International Journal of Engineering, Science and Mathematics
Vol. 7,Issue 3, March 2018, (Special Issue)
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Geospatial Technologies for Water Sensitive Urban Design

Manchem Dhana Rama Srinivas[a]
Reddi SankaraRao[b]
Killana Dileep[c]
Mutyala Durga[d]

Abstract

Urban developments for the growing population have consequential impacts on the land and water resources. The modern growth of urbanization has led to the exploitation of the water resources for the human needs which disturbed the ecological balance and degradation of the environmental quality. The precipitation, potable water and Stormwater generated from the runoff constitute the urban water. Water Sensitive Urban Design (WSUD) is a multidisciplinary approach in management of the urban Stormwater with the integration of Best Planning Practices (BPPs) and management techniques. The sustainable Stormwater management practices include the green roof systems, porous pavements etc..,. The demand for the potable water will be reduced through the demand and supply side of the water management. The WSUD features include the vegetation as part of overall landscape aesthetic, then amenity improvement and overall function of a development. The WSUD benefits are Biodiversity enhancement, climate change adaptation, hydrologic management etc. The underlying aim of this need is to provide more economical and less environmentally damaging ways of providing urban water, waste water and Stormwater solutions. The Geospatial technologies like Remote Sensing and GIS would be helpful in the decision support system in implementation of BMPs and enhancement of greenery in urban environments.

Keywords:

Urbanization;
Stormwater ;
Potable water;
Amenity;
Biodiversity;
Hydrologic;
Remote Sensing & GIS.

Author correspondence:
Mr.ManchemDhana Rama Srinivas,
M.Tech (Pursuing) Civil Engineering (Geo Engineering),
Andhra University College of Engineering, Visakhapatnam, Andhra Pradesh,
India,

1. Introduction

Water plays significant role in our day to day life. Aside from exceptional experiences such as flood and drought disasters, most people are not aware of function of water. Due to the tremendous development urban areas, the impact of urbanization in the form of climatic changes, supplying and receiving resources around urban areas becoming finite. Even though the precipitation receiving in urban areas is very less, the generated stormwaterhas been treating as useless resource. The management of stormwater runoff in conventional urban development has been driven by an attitude that reflects the view that stormwater runoff has no value as a useful resource. The

[a]M.Tech Programme, Andhra University College of Engineering, Visakhapatnam, Andhra Pradesh, India
[b]B.Tech Graduate, Rajiv Gandhi University of Knowledge Technologies(RGUKT), Nuzvid, Andhra Pradesh, India
[c]Ph.D Programme, Andhra University College of Engineering, Visakhapatnam, Andhra Pradesh, India
[d]M.Tech Programme, Andhra University College of Engineering, Visakhapatnam, Andhra Pradesh, India

conventional methods of stormwater management which is highly efficient makes the risk of flooding, less evaporation and difficult for infiltration. The natural water cycle disturbs in these areas and cannot it's course which will reflect in future demand for water. So there is a need to adapt new technologies by realizing the resources of water and initiate a paradigm shift in urban water management. Water Sensitive Urban Design (WSUD), a water management of cooperation between the different disciplines, urban design and landscape planning which will be closer to natural cycle.

2. Introduction of Urban Water Cycle

The water cycle operates in a cycle of evarporation, rainfall, vertical hydraulic conductivity and surface runoff to the water bodies under the natural conditions. This water cycle gets disturbed in the urban areas and can't run its course like the natural conditions.

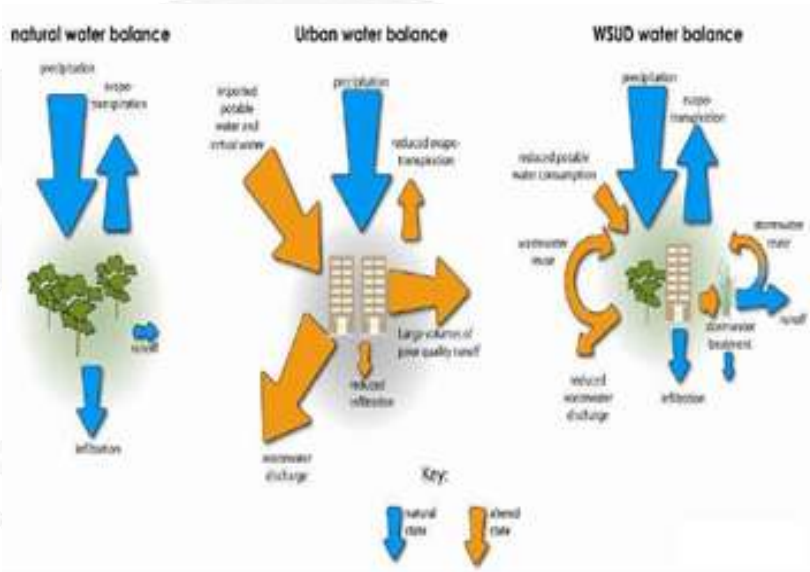

Figure 1.*Diagrammatic view of Urban water cycle*

3. Water Sensitive Urban Design

Water Sensitive Urban Design was originally coined in Western Australia. The objective is to aggregate the demands of sustainable stormwater management with demands of urban planning and thus contributing the urban water cycle to a natural one. It considers all parts of urban water cycle, stormwater is main element both for protection of receiving riversand as a resource. It provides sustainable solution for the impacts of urbanization i.e. land and water which were ecological, social and aesthetic qualities.The goals of WSUD are: Protection of Natural Systems, Protection of Water quality, Reduction of Stormwater runoff and peak flows, Reduction of Drainage Infrastructure, Integration of Stormwater Management into landscape.The elements of WSUD are: Best Planning Practices (BPP) and Best Management Practices (BMP).

WSUD seeks to ensure that urban development and urban landscapes are carefully designed, constructed and maintained so as to minimise the impacts on the urban water cycle – potable water, wastewater, and stormwater.

- "WATER SENSITIVE"
  - Sustainable solutions for managing water resources
  - Protecting aquatic ecosystems
- "URBAN DESIGN"
  - Integrating into the urban design
  - Enhancing landscape and habitat features
  - Creating an "Urban Ecology"

Fig 2: Water Sensitive Urban Design

The BMP's include the potable water demand management and stormwater management techniques. To achieve WSUD methods like wet lands, infiltration basins, storm water harvesting techniques, rain water tanks, permeable pavements, green roof systems, bio retention systems etc. were used. Some of them are shown below:

4. POTABLE WATER DEMAND MANAGEMENT

The potable water is treated and transported to urban areas from long distances. The people are using it for everything including the household consumption, gardening, etc... As the resources are finite so there is a need to use potable water for essential purposes at optimumly.The potable water reduction techniques like:

Water Efficient Appliances & Fittings:- They significantly reduce the household consumption and subsequently reduce water demand on potable water supplies. They also reduce the wastewater generation like showerheads, taps, sprinklers, water timers etc..to reduce the consumption.

Rainwater Tanks: -To conserve the water through substituting potable water supply, protect urban streams by reducing stromwater runoff volumes. Maximum benefits are gained when collected water regularly used by application like toilet flushing and washing machine supply.

5. PERVIOUS/ PERMEABLE PAVEMENTS

These are an alternative to conventional pavements with many stormwater management benefits. These surfaces allow stormwater to be filtered by a coarse sub base and may allow infiltration to the underlying soil. These pavements are adopted in the pedestrian areas or roads with low traffic. The use of permeable pavement increases in North Calorina. Pervious/ permeable pavements generally focused on four areas those are runoff reduction, clogging, long-term hydrology and water quality. Two basic types: Porous pavement, Alternative pavers.

Most common type-Porous asphalt and Pervious Concrete Number of factors to be considered for permeable paving includes slope, traffic volume, sub grade, land use, soil infiltration, drainage characteristics and Groundwater conditions

Overview of Permeable Pavement:

Typical cross section: Nearly all permeable pavement types have the same general structure it is:

Surface Layer(Cover): This is the top layer that drivers and users see. It is distinguished by the type of pavement used, such as porousconcrete; gravel filled interlocking permeable pavers of concrete, or grass filled segmental plastic pavers.

Gravel Base: Most pavement types, with the notale exception of permeable concret, need a gravel (or aggregate) support layer to bear vehicles. The base is immediately beneath the surface layer (cover). After a storm event of occurrence, water would be stored by this layer. Even though the need of an aggregate base layer for structural support to a porous concrete, the layer often included to store additional water.

Sub base: This is the layer of soil immediately below the base layer. The sub base is neccesarily compacted during the construction of the permeable lot. It is also referred to as in place soil or underlying soil beneath the pavement.

Underdrains: These underdrains are usually with plastic pipe of small sizes, diameters of 4 to 8inches. The locations of the drainage lines are near or at the bottom of the sub-base layer to collect the infiltrated water and convey it to the storm sewer network or to the ponds or trenches. Most probably in the soils like clay, the permeable pavements with underdrains are arranged.

Fig3: Cross section of Peremeable Pavement

6. BIORETENTION SYSTEMS

It is a well vegetated retention cell or pond designed to enhance water filtration before it is infiltrated or discharged to the downstream.Bioretention systems can provide detention or retention of runoff water and will suspended solids are removed after trap and filter or pollutants to plant material and soils are absorbed depending on the design. It is well suited for urban areas with less open space and is in various shapes and support different types of vegetation.

Bioretention systems involve treatment by vegetation prior to filtration of sediment and other solids through prescribed media.Vegetation provides biological uptake of nitrogen, phosphorus and other soluble or ne particulate contaminants. Bioretention systems are commonly used to filter the runoff and treat prior to it reaching the street drains and they extend like similar measures (eg: constructed wetlands) of smaller footprint. The complication will come when used on larger scales and other many other devices will be appropriate. Bioretentionsystesm comprise of biorentention basins and swales (termed as drainage channels or grassed swales).

Bioretention system elements and functions are: Ponding Area, Root zone, Sand bed, Organic Layer. The bioretention areas were designed to provide water storage for uptake by vegetation.

The water storage and pollutant removal functions of bioretention areas are described in following:

PONDING AREA: The ponding area over the root zone provides for surface storage of the storm water runoff and provides for the evaporation of a portion of the runoff.

ROOT ZONE: The root zone is the region which provides the source of water and nutrients for the plant to sustain growth. The voids in the soil also provide for stormwater storage.

SAND BED: The sand bed provides for drainage and aeration of the root zone. The infiltration capacity of the bioretention areas the drainage provided by the sand will assist in the flushing ofpollutants from the soil material.

ORGANIC LAYER: The organic layer on the surface of the soil has the following functions like: Act as a filter for pollutants in the runoff, Protect the soil from drying and eroding, Enable micro organisms with in organic layer to degrade petroleum based solvents, Provide for the decomposition of leaves and other organic matter.

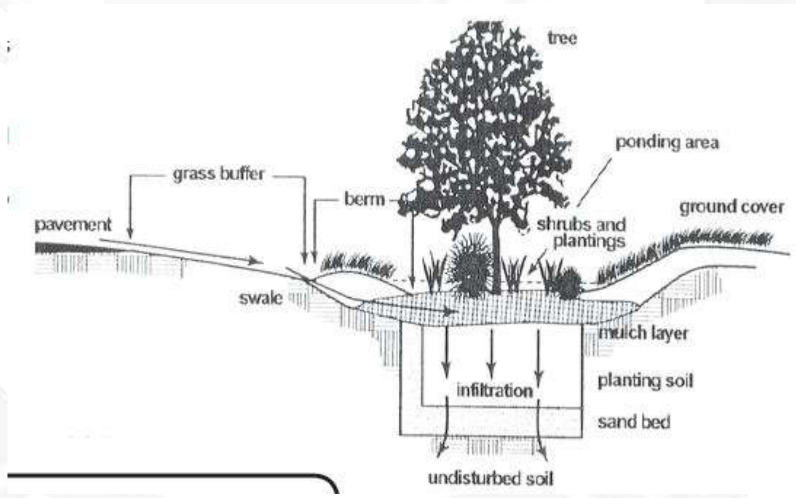

Fig 4: Cross section of Bioretention Swale system

7. Geospatial Technologies:

Remote sensing and GIS or other software packages constitute the geospatial technologies. The observation and measurement of the information from the remotely object without being in touch termed as the Remote sensing. The various types of remote sensing helps in the delineating the objects based on the different factors, coverage of information in repetitive mode, cheaper cost compared to the conventional methods. The GIS package provides the mapping and analysis results of the collected information using various remote sensing techniques. To ensure the collected data and generation of models by combining different data easily be done in GIS.

Stormwater Management:

The Stormwater was generated due to the impervious concrete surfaces like roads, roof tops and parking lots in the urban areas. The rapid runoff of this rainfall into the drains or other water bodies at high speed rates is due to the lack of infiltration facilities in the urban areas. The Best Management Practices (BMPs) implementation with various factors involvement and mapping locations based on the analysis can be done easily in GIS. The generation of

Digital Elevation Model (DEM), Land Use Land Cover (LULC) and Impervious surface area will help in the detailed information on the runoff generated, reducing the runoff speed. The various analysis works has done after the input of desired remotely sensed data into the GIS will help in concluding the best BMP sites after various factors of evaluation in terms of ecological and environmental considerations. The Hydrologic soil group's map would be prepared for a desired study area from soil data based on each polygon's soil type. The curve numbers vary for season and different land use conditions and it used in hydrologic models to generate storm runoff from rainfall events and other losses accountancy. The combination of the soil data and land use extracts the curve numbers using the GIS. A rainfall frequency distribution transformed into a runoff frequency distribution often by using the runoff curve number.

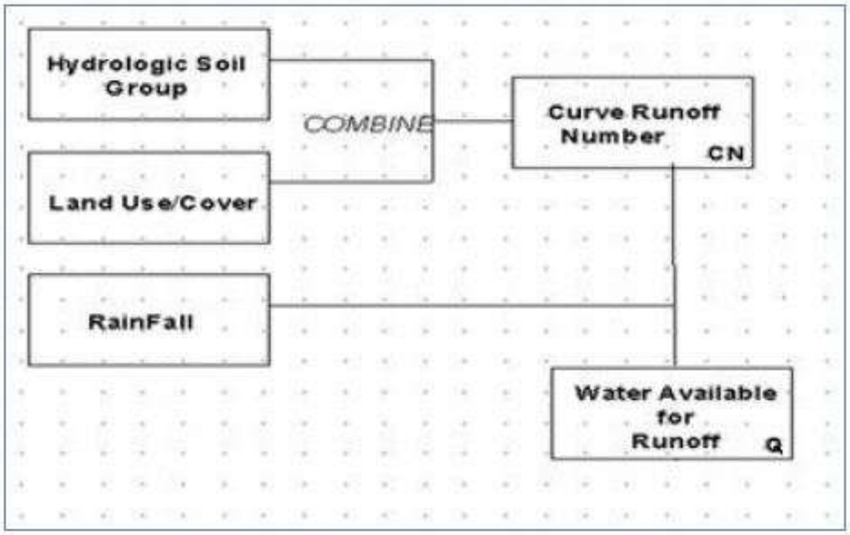

Fig 5: Flowchart for Stormwater runoff analysis

Porous or Permeable Pavements:

The Stormwater runoff volume, rate and pollutants will be reduced by permeable pavement design methods in the urban environment. The traditional impervious pavements are replaced with the pervious pavements for most automobile usage and pedestrian purposes. The methodology followed was to analyzing the pervious surfaces from multiple layers of GIS maps, quantization of runoff from the flow and load calculations of different areas, priority of areas for developing the Best Management Practices (BMPs) and design of permeable pavements in reduction of floods in urban areas.

COMPARISON OF WSUD WITH CONVENTIONAL METHODS

PARAMETER	CONVENTIONAL STORMWATER MANAGEMENT	DECENTRALISED STORMWATER MANAGEMENT
Pollution	Increases	Reduces
Public Health	Degrades	Improves
Nature of Surroundings	Gives out bad smell	Very Hygiene
Maintenance Cost	Very High	Relatively less
Flooding Risk	Very High	Low
Developmental Changes	Can't Adaptable	Adaptable
Ground Water Recharge	Decreases	Increases
Economical	Less	More

Fig 6: Comparison of WSUD with Conventional Methods

8. AWARENESS:

Public awareness of water conservation is necessary to conserve water, water use and to increase the knowledge of water resources. Conservation is a cost-effective means of securing water supplies for all of us. To develop an effective water conservation program, your utility should have clear set of goals. The programs like: Water Use Education programs at community level, Water usage stories through media, Public Service Announcements, Poster's/ Banner's in Public place, Conducting Workshop's or events or competitions on water.

9. DISCUSSION& CONCLUSION:

The benefits of WSUD are: Decreases the flood risk, Creation of more attractive places, Reduces the water pollution, Cost savings and Efficiencies, Eases the Urban Heat Island Effect, Greater Security of water Supply.

The conclusion of WSUD will helps in maintaining ecological balance, maintaining the quality of water, maintaining the resources for future demands, improving the ecosystem healthy.

Acknowledgements

We acknowledge a deep sense of gratitude towards Prof. G. Jai Shankar, Head of Geo Engineering Department, Andhra University College of Engineering, Visakhapatnam for giving us the valuable information and guidance in the course programme. We would also like thank Prof. P. JagadeeswaraRao, Geo Engineering Department, Andhra University College of Engineering, Visakhapatnam for giving us the opportunity to work on this paper.The authors wish to thank Sravani.D, Lecturer in Civil Engineering, RGU-IIIT, Nuzvid in preparing this paper and her continuous support.

References

1. Dipanjan Mukherjee., "Manage Storm Water by using Porous Pavement," *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, vol. 11, PP 01-03, Jul-Aug (2014).
2. AbcAkshay.T.,Aditya.L., Manish.H., Prem.G., "The Use of Permeable Concrete for Ground Water Recharge," *International Journal of Engineering Research and Application (IJERA)*, Vol. 6, PP 60-03, Sep (2016).
3. Guruj.A.L.,Rana.A.V., "Ground Water Recharging Through Pervious Concrete Pavement," *International Conference on: "Engineering: Issues, opportunities and Challenges for Development"*, 11th April (2015).
4. Ajay Gamit, P.P.Lodha, IndraPrakash and Khalid Mehmood, *"Storm water management using Remote Sensing and GIS- A case study of Surat City", Journal of Emerging Technologies and Innovative Research(JETIR)*, Volume 4, Issue 05, May(2017).
5. Tony H F Wong, "*Water Sensitive Urban Design- the Journey Thus Far", Australian Journal of Water Resources,* Des 11, August (2007).
6. Phillip Rode, Rickey Burdett, *"Cities"*, Investing in energy and resource efficiency, 2011
7. Jacqueline Hover, Wolfgang Dickhaut, Lukas Kronawitter, Biorn weber, "*Water Sensitive Urban Design Principles and Inspriation for Sustainable Stormwater Management in the City of Future Manual"*, jovisjovisVerlangGmbH,pp.
8. "*Evaluating Options for Water Sensitive Urban Design",* A National Guide, July 2009