BIORETENTION CELL IMPLEMENTATION IN CLUJ-NAPOCA, ROMANIA – ECOMOMIC ASPECTS

Boanca Paunita Iuliana, Adelina Dumitras, M. Dirja, V. Singureanu, R. Nistor, T. Salagean

University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Manastur Street 400372, Cluj-Napoca, Romania; paunita_boanca@yahoo.com

Abstract. One of the deciding factors in bioretention cells implementation is represented by the economic implications. In Romania due to limited knowledge regarding bioretention systems and the economic aspects deriving, can arise difficulties in promotion and errors of perception. This paper presents an economic analysis intended to clarify the implementation costs of bioretention cells. In the economic analysis of bioretention cells implementation in Romania were used for design, construction, maintenance costs and other additional data collected from different sources. Comparative analysis of three landscape planning types (bioretention, green roof, and green space) provides an overview on the costs implied by bioretention cells implementing.

Keywords: Bioretention, steps, sustainable, cost, analysis, urban, runoff.

INTRODUCTION

Bioretention cells belong to the sustainable drainage systems category (Kazemi et collab., 2011; Coffman, 2000, Washington State Department of Ecology Water Quality Program, 2005) with an important role in urban runoff management (Mitchell et collab., 2002, Begum et collab., 2008). These systems are not currently implemented in Romania. The only sustainable practices for runoff management known and implemented, on a small scale however, are green roofs and vertical gardens ("*green wall*").

Storm water management approaches must be flexible, based on local characteristics and must take into account the factors and laws (temporal, spatial and administrative) along with other issues that may arise. Economic and technical constraints define thus varied scenarios and decisions. This paper presents an economic analysis intended to clarify the implementation costs of bioretention cells. We consider that this type of analysis, under the given context should be based on a comparison between a bioretention cell costs and cost of a green space.

MATERIAL AND METHOD

For objectiveness and having available information about one of these two rainwater management sustainable practices that have been implemented in Romania - green roofs - were included in the economic analysis supplementary data about green roof construction costs. In the economic analysis of bioretention cells implementation in Romania were used design, construction, maintenance costs and other additional data collected from different sources. Information about the design, construction and maintenance cost were obtained from three sources: international sources, national sources; own sources.

International sources are represented by various organizations, research institutions, companies, public institutions (from countries where bioretention cells were implemented).

Several of information sources about costs are the following: CIRIA's SUDS manual; U.S. Environmental Protection Agency; Construction Industry Research and Information Association – CIRIA; Hydro International Stormwater; Filterra Bioretention System; SEPA – Scottish Environment Protection Agency. National sources are represented by organizations, construction firms, landscaping companies, public service, state institutions. Information from national sources was used in addition to those from international sources in order to adapt them to the reality of Romania's economic development.

Own sources are: green roofs on buildings in Cluj-Napoca planning project and landscape architecture projects implemented in Romania. Projects include both technical and economic documentation. Projects were carried out in 2009-2012, data about prices being up-to-date and offered by companies that sell and build green roofs systems and other specialized companies in the field of landscape architecture existing on the Cluj-Napoca, Romania market. Therefore was extracted required information about:

- bioretention cells construction steps and materials, future maintenance actions required and ulterior, have been applied prices obtained from information arising from national sources processing;
- green roofs construction stages and materials, subsequent maintenance costs;
- green spaces planning stages, materials, construction and maintenance costs.

Bioretention cells, green roofs and green landscaping cost information were collected between years 2009-2012.

RESULTS AND DISCUSSION

A substantial number of technical papers that had as subject bioretention cells cost attempted to define the cost-benefit ratio based on variables such as controlled drainage area, a given storage area or the used surface. The methodology aims to deliver cost formulas that can be used by the designer to rapid value calculation.

In the PGC (2007) manual it is shown that this approach is wrong because the involved limiting factors (site restrictions, availability of materials, efficiency etc.). A better approach is the anticipated analysis of elements and sub-elements cost within a bioretention cells implementation project (Prince George's County - PGC, 2007).

Fixed costs derive from the materials cost. Total cost includes resources (equipment, materials, manpower costs) associated with a certain stage or tasks.

After establishing the costs of analysed bioretention cell constructive type implementation in Cluj-Napoca and for the other two types selected - green roofs and traditional green spaces - has been carried out a comparative and a cost-benefit analysis.

Table 1 summarizes the stages and works required for green space, green roof and bioretention cells establishment.

Works for a green space establishment, even if appear to be less in number than the bioretention cells establishment works, are complex and involve additional steps each. This fact leads to a price increase for green space implementation process in comparison with that of the bioretention cell. Regarding the previous steps of the construction process, these are required for all three types of facilities.

Table 1

Phases and work necessary for the establishment of a green space, a green roof and a bioretention cell

Green space	Green roof	Bioretention cell
Prefeasibility phase	*Prefeasibility phase*	*Prefeasibility phase*
Site analysis	Site analysis	Site analysis
Concept development	Concept development	Concept development
Preliminary plan and approvals	Preliminary plan and approvals	Preliminary plan and approvals
Final approvals	Final approvals	Final approvals
Planning phase	*Planning phase*	*Planning phase*
Technical project	Technical project	Technical project
Obtaining final approval	Obtaining final approval	Obtaining final approval
Construction phase	*Construction phase*	*Construction phase*
Start notification	Start notification	Start notification
Preliminary meetings	Preliminary meetings	Preliminary meetings
Site preparation	Site preparation	Site preparation
Uncovering	Removing existing pavement and grass, their evacuation from the terrace	Ordering plants
Tillage	Gravel and sand gathering, sorting material that can be reused for the new green roof	Soil preparation
Shredding	Installing protection layer - used as a protective layer to mechanical stress	Installation of sediment control devices
Fertile soil spread	Installing drainage and water retention layer	Excavation
Alley construction	Installing filtering layer	Geotextile installation
Furniture installation	Delimitation of gravel strips by mounting separation profiles	Gravel placement
Plantation	Mounting the filtering inspection pits	Underdrain installation and connection
Irrigation system installation	Gravel spreading and grading	Soil placement
Lawn installation	Spreading growing substrate	Watering for soil stabilization
Geotextile installation	Var. 1 Vegetation installation – *Sedum* sp. 15 units/m^2	Finishing
Mulch installation	Var. 2 Vegetation installation – *Sedum* rolls	Vegetation planting
Watering and cleaning	Installing of safety devices	Mulch installation
-	Watering and cleaning	Watering and cleaning
-	-	Stabilization
Delivery phase	*Delivery phase*	*Delivery phase*
Final inspection	Final inspection	Final inspection
Maintenance	*Maintenance*	*Maintenance*

Difference lies in the necessary studies. Design phase costs are approximately equal for all three types of arrangement. Bioretention cell construction works are simple

and reduced in number. The most expensive bioretention cell construction operation is the excavation. This operation involves the removal of a larger soil quantity compared to uncovering work necessary for lawn establishment in green spaces (parks, garden, square etc.). Table 2 synthesizes the total cost of a green roof, green space and a bioretention cell development. Prices were calculated for an area of 500 m^2 for each planning type. The data presented in Table 2 show that bioretention cells and green roofs have similar prices; the difference between these two sustainable landscape planning types and a conventional green space is high.

Table 2

Type	*Total cost* (lei/100m^2)
Green space	6000
Green roof	21100
Bioretention cell	19000

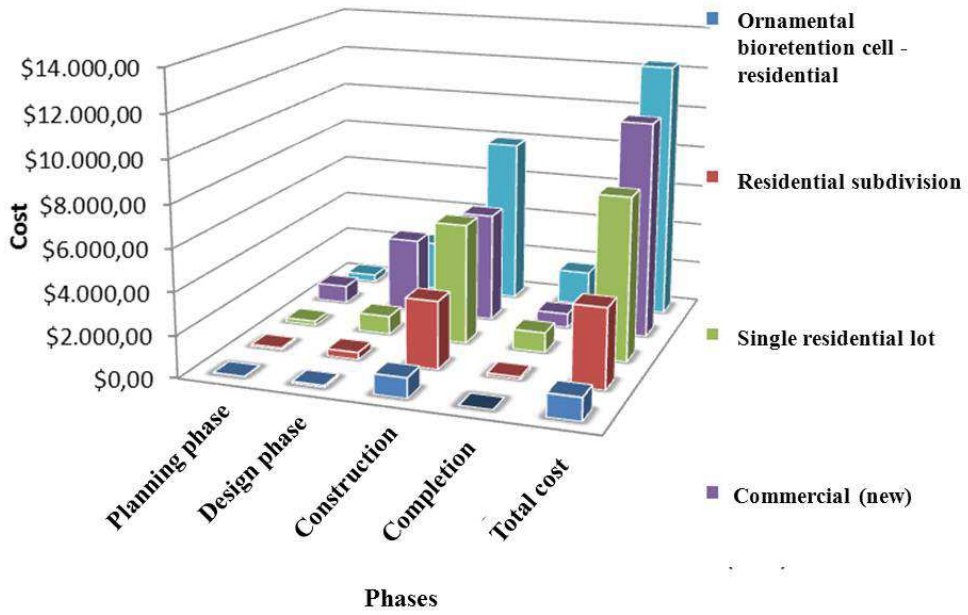

Fig. 1. Typical costs for bioretention systems

Figure 1 illustrates the typical costs variance related to some of bioretention systems applications, including systems installed on residential and commercial lots. Costs are divided into phases: planning (pre-feasibility), design, construction, and termination. Data source about costs is Prince George's County, 2002. It is noted that in terms of total cost is more effective planning and construct a bioretention cell in a specific area since from the incipient phase of development (design). Rehabilitation and improvement involves additional work - which will increase costs.

Economic benefits offered by bioretention cells are related to served areas and the supplementary functions which they have and that a conventional landscape cannot provide (comparing effectiveness landscaped area-function-benefit). Beyond the environmental benefits, a bioretention system offers economic benefits.

Through the runoff interception near the generators source, the drainage infrastructure can be reduced leading to significant cost savings. In the scientific literature there are several case studies that compared conventional methods with bioretention systems. The results indicate that bioretention integration can achieve a net reduction between 15% and 50% of development costs compared to the conventional BMP.

Analysis of existing case studies show that bioretention can be an economical alternative, effective in the runoff treatment and control.

The economic advantages of using bioretention systems in rainwater management include:

- significant reduction of the costs and the stormwater management systems design complexity;
- reducing risk factors related to safety during construction, maintenance and other operations, reduce planning costs and sedimentation control;
- reducing installation costs by using a non-structural design;
- encourage land planning;
- drainage infrastructure reduction or elimination;
- runoff amount reduction;
- reduction or eliminate the need to use large rainwater control systems and pipelines systems required for an areas treatment;
- maintenance management systems can proceed from local authorities in the administration landowners.

CONCLUSIONS

The three types planning comparative analysis (bioretention, green roof, terrestrial green space) provides an overview of the costs involved in bioretention cells implementation. Given the fact that in Romania there are no regulations for the bioretention cells design and construction, costs can grows due to unexpected circumstances.

After this analysis can be noticed that bioretention cell costs are much higher than cost of the conventional green spaces. This apparently negative aspect is diminished by the additional benefits offered. Bioretention cells costs vary depending by the development areas and implementation type (rehabilitation or new development). Retrofit of some areas in terms of sustainable planning is more expensive.

For Romania, from economic point of view, bioretention cells are feasible. Implementation problems can arise, at present, due to lack of regulations in accordance with the laws of Romania, national or local, related to design, location, construction and implementation.

Due to the existence of wide-range of bioretention cells constructive systems, implementation areas and conditions, is suggested to perform extensive economic studies, highlighting positive and negative aspects of the implementation according to these aspects. It is recommended the construction of bioretention systems in different areas (or other sustainable systems for landscapes planning) since the early stage of developments. Cost management strategies associated with urban runoff can be measured only in the context of the provided benefits.

REFERENCES

1. Begum S., Rasul M.G., Brown R.J., 2008, Stormwater treatment and reuse techniques: A review, 2nd International Conference on Waste Management, Water Pollution, Air Pollution, Indoor Climate, 144-50.

2. Coffman L., 2000, Low-impact Development Design Strategies, an Integrated Design Approach EPA 841-B-00-003 Department of Environmental Resources, Programs and Planning Division, Prince George's County, MD.

3. Kazemi F., S. Beechama, Joan Gibbsa, 2011, Streetscape biodiversity and the role of bioretention swales in an Australian urban environment, Landscape and Urban Planning 101 (2011) 139–148.

4. Mitchell V.G., Mein R.G., McMahon T.A., 2002, Utilising stormwater and wastewater resources in urban areas, Australian Journal of Water Resources 6(1), 31-43.

5. Prince George's County, 2002, Bioretention Manual, Programs and Planning Division, Department of Environmental Services, Prince George's County, MD.

6. Prince George's County (PGC), 2007, Bioretention Manual. Prince George's County, Maryland, Department of Environmental Resources, Environmental Services Division, Landover, MD.

7. Washington State Department of Ecology Water Quality Program, 2005, Stormwater Management Manual for Western Washington.