# Aesthetic and Ecological Stream Reclamation Using Bioengineering Techniques

BIBIANA RODRIGUES RAMOS
*VERDESIGN, Arquitectura Paisagista e Consultoria Ambiental, Lda., 8100 Loule*

THOMAS PANAGOPOULOS
Department of Landscape Architecture, Faculty of Natural Resources,
University of Algarve, 8005-139 Faro

PORTUGAL

*Abstract*: The common stream regularization is not sufficient for sustainable planning and development. The present paper explores some of the issues relating aesthetics ideals and aesthetic values, with sustainability principles and reclamation measures in a stream line reclamation project. The understanding of aesthetic aspects of landscape and the clarification of its relation to sustainable principles in a landscape reclamation project presents itself as a useful tool, resolving potential conflicts between ecology and sustainability principles and public perceptions and expectations. In developed societies aesthetics plays a relevant role in public acceptance of landscape design interventions. The solutions and techniques applied in the present rehabilitation approach might be interpreted in terms of social care and help to achieve ecologically richer and aesthetically pleasant landscapes. Stream reclamation is a key area where aesthetics and sustainability ought to be aligned, in order to overcome the human errors of the past and built a sustainable, but also beautiful landscape.

*Keywords*: Landscape reclamation, sustainable development, aesthetic, bioengineering, Portugal.

## 1 Introduction

Landscapes are themselves resources [8] constantly changing in result of human interests and activities [2, 14]. In fact, in western society scientific and technical definitions have come to dominate, producing changes and rearranging features of the landscape [8, 14] in such a manner that landscape deterioration is nowadays an issue of increasing concern [16]. The former scenario is particular evident in waterscapes where the necessity of correcting past errors in the use and handling of river ecosystems creates an imperative necessity of watercourses rehabilitation [20, 25] with aesthetic and sustainable principles in mind [15].

The aesthetics, a complex and endlessly changing subject, emerge has a western concept by the hand of a German philosopher, in about 1750 [9, 26]. Dependent of human judgment and biological heritage it changes from culture to culture and from place to place [17].

The importance of landscape aesthetic values has been recognized all around world [1] as a result several approaches and aesthetic theories were established [5, 18, 19, 23]. The dominant one is still today the scenic aesthetics or romantic aesthetic [5, 18]. Largely appraised by experts [22] is considered by some professionals as morally inferior [18] and by others "out of step" because it romanticize untouched and pristine landscapes [5, 23]. This theory, even though generally criticized for being too narrow, it does appear to be in tune with the dominant set of current public perceptions [22].

According to Nohl [15] an improvement of landscape aesthetic will have much to do with a sustainable development of landscapes. In fact, and contrasting scenic aesthetics, which is considered to be inconsistent with contemporary ecology [5], and so with sustainability principles, other new aesthetic paradigms have been defined seeking to settle aesthetics and ecological sustainability [5, 22]. The ecological aesthetic [18] or environmental aesthetics [10], based in biological principles of ecosystem management [18] constitutes the main example.

What is ecologically good or sustainable may not always look beautiful [3, 12], as a result aesthetics and ecological sustainability, two highly regarded values of landscapes, sometimes can conflict with one another [3, 22].

According to Tánago & Jalón [25] "…man broke off this dialogue with his natural environment and thought he could usurp its superiority by technical means." The aesthetic quality is a

fundamental component of the landscape [13] and traditional hydraulic engineering applied to some rivers eliminates his natural beauty [25].

For some authors it is not correct to simplify rivers and redesigning them mathematically producing monotonous and geometrical forms, because appearances are of particular influential for the management of riparian landscapes [13, 25]. The incorporation of natural methods in the rehabilitation works, which entail the use of live materials, especially vegetation, such as the bioengineering techniques, fits harmoniously into the landscape and accomplishes the regulation, protection and stabilization of river courses [4, 21]. In fact, live building materials, which were used for centuries for the protection of river and stream banks, lakes and sea shores, were gradually forgotten, to be rediscovered after the turn of the last century [21].

In order to sustainable thinking succeed in society the human action in the landscape needs guidance [15]. Since it can be expected some correspondence between landscapes which have aesthetic qualities and those which are preferred the negative aesthetic state of some landscape today's has to be overcome. To help accomplish this, the present study aims to bring enlightenment into the reclamation projects with sustainable and aesthetic goals, especially in study cases like stream lines, where keeping beauty or aesthetic ideals and promoting sustainability, are essential issues.

In the present paper the word sustainability is focused in a narrow perspective – ecological sustainability. In contrast the term aesthetics, is taken in its broad sense, referring not only to the visual appeal of an environment but encompassing the full range of aesthetic and perceptual qualities [26].

In short, the current paper explores some of the issues relating aesthetics ideals, sustainability principles and reclamation measures in a reclamation project of a stream line located in Algarve, Portugal. It is believed that aesthetics, can present itself as a useful tool, resolving potential conflicts between ecological and sustainable principles and public perceptions and expectations.

# 2 Materials and methods

## 2.1 Case study description

The setting for the study is countryside scenery, in the core of Algarve, Portugal. The study was developed in a torrential flow stream line, embracing 500 meters of his extension. This particular project was selected due to its characteristics – integrated in an industrial complex, and near a residential area – which was believed to provide a critical example, where sustainable nature must meet human economic interests and human aesthetic expectations.

## 2.3 Procedure

The landscape was analyzed for cultural, biophysical and aesthetical components, since they have important effects on the rehabilitation alternatives. For purposes of stream line analyses, the main natural features that influence its aesthetics – river typology, river morphology, biological components, natural and technological hazards – were examined as proposed by Silva [24]. Figure 1 is showing a representation of the present study concept of sustainable stream reclamation.

Figure 1- Stream line cross-section showing the idealised result of the application of the rehabilitation and bioengineering measures.

The bioengineering techniques were chosen after analysing functions and evaluating geotechnical, ecological, economic and aesthetic effects of several approaches [21]. Constrains of application (biological, technical and time constraints) and construction cost were also considered along the selection process. Afterwards, species selection took place according to ecological, biotechnical, aesthetic properties and origin or provenance [20]. The next phase was to elaborate the reclamation project composed by the layout plan, grading plan, plantation and ground cover plan, cross-sections, etc.

During this study it was paid special attention at the phase of vegetation care and maintenance, which is a crucial step to the accomplishment of stream rehabilitation projects according to Saraiva [20].

## 3 Results and Discussion

The project tried to reduce changes in the affected landscape, in order to minimise landscape instability and promotes sustainability. In figure 1, the stream line cross-section is showing the idealistic rehabilitation final result.

A "buffer zone" (strip with 10 meters width) was defined, according to Portuguese legislation (D.L. nº. 468/71, 1971-11-05 and Law nº. 54/2005, 2005-11-15), contiguous to the stream line, in order to protect the stream line from the nearby pressure and hazards.

In the present study several bioengineering techniques (table 1) were combined in order to increase effectiveness of the rehabilitation project. The hydroseeding was applied to the stream margins, and to the 10 meters ´buffer zone`. The gabions were specifically selected for the stream line curves, in areas where the erosion can be a problematic issue. Live fascines, combined with hydroseeding, were used in the stream banks, where the slope (1/1 and 1/2) requires some efficient measures. This last procedure was necessary, since space limitations implied such a slope in the stream line margins.

Table 1 – Bioengineering techniques applied of the stream reclamation project.

| Bioengineering technique | Area ($m^2$) | Ecological situation | Cost (€/$m^2$) |
|---|---|---|---|
| Hydroseeding | 7765 | 10 m buffer zone | 3,25 |
| Gabion walls | 210 | High water velocity | 110 |
| Live fascines | 1131 | Unstable slopes | 30 |

Figure 2 is showing the bioengineering techniques distribution in a stream line section. The rehabilitation treatment for the margins and ´buffer zone`, the hydroseeding, was formed by two mixtures, with different plants species composition and seeding density. In addition, trees were planted in the ´buffer zone` strip and shrubs were planted in the adjacent area. Table 2 show the list of species proposed for the stream rehabilitation project.

Solution A (´buffer zone`) – hydroseeding mixture (Cistus cripus 10%; Crataegus monogyma 10%; Lavandula sp.10%; Myrtus communis 10% ; Nerium oleander 10%; Pistacia lentiscus 15%; Rhamnus alaternus 10%; Cynodon dactylon 5%; Trifolium repens 5%; Festuca arundinacea 15%).

Solution B (in accentuated unstable slopes 1/1 and 1/2) – live fascines and hydroseeding mixture (Festuca arundinacea 35%, Cynodon dactilon 15%, Festuca rubra rubra 50%)

Solution C (in curves where water velocity was higher) – Gabions walls

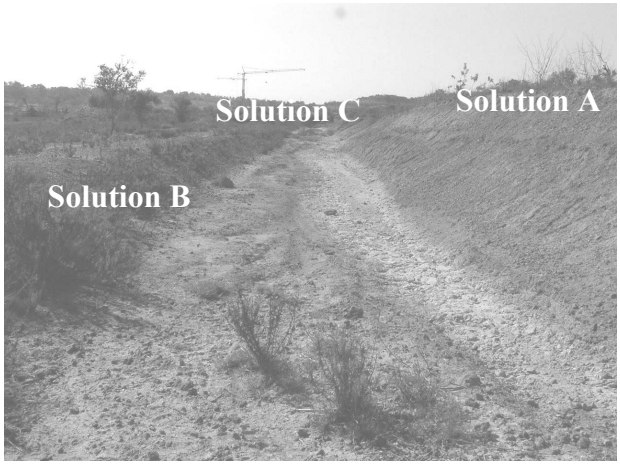


Figure 2- Distribution of the adopted bioengineering techniques on the study area.

Table 2 – List of species proposed for the rehabilitation project

| Vegetation type | Species | Individuals planted (n) | Propagation type |
|---|---|---|---|
| Trees | *Populus alba* | 12 | Seed/stalk |
| | *Fraxinus angustifolia* | 13 | Seed/stalk |
| | *Olea europea* var. sylvestris* | 38 | Seed/stalk |
| Shrubs | *Crataegus monogyma* | - | Seed/stalk |
| | *Nerium oleander* | 77 | Seed/stalk |
| | *Rhamnus alaternus* | 13 | Seed |
| | *Pistacia lentiscus** | 47 | Seed/stalk |
| | *Myrtus communis** | 10 | Seed/stalk |
| | *Lavandula sp.* * | - | Seed/stalk |
| | *Cystus sp.* * | - | Seed |
| Herbs/ Grasses | *Cynodon dactilon* | - | Seed/rootstalk |
| | *Festuca rubra rubra* | - | Seed/ rootstalk |
| | *Festuca arundinacea* | - | Seed/ rootstalk |
| | *Trifolium repens* | | Seed |

*Specie identified in the study area.

The selection of suitable plants is a requisite for the success of the rehabilitation measures (Schiechtl & Stern, 1997) adopted. Consequently, the aim was to use plants and plant material from areas in close proximity in order to reduce costs and increase potential success of the rehabilitation project. Plus, the selected plants were characterized by their wide ecological amplitude, stress hydric tolerance, adaptation to local conditions and quick establishment phase and short maintenance.

Bioengineering techniques have an important role in stream reclamation, allowing, besides stabilization of banks and water ways, the increase of the aesthetic appeal. In this respect we find interesting similarities between Tánago & Jalón [25]

and the present paper. In figure 3 it can be seen a typical profile of the stream bank after bioengineering rehabilitation.

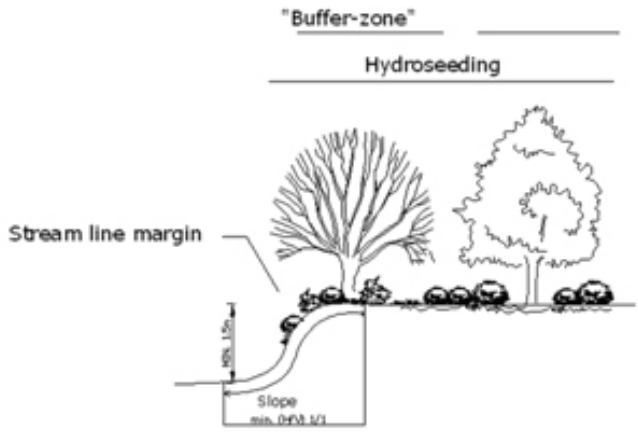


Figure 3. Typical profile of the main solution adopted for the study area (Autocad 2007 software).

Since public preference is commonly correlate with the amount of natural elements in the setting it is not surprised that bioengineering techniques, which requires the use of several natural and live materials, like vegetation, constitutes a powerful alternative for this type of intervention [7]. Other benefits of bioengineering techniques are the self evoluting character and the increasing stabilization capacity with time of the natural elements.

The results showed that the recommendation of Gobster [3] – *adoption of an aesthetic alternative, which incorporates principles of ecology* – is one way in which aesthetic and sustainability values might be integrated. But it goes further and points out that, beauty and aesthetic values may be preserved by means of the implementation of bioengineering techniques, gives a sense of naturalness, which according to Ikemi [7], are highly appreciated by public. In fact, Tanago & Jalón [25] considers *"...aesthetics of river processes as a synonymous of naturalness"*.

In the present study, bioengineering techniques replaced traditional measures entirely. Nevertheless, it must be recognize that in some cases the use of vegetative materials has biological, technical and/or time constraints: needs of space, timing of construction, time necessary to establish vegetation and waiting time until maximum performance, are the most frequent examples. In some cases construction costs can also be a limitation of the practical expansion of these techniques in civil engineering. This is why bioengineering techniques are not always a substitute, but commonly a supplement, for conventional purely technical methods [21].

## 5. Conclusions

The common stream regularization is not sufficient for sustainable planning and development. The present work shows that aesthetic and ecological considerations should be taken in stream reclamation. According to the results in a stream line reclamation project the scenic beauty is an important attribute of the landscape, because as Hull & Buhyoff [6] referred, in these cases, beauty is readily available for public critique.

The main advantages of the project proposed are various, with the most important the biodiversity – habitat conservation, the landscape improvement, the increased and constant stability of the soils and the ecosystem preservation with possibility of self evolution.

Finally, aesthetic values (scenic, ecological or environmental) and the bioengineering techniques seem to be in harmony with sustainable goals, in stream line reclamation project. In fact, it is suggested that reclamation is a key area where aesthetic and sustainability ought to be aligned, in order to overcome the human errors of the past and built a sustainable, but also beautiful landscapes.

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