater Management Best Practices Available: http://www.epa.gov/oaintrnt/stormwater/best_practices.htm. Accessed 26th April, 2013. Van Roon. M. (2007) Water localization and reclamation: steps towards low impact urban design and development. J of Env Mgt, 83, pp. 437-447. Viavattene, C. and Ellis, J. B.(2011) The management of urban surface water flood risks: 12nd International Conference on Urban Drainage, Porto Alegre/Brazil, 10-15 September 2011 Villarreal, E. L.; Dixon. A. (2005). Analysis of a rainwater collection system for domestic water supply in Ringdansen, Norrkoping, Sweden. Building and Environment, 40 (2005), pp. 1174-1184. Ward, R. (1978) Floods: A geographical perspective. The Macmillian press ltd. Water Environment Federation and American Society of Civil Engineers (1998). Urban runoff quality management. WEF Manual of Practice No. 23 and ASCE Manual of Report on Engineering Practice No. 87. Alexandria, VA. Welshwater (2013). Surface Water Management Strategy. Available: <http://www.dwrcymru.com/en/Environment/Surface-Water-Management-Strategy.aspx> Accessed 29th April, 2013. Zhu, K.; Zhang, L.; Hart, W.; Liu, M.; Chen H;

(2004) Quality issues in harvested rainwater in arid and semi-arid Loess Plateau of northern China. *J. of Arid Env.* Vol 57, Iss 4, Pages 487–505.