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Developing of evolution analysis algorithms in regenerative design and decision-making; demonstrated through a case study in Shiraz, Iran

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Abstract

Over the last decade the concept of 'Regenerative Design and Decision-Making' has been introduced as a mind-set which considers the integration of all humans' activities and natural systems, in a broader vision than the classic concept of 'Sustainability' (mostly focused on the present). This vision identifies a greater scope, considering 'Regenerative' as a package of 'sustainable for today', 'sustainable for future', and 'heal the past'. The 'system evolutions' and uncertainty of changes, are key factor to be considered in designing of required infrastructures of sustainability for future and healing the damages to the economy, society and environment in the past. this in turn, highlights the role of 'Evolution Analysis (EA)' and 'Future Identification (FI)' in regenerative developments.
A practical solution for FI is to develop EA algorithms, to be applied to identify the rates of changes over the integrating flows, through projects' time-frames in a more precise way. This in turn, saves huge rates of resources through design and implementation of extra infrastructures, to deal with future changes; as well as supporting the decision-makers to reach more realistic solutions, with higher levels of precision.
This paper focuses on a real case-study, the Faculty of Art and Architecture campus, in Shiraz University, Shiraz, Iran, as a part of an evolution analysis research project, sponsored by 'Iran's National Elites Foundation', and the solutions to deal with the real-projects' limitations, such as disorganisation/lack of History Data (HD), stored by different teams over a ten-year period of the campus history. Such limitations, are principally caused by 'changes in management systems', as a key integrating flow in systems' lives, and cause of uncertainties in FI.
Indeed, the paper demonstrates some critical and practical solutions, to develop EA algorithms for Regenerative Design and Decision-Making in real practices.

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Keywords: Evolution analysis algorithms, future identification, history data, management strategy change, regenerative design and decision-making

1. Introduction

During the last century the global of industrialisation has caused some un-wanted negative impacts on human socio-economic behaviours as well as the global environment. Although The 'Sustainability Concept' (also introduced as 'green design' concept in many literatures) has tried to address the resource consumptions (such as energy, water, food etc.) and preventation of the further socio-economic and environmental impacts, the previous one-century damages are still existing. This in turn, has translated into a further solution recently introduced as 'Regeneration' or 'Regenerative Developments' (RD) [1, 2] . The main challenge of RD is to provide and to consider the potentials for 'Renew', 'Re-

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birth' and 'Recover' the previously caused damages to human socio-economic relations as well as the environment. Accordingly, the regeneration concept intends on further than 'generation-consumption' systems (see figure1). Therefore, in order to be regenerative, a system must provide the factors such as 'being sustainable for today', 'being sustainable for tomorrow', and 'recovering the previously caused damages on economy, society and environment'.

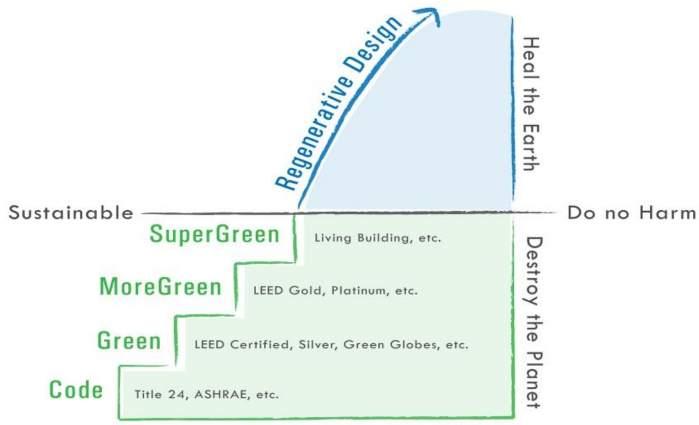

Fig. 1. Regenerative vs. Sustainable; the general concept [3].

Therefore, a set of "resource-related strategies within cycles – from nature and back to nature" have been proposed as follows:

- "Produce: resources are renewable and are sourced or generated either onsite or locally.
- Use: resources are used effectively in satisfying human needs.
- Recycle: resources are used for multiple purposes and benefits.
- Replenish: rather than diminish natural capital during the production of resources and assimilation of 'waste', replenishes and builds natural capital."[4, 5]

Regenerative Design considers a much more complex set of potential exchanges associated with both Net Zero and Net Positive systems. Accordingly, the impacts are being assessed in the following ways [5]:

- Grid-connected impacts: includes all inter-connections of the system/s with their surrounding system/s and neighbourhoods and exchanges of energy, water, wastes etc. "Grid connection is a necessary and core requirement of net zero/[positive] energy buildings" [5].
- Waste scavenging: includes spotting the wastes and problems within the existing systems and infrastructures to prevent further damages. This process considers the improvements of 'quality of performance' within the system/s exchanges and the 'quality of Net expectation'.
- Recovery potentials: includes adding of potentials and new infrastructures as well as improvement of the existing systems and/or infrastructures to achieve a faster recovery of the previously caused damage to the assessing society/ies, environment and economic system.

The optimisation factors of RD are as follows:

- Covering all requirements of a sustainable system such as economic, social and environmental preservation;
- Considering and providing of infrastructures to address the future requirements of systems, based on future identification;
- Recovering of the existing omissions in-with the systems, caused in past events.

In contrast with Sustainable Developments, the Regenerative system considers the human and environmental activities as 'inter-related flows', and the impact of each flow on the others in a greater scale (See figure 2).

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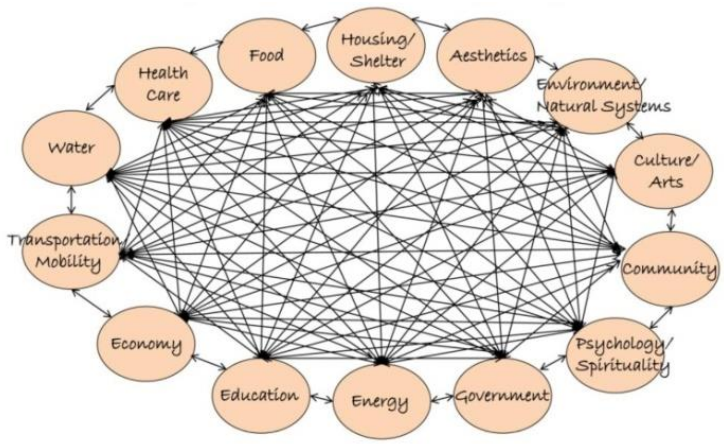

Fig. 2. the inter-relation of the flows in a Regenerative Community [6]

1.1. Role of Evolution and Future Identification

As the Regenerative Design intends to provide a better system which recognizes human as a part of the 'ecosystem'; and respects to the need of human to be incorporated into it. This in turn, is being translated into another model for sustainable living "that relies on synergy, or the idea of separate components forming a whole that is greater than the sum of its parts. It emphasizes patterns and groupings that occur naturally"[7]. Accordingly, the Regenerative Design attempts to consider the evolutions within and out-with its assessing system/s. "[t]he All these ideas combine to create patterns that mimic nature so that humans can take a symbiotic role in their environment rather than a destructive one. Obviously, a perfect closed system that regenerates itself 100 percent is not mathematically possible, so the current goal is 99.9 percent regeneration. Even that goal is a challenging one, but the process of attempting it is viable, and the result of not adapting to a changing environment is very clearly demonstrated in history: it is extinction" [7] (See figure 3).

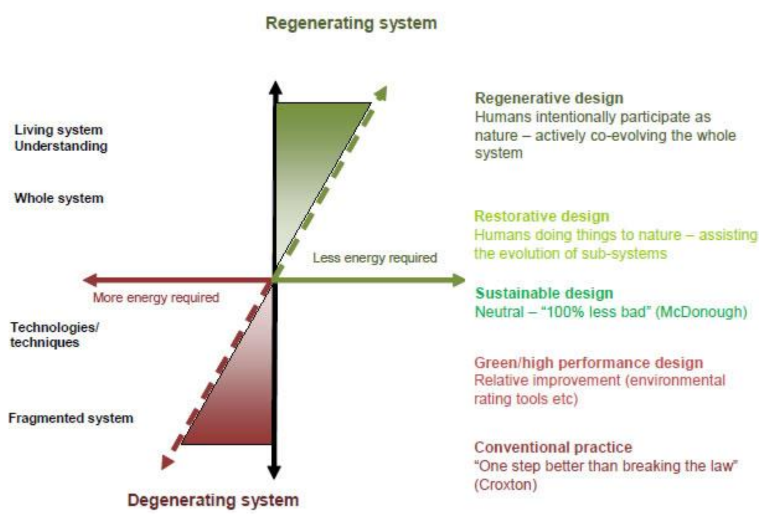

Fig. 3. the evolution-based view of RD [8].

As previously stated, one of the main attributions of regenerative design is to have a 'net positive' system, which considers in 'providing potentials to deal with future changes' and 'to recover the previously caused damages to environment, society and economy. This in turn, identifies the great demand for 'anticipation and pre-assessment' of the future events. This demand principally comes from the need of market to secure the investments on extra

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infrastructure for dealing with possible future changes and events. However, the role of uncertainty is supposed to be considered. In comparison with the length of human life, the systems contain very long-term service-lives. As shown in figure 4 a typical building neighbourhood (as a system example) can face several changes during its service-life. These changes can be greater and more diverse regarding the longer proposed building timeframes.

The aforementioned changes can be considered in following factors/flows: Population, building occupation and functional changes, end-users' behaviours, ethnics and culture, environmental changes (such as temperature, rain and snow, wind, green area type, lakes, rivers etc), technology changes (utilities' technology, in-site and out-site energy generation system/s, wireless systems etc.), market changes etc. [9, 10]. Moreover, the new developments in a neighbourhood/system will change the traffic and energy-water-waste management systems. Furthermore, the level of pollutions and time-based strategies of pollution management will be altered.

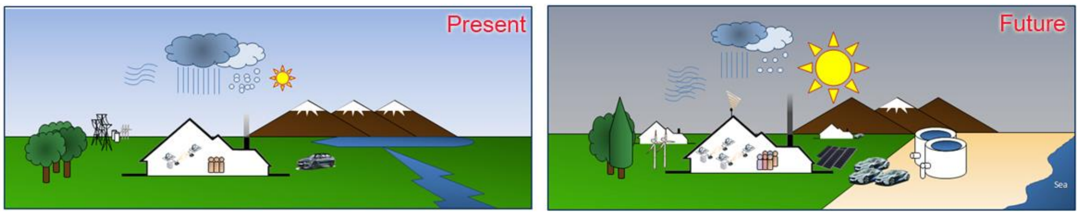

Fig. 4. a comparison of internal and external influences on a building in a typical timeframe [11].

2. Regenerative life cycle assessment: development of a critical evolution analysis algorithm

Established on level of complexity, parameters of interest, and number of optimization factors in-with each system, detailed mathematical models are being developed, which describe the components' interactions, properties of the environment and the goals that one wants to achieve. These goals may include; minimizing the resource consumptions, generating the least possible pollution, maximizing the number of housings in a limited urban area and etc. The proposed algorithm subject of this paper includes two major phases as follows.

2.1. Data Pre-processing Phase

In Real practice, data is highly susceptible to missing and inconsistent values due to their origins, multiple and heterogeneous resources, lack of valid information and human errors. Therefore, data pre-processing is a fundamental phase to improve the quality of data and the accuracy of algorithms.

Data pre-processing includes variety of steps such as data cleaning, data integration, etc.

In cases such as proposing algorithm with specific 'energy' intention, a disaggregation phase is being added in to the process, depending on data quality and availabilities of assessment values for affecting flows.

To disaggregate total consumptions, the consumption ratio for each flow of energy in the whole dataset must be calculated and accordingly, it is possible to calculate and assign the consumption for each flow. Figure 5 reveals the full procedure of Pre-processing phase in development of a typical Evolution Analysis Algorithm.

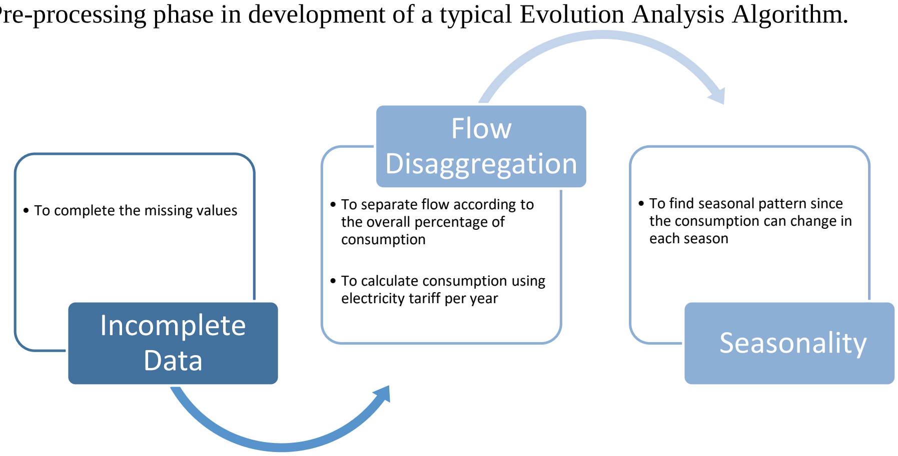

Fig. 5. Pre-processing phase in development of a typical Evolution Analysis Algorithm

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2.2. Forecasting Phase

Forecasting is considered as a common task in several areas of ‘Evolutionary Flows’ such as business, transportation, production, etc. It is an approach to predict the future events as accurate as possible, using the resulted knowledge from data extraction and history-data to be employed as an integral part of greater and complex systems. Basically, forecasting methods and algorithms can be extremely simple or highly complex. Moreover, choosing of a proper algorithm depends on dataset, goals and plans of a project.

This paper compares and evaluates two forecasting methods, methods of Genetic Algorithms (GA), a previously introduced algorithmic approach based on GA [12], vs. Artificial Neural Networks (ANN), to examine the reliability of each to be applied into RLCA. In 2015 Kashkooli et.al[12] introduced a GA as a practical algorithm to be applied in-to the future identification of RLCA, as the two GA operation parts of crossover and mutation; in order to provide the best solutions to address the following goals.

- Survive
- Combine
- Generate a better solution

However, there are several limitations and deficiencies. Therefore, the fitting models should be generated and tested separately from GA, in advance. This in turn, can be time-consuming. Moreover, that would be difficult to develop a practical GA-based system to predict the evolution of flows accurately and efficiently, when the flows create a dense network (See figure 2). As a result, it has been understood that the ANN systems (inspired from brains’ neural networks) can be considered as a more practical solution to identify the ratios and levels of future changes, as a part of RLCAs. In addition, the aforementioned ANNs are significantly adaptive to the network regarding to the variety of affecting flows. A critical distinction between the aforementioned ANN and the previously stated GA is in their capabilities to be adapted in-to greater networks, because of the fitting models, learning and forecasting capabilities of ANN.

3. Case-Study

To continue, this paper focuses on the ‘Evolution Analysis Project at Faculty of Art and Architecture, Shiraz University’, as a real case study, located in Shiraz, Iran. This project has been started on September 2017. The principal goal of the project is to design a platform for a practical tool for realistic future identification, to be employed to regenerative design and decision making. Therefore, the project intends to develop a regenerative set of algorithms, to analyse the evolution in-with the systems, with the highest levels of adaptability to unlimited affecting flows. As a sample flow, the research has considered the cost of resource consumption in–with the academic campus of Faculty of Art and Architecture at Shiraz University (See figure 6).

Fig. 6. academic campus (left) and main building (right) of Faculty of Art and Architecture at Shiraz University

3.1. Case-study pre-processing phase

At this stage the dataset of the case-study has been gathered, as a time series of four attributes such as ‘start date’, ‘end date’, ‘name of flows’, and ‘cost’ (As revealed in Formula 1). A sample of the prepared dataset is identified in figure 7.

$$l = [\text{start - date.end - date.flow. cost}] \quad (1)$$

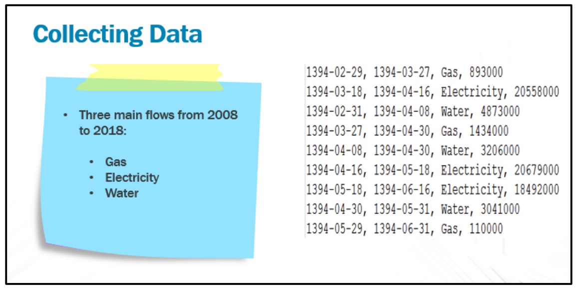


Fig. 7. a sample of dataset: Case-study of academic campus of Faculty of Art and Architecture at Shiraz University

To tackle the data omissions in values such as 'start date' or 'end date' (also known as 'Missing values'), the missing fields have been estimated established on the ratios of the similar values, which can be found in the other parts of the gathered data. Such omissions are often made by casualties in data storing at the accounting departments, and are mostly caused by changes of management systems/human errors over the projects' time scopes.

Furthermore, in some tuples, the values of cost are aggregated of two or three flows. In such cases, it is necessary to disaggregate the costs and consumptions by calculating the consumption ratio of each flow.

At this point, the assumption has been made in basis of applying the rates of highest usages and consumption tariffs into estimation of consumption. Since resource consumptions are presented by their costs in our dataset, and cost is not a reliable factor to forecast, the flow with highest usage has been considered and applied. As table 1 argues, the 'Electricity' has the highest usage among the flows.

Table 1. Flow consumption ratio

Flow	Consumption Ratio
Electricity	76%
Gas	18 %
Water	6%

To describe out time series dataset, specific patterns such as 'seasonality' and 'trend' should be recognised. In this case-study, the significant effects of weather conditions, temperature and season changes (known as 'seasonality' impacts) must be considered. Thus, the effect of 'seasonality' has been detected in calculations of the total consumptions (See figures 8 and 9). As it is shown in figure 8, electricity consumption increases in summer because of the usage of air conditioner and other cooling systems.

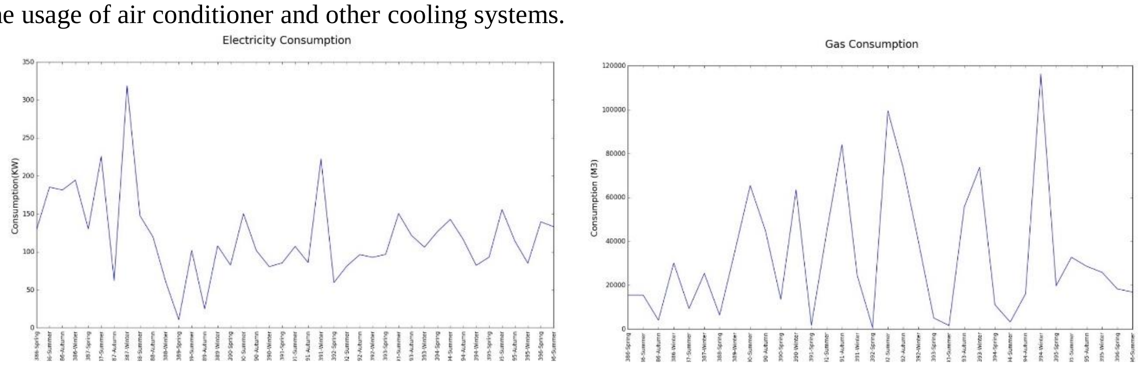


Fig. 8. seasonality in electricity and gas consumption between September 2008- September 2018: Case-study of academic campus of Faculty of Art and Architecture at Shiraz University

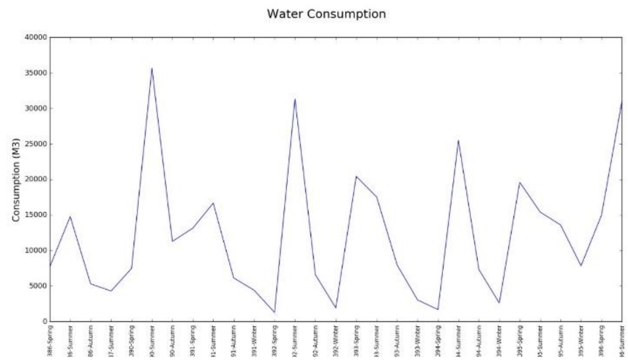
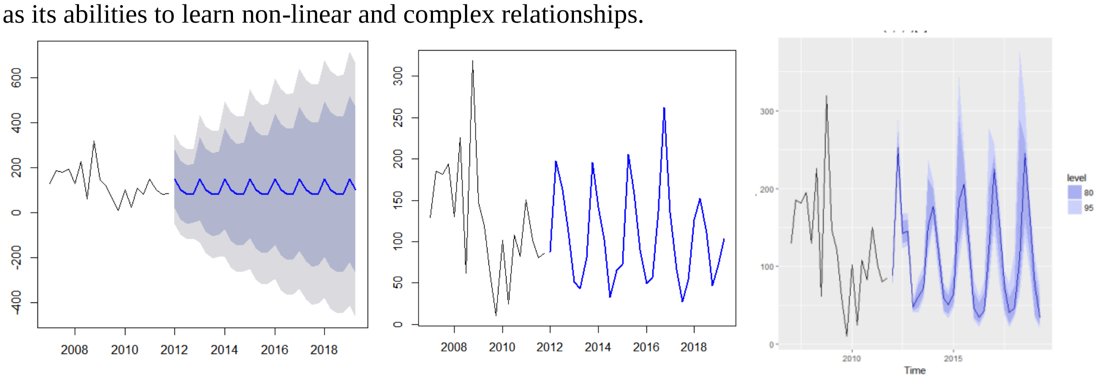


Fig. 9. seasonality in Water consumption between September 2008- September 2018: Case-study of academic campus of Faculty of Art and Architecture at Shiraz University

3.2. Case-study forecasting phase

At this phase, to validate the practicality of the three RLCA forecasting algorithms, they have been tested and compared with the real metered consumption data i.e. half of the data (from 2008 to 2012) have been considered to generate models for algorithms, and to anticipate the changes over their next five years (from 2012 to 2018). The first algorithm is based on 'seasonal naïve forecasting (SNF) method' that fails to predict future consumptions, as its predicted values are significantly different with the real recorded consumption values. The second algorithm, specific class of 'autoregressive moving average (AMA) method', is able to predict future consumptions more accurate in comparison to the previous method (naïve forecasting method).

In order to provide higher level of precision adaptability to the other integrating flows, a critical algorithm has been developed established on Artificial Neural Network (ANN), which is inspired from the structure of neural network in human's brain. As it is figure 10 revels, among the performed forecasting methods, the ANN provides the highest precision in predicting the future consumption. This capability is caused by the ANN's high levels of self-organisation, as well as its abilities to learn non-linear and complex relationships.



SNF method AMA method ANN method

Fig. 10. a comparison of the three method of RLCA forecasting algorithms: Case-study of academic campus of Faculty of Art and Architecture at Shiraz University

4. Discussion

The 2015 paper argued the practicality of Genetic algorithms (GA), introduced by Kashkooli et al., 2015 [12]. Therefore, the typical omissions of aforementioned GA have been investigated. Such omissions have been translated into the demands to shift into the other generation of EAs, and to benefit from ANN in order to provide more realistic and practical results for future identification systems. The results of such algorithms can be applied into the design and decision-making 3D modelling programmes (See figure 11) to identify a more realistic future. This identification can support the designers and decision-makers to design better infrastructures to practically deal with the future changes.

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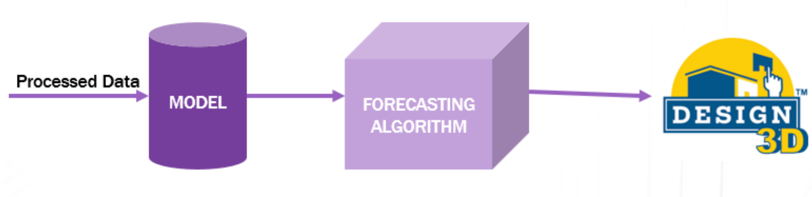

Fig. 11. general process applying the EA algorithms to design and decision-making 3D modelling programmes

5. Conclusion

In conclusion to develop a practical Regenerative LCA algorithm the following factors must be considered:

- Clear modelling of the previous stories of the systems, which are introduced as 'evolutionary flows', based on reliable data sources;
- Developing of the algorithms with high capacities and flexibilities to be developed, merged and adapted with other EA algorithms. This in turn, supports the EAs to consider as more flows as possible, in order to reach more practical and realistic results of future identification.

This research opened new door to further studies in subjects such as 'Future identification programmes and technologies'.

References

[1] Cole, R.J., Transitioning from green to regenerative design. Building Research & Information, 2011. 40(1): p. 39-53.
[2] Cole, R.J., Regenerative design and development: current theory and practice. Building Research & Information, 2011. 40(1): p. 1-6.
[3] Lewis, S. Energy, Climate and Politics. 2010 [cited 2013; Available from: http://brightworksadvisors.wordpress.com/2010/01/01/the-view-from-here/.
[4] Cole, R.J., et al., A regenerative design framework: setting new aspirations and initiating new discussions. Building Research & Information, 2011. 40(1): p. 95-111.
[5] Cole, R.J. and A.M.S. Kashkooli, Clarifying Net Positive Energy, in Stream 5 – Pushing the Boundaries: Net Positive Buildings (SB13), CaGBC National Conference and Expo. 2013: Vancouver, BC, Canada.
[6] Livingston, P. and J. Stark. Lecture: Transition Towns - A Localized Planetarian Response. 2013 [cited 2013; Available from: http://www.eon3.net/about/about_pix_chaps/about_pix_ch11.html.
[7] RLI. What is regenerative design? 2013 [cited 2013; Available from: http://www.regenerative.com/regenerative-design.
[8] Computing-For-Sustainability. Trajectory of environmentally responsible design. 2010 [cited 2015; Available from: http://computingforsustainability.com/2010/05/17/need-your-help-looking-for-sustainability-diagrams/.
[9] Rigosi, A. and F.J. Rueda, Propagation of uncertainty in ecological models of reservoirs: From physical to population dynamic predictions. Ecological Modelling, 2012. 247(0): p. 199-209.
[10]Kolokotsa, D., et al., Implementation of an integrated indoor environment and energy management system. Energy and Buildings, 2005. 37(1): p. 93–99.
[11]Kashkooli, A.M.S., A Road Map Towards Sustainable Building Design: State of Art in Realistic Decision Making. 2013, Germany: LAP Lambert Academic Publishing.
[12]Kashkooli, A.M.S., E. Daneshi, and A. Hashemian, A Critical Approach for Evolution Analysis in Regenerative Developments. International Journal of Swarm Intelligence and Evolutionary Computation, 2015. 4(2).