Problem statement

How can the needs of nature and people be met by focusing on the role of water in green Landscape Architecture?

Sub questions

- Can the integration of the following aspects assist in the management of the South African water crisis?
    - Creative solutions for the treatment of watercourses
    - Storm water and storm water runoff strategies
    - Groundwater recharge methods
    - Irrigation design strategies
    - Plant selection and grouping

- What is the drive behind these strategies?
- Can a systems approach to site design help maintain the ecological function and improve biodiversity?

Hypothesis

An integrated and encompassing approach to water as a system is the base of green Landscape Architectural design.

The design of a Water Centre in Pretoria at an intersection of the Apies River and Nelson Mandela Drive can generate strategies for green Landscape Architecture through an intervention that addresses the Apies River channel, storm water runoff and rainwater.

By focusing on the role of water in ecosystem services, these aims can be distilled and strategies to achieve these aims can be formulated.

Relevance of ecosystem services

Chapter 2 concluded that a reformulation of Green Star SA is needed before it can be applied to Landscape Architecture. But how to achieve this reformulation?

From the investigation of site components (see figure 7 chapter 2) it becomes apparent that the way we live depends on nature for the resources we need.

The natural resources humans use are provided by ecosystems. Ecosystems can be defined as the "…dynamic complex of plant, animal and micro-organism communities and their nonliving environment, interacting as a functional unit." (Yara, 2007)

The resources from ecosystems are called ecosystem services. A study of ecosystem services could show how water supports ecosystems and thus help formulate strategies on how to deal with water in a way that will sustain these ecosystem services.

The Sustainable Sites Initiative (SSI) is a rating tool that works to protect and improve the services that ecosystems supply that man depends on. Thus to identify areas of improvement in the Green Star SA tool, the author will investigate the SSI.

Sustainable Sites Initiative

"A sustainable site links natural and built systems to achieve balanced environmental, social and economic outcomes and improves quality of life and the long-term health of communities and the environment. Sustainable landscapes balance the needs of people and the environment and benefit both" (Sustainable Sites Initiative , 2008).

The Sustainable Sites Initiative (see Chapter 2 – Measuring green for description) promotes site development and management strategies that can be sustained and is applicable on any site, whether it has a major building component or not (Sustainable Sites Initiative, 2008). The initiative provides guidelines and tools for all parties involved in design, construction and maintenance of sites that has landscape components. The strategies aim to address climate change, biodiversity issues and resource utilization (Sustainable Sites Initiative, 2008).

Aims of the Sustainable Sites Initiative

"Elevate the value of landscapes by outlining the economic, environmental and human well-being benefits of sustainable sites

- Connect buildings and landscapes to contribute to environmental and community health
- Provide performance benchmarks for site sustainability
- Link research and practice associated with the most sustainable materials and techniques for site development construction and maintenance
- Provide recognition for high performance in sustainable site design, development and maintenance
- Encourage innovation "
  (Sustainable Sites Initiative, 2008)

The need for a site-specific rating tool

The GREEN building industry is developing and is reducing the environmental impacts that buildings have on the environment and on specific sites. The Sustainable Sites Initiative recognizes the lack of an encompassing approach to sites and landscapes. The initiative recognize that the current building rating tools addresses some site aspects but states that sustainability in landscapes are not completely dealt with (Sustainable Sites Initiative , 2008).

The Sustainable Sites Initiative rating system aims at being integrated into the American LEED Green Building Rating system (Sustainable Sites Initiative, 2008).

Overview of the tool

The tool is structured around prerequisites and credits. Prerequisites are nonnegotiable benchmarks and credits are additional standards.

Ecosystem services

Nature provides man with what he needs to live; these needs are fulfilled by the services that ecosystems provide. The Sustainable Sites Initiative lists these services and addresses them through some of the prerequisites and credits. The author reviewed the ecosystem services matrix critically. The relevant aspects are summarized for ease of interpretation in Table 4. (Sustainable Sites Initiative, 2008)

Ecosystem services:	Number of *prerequisites* that protects and maintains ecosystem service vs. total prerequisites:	Number of *credits* that maintains or protects the ecosystem service:	Total amount of *components* that maintains or protect the ecosystem services:
Global climate change regulation	13 / 14	46	59
Local climate regulation	8 / 14	12	20
Air and water cleaning	14 / 14	23	37
Water supply and regulation	12 / 14	22	34
Erosion and sediment control	11 / 14	16	27
Hazard mitigation	7 / 14	11	18
Pollination	11 / 14	9	20
Habitat functions	11 / 14	23	34
Waste decomposition and treatment	12 / 14	18	30
Human health and well-being benefits	10 / 14	28	38
Food and renewable non-food products	13 / 14	16	29
Cultural benefits	9 / 14	22	31

Table 4- Summary of ecosystem service components by author

Interpretation

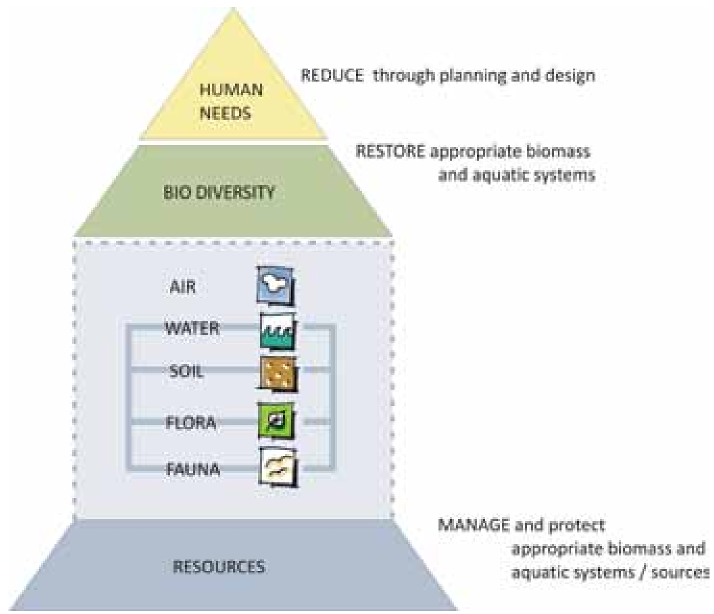
- The number of prerequisites (table 4 column 1) possiblysignifies the bare minimum parts needed to satisfythe needs of an ecosystem services
- The number of credits (table 4 column 2) are perceived to contribute to a richer and optimally functioning ecosystem service
- The total amount of components listed (table 4 column 3)seems to point to the amount of variables that should be considered for maintaining or recreating the ecosystem service it describes

Investigating the ecosystem services

The author will diagrammatically explore the prerequisites and credits mentioned above and distil the possible relationships of components of the system with each other and with other systems.
Figure 8 - 19 explores each of the ecosystem services distilled from the amount of prerequisites and credits mentioned in table 4.

In each diagram, the levels of the pyramid represent levels of hierarchy. Each level supports the levels above, thus the higher levels depend on the lower levels for support

GLOBAL CLIMATE CHANGE REGULATION



LEGEND FIGURE 8 -19

FIGURE 8. GLOBAL CLIMATE CHANGE DIAGRAM - WATER IS SUPPORTS MOST OF THE RESOURCES PROVIDED BY ECOSYSTEM SERVICES

LOCAL CLIMATE CHANGE REGULATION

FIGURE 9: LOCAL CLIMATE CHANGE DIAGRAM - WATER IS AT THE CORE OF REGULATING THE LOCAL CLIMATE AS IT SUPPORTS THE MAIN SYSTEMS RESPONSIBLE FOR ON SITE CLIMATE

AIR AND WATER CLEANING

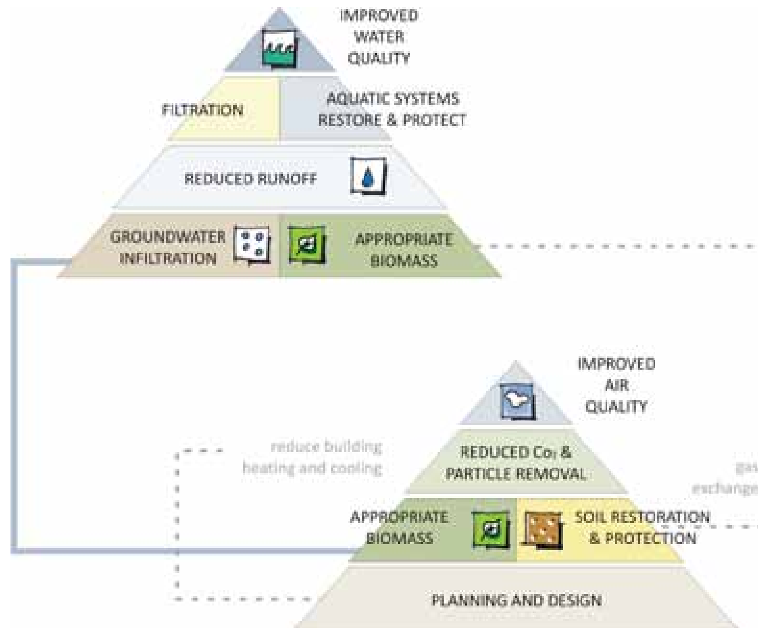


FIGURE 10. AIR AND WATER CLEANING - WATER SUSTAINS THE BIOMASS THAT FACILITATES AIR AND WATER CLEANING AND SUPPORTS HEALTHY SOIL THAT SUPPORTS BIOMASS AND AQUATIC SYSTEMS

Water supply and regulation

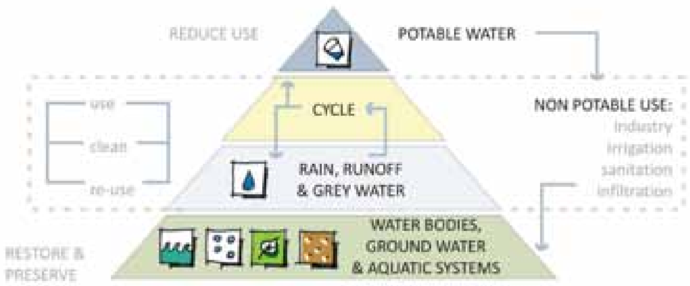


FIGURE 11. WATER SUPPLY AND REGULATION - REDUCING USE OF POTABLE WATER THROUGH OPTIMISING A SYSTEM OF ON SITE WATER USE AND RE-USE WHILE RESTORING AND PRESERVING WATER BODIES, GROUND WATER AND AQUATIC SYSTEMS

Erosion and sedimentation control

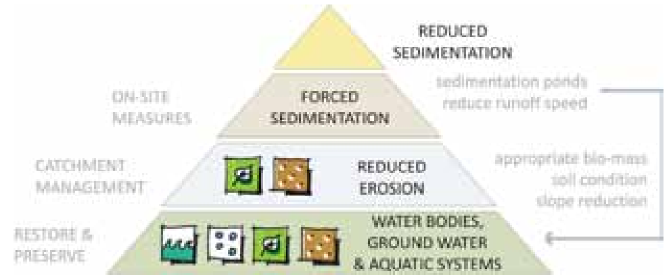


FIGURE 12. EROSION AND SEDIMENTATION CONTROL - THIS ECOSYSTEM SERVICE ADDRESSES DIFFERENT PARTS OF THE SOLUTION ON DIFFERENT SCALES, FROM NATIONAL TO CATCHMENT, TO SITE SPECIFIC. ALL MEASURES CAN BE APPLIED ON A LARGE OR SMALL SCALE.

Hazard mitigation

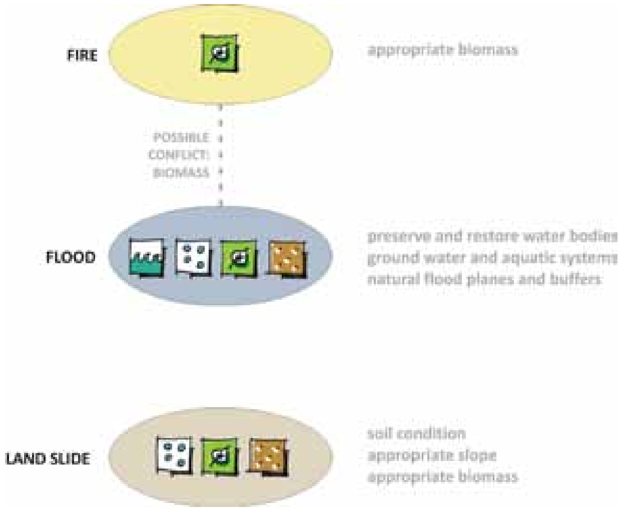


FIGURE 13. Hazard mitigation - The designer needs to take these issues into account; they are site specific. The management of natural flood planes and buffers are important, but conflict may occur, for example excess biomass on site might pose a fire hazard.

Pollination

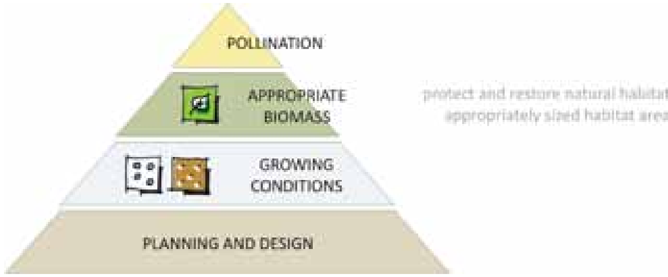


FIGURE 14. Pollination - water supports the soil and biomass for pollination. Specialist studies needed

Habitat function

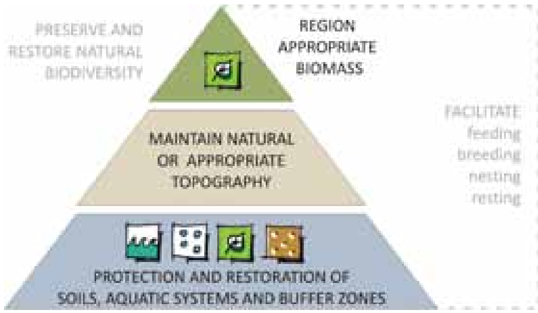


FIGURE 15. Habitat function - Water is part of the support of all life forms and part of the life cycles of many insects, fauna and flora. Feeding, breeding, nesting, resting (Breedlove: 2005)

Waste decomposition and treatment

FIGURE 16. Waste decomposition and treatment - Water supports systems where decomposition takes place and provides moisture for optimal decomposition conditions

Human health and well-being benefits

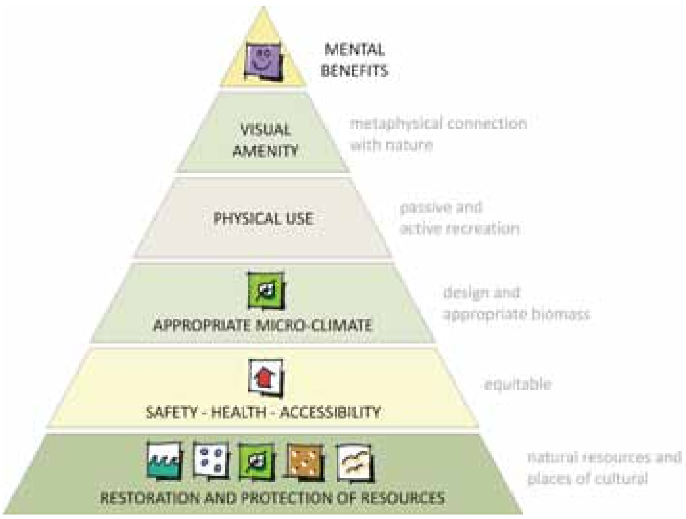


FIGURE 17. Human health and well-being benefits - resource management supports both the physical and mental benefits found in the landscape while water supports the resources

Food and renewable non-food products

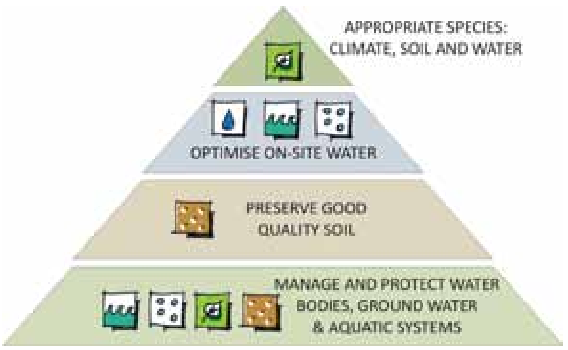


FIGURE 18. Food and renewable non-food products - Use on site Rainwater, runoff, groundwater and water bodies wisely, while reducing use of treated potable water

Cultural benefits

FIGURE 19. Cultural benefits - Water sustains and enhances resources while providing opportunity to create new cultural and socially significant spaces

Relating the Eco-system services

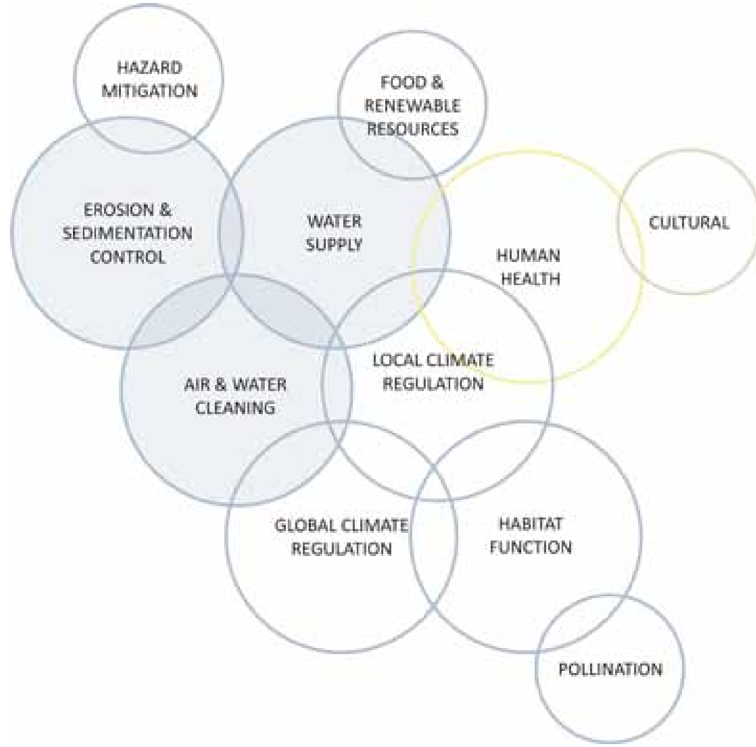


FIGURE 20. Eco-systems relation diagram

Figure 20 illustrates the role of water as the core of three of the eco-system services (blue fill). The connections with the other eco-system services are shown by overlapping. A smaller circle indicates a perceived secondary or 'spinn-off' nature of the eco-system service

Figure 21. Hierarchical structure of core concepts

Conclusion from the SSI investigation

The most prominent themes from the ecosystem service analysis diagrams are

- Conserving water sources and the systems they support while optimising the use of on-site water and reducing the use of potable water
- Introducing and preserving existing natural and on site region appropriate biomass
- Using renewable- and waste minimising materials that does not pollute through manufacturing application or after installation
- Optimise human use and health benefits by integrating the on site systems to improve the experience of man's environment

The base of most of the ecosystem services are the protection of resources that includes aquatic and terrestrial systems along with on site biomass and associated soil conditions. Tied to these resources are groundwater, water bodies (streams, rivers, lakes, oceans), rainwater and site runoff. Figure 20 illustrates conceptually how the ecosystem services relate to one another.

Water appears to be the golden thread that links most of the systems; *therefore addressing the multifaceted topic of water as an integrated system will satisfy the majority of aims and criteria for green Landscape Architecture.*

The hierarchical structure (figure 21) that manifests from the relational diagram (figure 20) confirms the dependencies between on site systems, components and ecosystem services, proving that *green* design through the eyes of ecosystem services, functions as an integrated whole and cannot be measured or rated with a fragmented 'pick off a list' approach.

The prominent themes from the SSI investigation (listed above), will be used to shape the design approach and objectives as they are broad aims and not strategies. After the design is completed, the design strategies could be formulated into strategies that will contribute towards reaching the above mentioned aims.

The relevance of a General Systems approach

When we deal with eco-systems, we must approach what we introduce into them as systems. According to von Bertalanffy (1971, p. 38), systems are groups of interrelated components.

The influence of people on ecosystems have increased the complexity of systems; thus a holistic and generalist interdisciplinary approach seems to be needed to understand, manage, create and maintain them (von Bertalanffy, 1971, p. VIII).

This further strengthens the stance that a green rating system should for a large part focus on relationships. A study of General System Theory will revolutionize the approach to ecosystems in Landscape Architecture and their relationships to human users.

General Systems Theory

In the publication entitled General Systems Theory, Von Bertalanffy (1971, p. 36) makes the argument that there are certain general 'system laws' from mathematics that are relevant to any system of a specific classification (see open and closed systems below), no matter how specific aspects may vary. Von Bertalanffy states that:

> *"… the only meaningful way to study organization is to study it as a system of mutually dependant variables…" (1971, p. 7)*

Von Bertalanffy argues that analytical methods fails in explaining systems because they are limited and focuses on linear links and not on hierarchical order that depends on the interactions between parts (1971, pp. 16 - 17, 27).

The overarching aim of General Systems Theory should be the base for integrating natural and social science and that this integration may introduce exactness to non-physical fields in science (von Bertalanffy, 1971, p. 37).

Von Bertalanffy identifies two types of systems:

He states that closed systems stand alone and do not depend on an environment, where open systems "…maintains itself in a continuous inflow and outflow, a building up and breaking down of components, …never in equilibrium but maintained in a so called steady state…" (von Bertalanffy, 1971, p. 38). Open systems relate to the concept of metabolism where specific inputs are needed to generate the desired output.

Characteristics of open systems

- *Equifinality* is the ability of an open system to reach a certain state from many starting points. According to Von Bertalanffy on Dreish (1971, p. 39): "Equifinality… contradicts the laws of physics, and can be accomplished only by a soul-like vitalistic factor which governs the processes in foresight of the goal…"
- A *higher order* and more *complex organisation* are created by open systems. This is in contrast wit the laws of physics that aims towards dissipation (von Bertalanffy, 1971, pp. 39 - 40)

Application by the author

> *Landscapes for the most part are open systems, with inputs like rainwater and sunlight, using these in metabolic processes. Photosynthesis leads to the production of living matter (a higher order) that continues to increase in numbers and complexity. The principle of Equifinality becomes visible through landscapes that, on separate sites, can develop into similar though physically unrelated systems. Systems like these are guided by genetic*

qualities and needs of individual parts as guided by common limiting factors. This evolution of a system will lead to a somewhat predictable and common climax community.

The role of Information in General systems

Information is based on the concept of decisions; these decisions establish and measure the organisation in a system. Feedback of information in a system lets the system regulate itself. (von Bertalanffy, 1971, p. 41) (See figure 22) According to von Bertalanffy "…mechanisms of a feedback nature are the base of purposeful behaviour in man made machines as well as in living organisms, and in social systems." (1971, p. 43) Thus feedback helps to improve a system to reach a goal more easily. A repeated trial and error cycle will help a system adapt to a mode of the least conflict.

Organisation

The adaptive ability of a system that stems from the feedback of information leads to higher levels of organisation that can be identified by:

- *Growth* of a system is directly proportionate to the number of elements. The law of Malthus statesthat population growth is unlimited where the natality overshoots the mortality. Two scenarios are possible: exponential where there are no limiting factors and s-curve where there are limits (asymptote) to growth, e.g. resources. It is therefore imperative for all systems, weather natural, man made or human, to find the limiting factor in each system, evaluate it and amend it where possible or needed (von Bertalanffy, 1971, p. 60).
- *Competition* occurs where two systems are dependent on the same resource. (von Bertalanffy, 1971, p. 63).
- *Centralisation* in a system occurs where a single element or part of a system becomes irreplaceable; this leads to individualization and renders the system indivisible (von Bertalanffy, 1971, p. 71).
- *Equifinality* as discussed previously.

The author concludes

The designer should understand the hierarchical order and dependencies of system components. By manipulating the characteristics and components, the design intent enables a system to reach a state of equifinality.

Feedback loops are already used in many Landscape Architectural designs for example a floating ball valve that regulates a predetermined water level.

Landscape Architects need to understand growth in systems maturation and life cycles of individual plants and plant communities should be taken into consideration when designing.

Competition is something that occurs in all landscapes and are addressed to some degree already, for example the spacing of plants allows for each plant to mature to a full size without having to compete for space. Sunlight, water and nutrients are some of the other obvious sources of competition. This concept should be applied more extensively where less obvious resources is competed for. Each system will have unique critical resources that needs to be identified and taken into account.

Water is the resource that is most commonly the source of centralisation in Landscape Architecture.

Landscape Architects should avoid treating all resources as unlimited and work with sites as systems with finite on site resources.

As systems theory deals with components, relationships and integration of parts, it will contribute to the conceptual design of the on site water systems and shape the technical investigation.

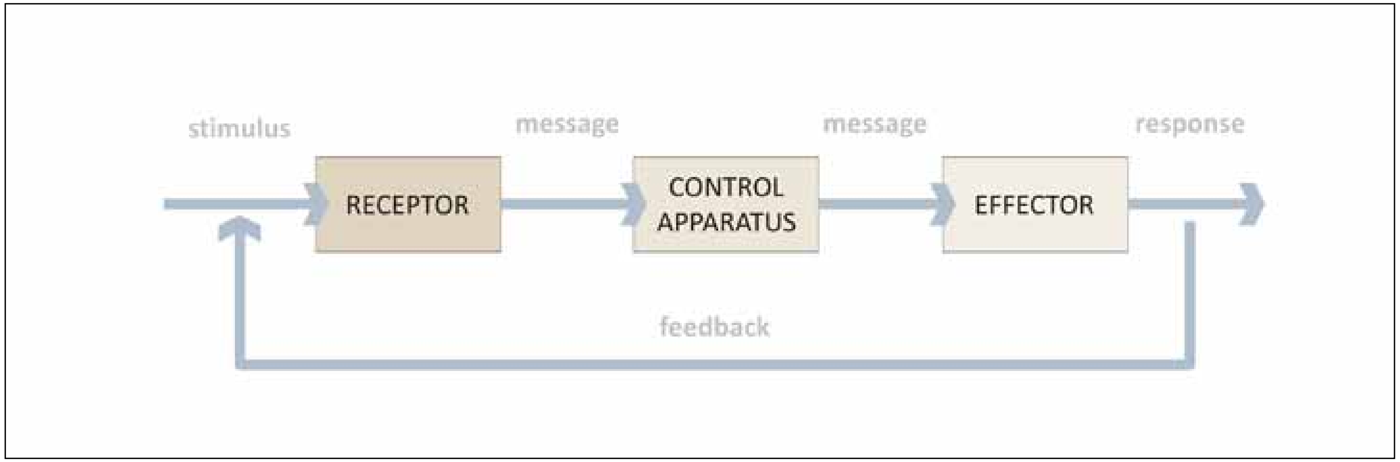


FIGURE 22. A feedback scheme - The designer can introduce technological components to act as receptors for example rain sensors, control apparatus like ball valves and effectors like automated parts to manage artificial systems