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Abstract

This paper has the objective to analyze the urban ecology, the biological diversity or biodiversity and their adaptive cycle as the fundamentals of green economic growth. The analysis begins questioning the implications that some assumptions of urban ecology and biodiversity, such as the socio-ecosystems, resilience, ecosystem services and adaptive cycle have on the creation of green economic growth. The method used is the analytical based on a review of the conceptual and theoretical literature. This analysis concludes that the connectivity of processes and functions of urban ecology and biodiversity are relevant to the creation of green economic growth in terms of green economic value.

Introduction

Cities are currently responsible for two thirds of global primary energy demand. If we consider urbanization processes towards cities with a minimum population of 300,000 inhabitants, in 2050 we will have around 68% of the world population living in cities, compared to the current 55% (United Nations, 2018). The urbanization process is tightly connected with the demographic growth. While in countries of low fertility in Europe and Asia, policies of redistribution of the population are promoted, increase in urbanization will be concentrated above all in developing countries, with India, China and Nigeria, which will make the main contribution.

Cities are complex ecological systems dominated by humans (Alberti, 2006). Although human manipulations of nature make cities foundamentally different from other types of natural ecosystems, the city can be considered as an ecosystem open to entry of energy, for consumption and waste generation. For this reason, we can speak about Urban Metabolism, similar to what we do for living organisms (Kennedy, 2011).

Expanding our ecological knowledge of urban regions could facilitate greater integration of nature, representing an investment opportunity and at the same time improving the quality of life of the population. High urban biodiversity can be able to provide many services, including cooling the urban area, reducing urban flood risk, filtering pollutants, supplying food, and providing accessible recreation. To understand and manage the complexity of nature in cities requires knowledge of the dynamics of both ecosystem and social systems (Douglas, 2011). Although an urban development without control or planning may be the reason for a greater ecological crisis, the phenomenon of demographic concentration may represent a positive element, which offers the possibility of designing lifestyles in compliance with environmental sustainability. As we are about to see, to achieve this goal it is necessary to boost green economic growth, based on the increase of resilience, redundancy and incorporation of adaptive cycles at the urban level. One of the first aspects to consider is the respect or regeneration of ecological nichos, able to allow local species to develop in harmony with human activities.

To accomplish this, there are several ecological parameters to consider in city planning, such as the Biotope Area Factor used in Berlin since 1990, which represents the division between the actually ecological areas for the total area. These green areas should also include the presence of ecological corridors to allow species to move according to their needs.

In this article we want to present the relevant aspects on which to work in order to have cities capable of providing for themselves, from the point of view of response to possible future external changes. Building resilient cities means being able to combine the various social, infrastructural and environmental dimensions of resilience. The availability of environmental services in terms of biodiversity present in the urban context, allows the increase of redundacy and therefore of the environmental resilience index, taking advantage of the principle of adaptability of cycles. But all this would not be possible with the simple planning of land use and space in the urban context. It is equally important that this relies on social resilience, that is, on the distinct individual, group, organizational, community and pshycological dimensions.

Urban ecology

The evolution sciences and the ecology of large urban systems assumes elasticity and springing back and do not assume deterministic trajectories and endpoints of ecological systems. Social and ecological systems are coupled and interdependent. Review of urban ecology focusing on land-use ecological combinations suggested by ecological premises to promote biodiversity, are based on the synergistically interactions of constituent land uses supporting biodiversity when clusteres and intercepted in an urban matrix (Calkins, 2005). In ecology, meta is a regional landscape community dynamics of population in scattered and patchy locations. An urbanmeta-mosaic comprises landscapes describing matter, organisms, energy and information flows, landscapes of social, evolved or political choices; and the spatial outcomes of the choices and flows.

The ecological value can be increased in high density urban contexts through the strategic implementation at different scales of green spaces interventions and solutions. Ecological indexes such as the Biotope Area Factor employed in Berlin, measured the ecological value as a percentage of permeability and evapo-transporation of the land surface of the urban green spaces including natural and artificial elements (International Energy Agency 2010). Some urban functions are more efficient with the other have a low BAF performance. The lower the urban fabric density the better the potential performance of BAF and the lower urban fabric coverage ratio, the higher the potential BAF.

The concept of resilience in urban ecology has different meanings; it is defined as the capacity of an ecosystem to absorb disturbances and natural disasters, reorganizing the undergoing changes to retain essentially the same function, structure, identity and feedbacks (Berkes et al., 2003; Carpenter and Folke, 2006; Holling, 1973). Resilience is an autonomous adaptation that responds as conditions change (Center for Clean Air Policy, 2011). Slow losses of resilience lead to large changes of the ecosystem when it crosses a threshold subjected to a random event as may be the climate change (Folke et al. 2005, Groffman et al. 2006).

Natural systems recover rapidly (Conway-Cranos, 2012). The strategic building in natural events may change the original levels of the resilience systems leading that the resilience index provides wrong information withouth connecting to a monitoring system of social, psychological, physical, structural and environmental parameters. An expert system is managed by automatic control systems whyle a non expert system is directed to the community resilience to indicate critical conditions. The resilience of a system is present when there is a coping strategy at a particular point in time.

These ecological solutions can be implemented through local private or public funded green strategies such as a municipal ecological networks (Peraboni, 2010). The different types of land-use have an ecological complementation involving different urban green spaces and areas which contribute to sustainable ecosystem services and build resilience in urban ecosystems (MA, 2005). Also, different types of resilience may have different outcomes on different types of urban land-use. Intentional resilience is related to planning ahead using common sense to maximize synergies. Accidental resilience considers that many solutions are not necessarily driven by climate concerns (Clay Nesler Efficient and Resilient Buildings: Vice President, Global Energy and Sustainability, Johnson Controls).

Recent insights on resilience and vulnerability have been developed in the context of socio-ecosystems based on complex systems and uncertainty theories. Distributed socio-ecosystems composed of independent and interactive elements deliver equivalent and better functionality with greater resilience. Resilience is the ability of the system to cope with esternal factors undermining with a system bouncing back. Resilience is defined as the capacity of complex and uncertain systems to cope with internal and external stresses through the implementation of strategies of adaptation and mutation processes and to return or achieve an equilibrium state. The system resilience becomes relevant when the equilibrium state is shifted after disruptions, disasters, pertubations and discontinuities occur.

Nature is resilient but receive impacts from the complex socio ecosystem design. Open systems have some properties that enable them the capacity to manage perturbations and disasters and to evolve and recover. Complex and hierarchically organized systems tend to be more resistant to stress within narrow boundaries, and is vulnerable to small and unforeseen perturbations.

Monitoring and assessments are essential to protect urban natural spaces and resilience. The elements of a complex urban system resilience assessment in a territorial application include the evaluation of all the interacting elements of all the systems in the method defined in the Resilience Index. This resilience index combines the subindexes of social, infrastructural and environmental resilience. The resilience coefficient is critical evolving in conection with both endogenous and exogenous factors of the system. This could be predicted the synthetic index at different levels contributing to the improvement of resilience.

Resilience as the ability to resist disorder characterized by thermodynamic changes, is considered the essence of sustainability. Resilient designing systems support sustainability. Technological improvements in socio-ecosystem design improve the human well-being by enhancing interactions between the nature, the ecosystem services and society, but requires to remove the adverse effects on the biosphere and reduce their adverse impacts and unintended consequiences. The incremental costs of design systems for new construction may be minimal. Environmental issues enhance sustainability and resilience as being global of transboundary (Collins and Kearins, 2010).

Resilience is fostered by maintaining a sustainable supply of ecosystems services to face the threats posed by climate change. Urban ecosystem services cycle and store carbon for regulating climate, help to baffer against disasters, disruptions and disturbances. Urban ecosystem services benefit population offering opportunities for recreation and education besides clean air and water, flood control, etc. Urban vegetation reduces air and noise pollution significantly.

Ontology can provide a frame of reference for resilience (Kuhn, 2003). The concept of resilience is dealing with environmental changes, disasters and disturbances caused by climate change which brings the point to develop vulnerability assessments and information management systems. Ecological resilience is a relevant concept in urban sciences of environment, sustainability and governance, defined as complex system´s ability to cope with external stresses and return to an equilibrium state, using adaptation and mutation strategies (de Lotto, Esopi & Sturla,). Poor governance leads to disfunctional behavior and decline of system conditions. Ecosystem ongoing stress are more vulnerable to change from disasters and disturbances (Gunderson and Holling, 2002; Walker and Salt, 2006). Eco system components allowing to propagate shocks are more vulnerable to systemic risks (May et al., 2008).

The socio-ecological system has quality inherent resilience. Resilience as a quality is an entity perceived and masured (Masolo et al., 2003). The qualities of resilience are considered essential to enable to take action to prevent the socio ecosystem breakdown. Social - ecological resilience, is the capacity of cross-scale interactions of complex system to respond and absorb disturbances, self-organize, learn and adapt. Resilience operationalizations is irregular because the different definitions. The debate on the meaning of resilience and its operationalization is the result of multiple approaches from ecology, sustianble sciences, climate change, disaster management, etc., in such a wat that the term resilience contains several ambiguities that are addressed ro posit a formal theory of resilience by Daniel (2011) and Daniel and Ortmann (2011) based on ontology engineering principles.

Resilience applied to engineered system design considers it is a process of hierarchical decomposition that have some properties to make it more or less resilient. Resilient engineering system manifests itself as diminishing failure probabilities (O´Rourke 2007). The resilience concepts have been already adopted for academics and practitioners of risk management.

Resilient ecosystems cope with the risks giving confidence and trust to management involved to solve the ecological situations. Green resilience can be considered as the climate adaptation and mitigation synergies. Resilient functional urban ecosystems are essential to provide ecosystem services and goods to benefit environment, structural and socio-economic systems. A resilient urban ecosystem pursue a balanced urban sustainable development model based on social participation planning and management in integration of economic, social and environmental issues, preservation and enhancement of local resources and reduction of environmental impacts.

Ecological land-use complementation theoretical framework draws on the island biogeography theory (MacArthur and Wilson, 1967). Ecological land-use complementation (ELC) is a theoretical framework that merges ecology and the landscape complementation/supplementation concepts developed by Dunning et al. (1992). The ELC approach is used for land management promoting the integration of qualitative attributes of species in biodiversity and urban residents. In heterogeneous patch types such as urban landscapes, the species need to move to obtain the complemented resources to fulfill different life cycles (Pope et al., 2000). A missing process of the landscape or seascape can be reestablished in other dispersed patch withing the range. Dispersal of species in heterogeneous landscapes confers resilience to disturbances (Peterson et al. 1998, Nyström and Folke 2001, Loreau et al. 2003, Cardinale et al. 2004).

Some mechanisms to achieve resilience are sense-making, organization structures, mistake orientation, structural flexibility and redundancy. Redundancy of species decrese where are sort into niches (Reich et al., 2012), and are critical for functioning under particular environmental conditions (Isbell et al., 2011). Ecosystem services resilience is dependent upon the sets of species existing in an ecosystem and performing similar ecosystem processes (Walker et al. 1999, Elmqvist et al. 2003). Species-level ecological data is required about function and response (Cumming and Child, 2009). In biological ecology, the shift in life history from r-selected features of rapid growth, high investment and disperse nature of offspring to K-selected features on slow growth, greater investment and local dispersal (Gunderson & Holling, 2002).

The socio-ecological system can be characterized as a single equilibrium and as a multiple equilibria (Holling, 1996). A specific socio-ecological system is an instance of a class socio-ecological system. The socio-ecological system is a sub-class of ecological system. The concept of socio-ecological system is a class that exists within resilience and is a type of an ecological system. Thus, the socio-ecological system as a class is a type of the relation with the ecology system or class.

In Ecology, the equilibrium state of an ecosystem is defined as Climax. The term equilibrium or steady state refers to the state where the socio-ecological system does not change unles it is subject to disturbances. The implicit assumption of stability is that there is only one equilibrium or steady state. In the event of existing other states, some safeguards should be applied. An ecological disturbance occurring at defined time and space scales may allow persistence of species, structures and processes at not affected scales (Elmqvist et al. 2003). Ecological processes replicated across a range of scales confers resilience (Peterson et al. 1998).

Systems design poses among the new technical challenges to achieve robustness through resilience, adaptability and diversity are the new concepts for task management, system state indicators are based on energy attributes. Adaptability requires the system change in the face of disturbances to retain essential properties (Folke et al., 2004; Walker et al., 2004).

Ecological resilience is supported by the capacities of the ecological system to absorb disturbance and reorganize while changing to retain essentially the same functions, structures, identities and feedbacks (Walker et al, 2004). Processes and feedbacks and later returning to its previous disturbance state (Walker and Salt, 2006). Constructive positive feedback loops help to identify the vulnerabilities in a crisis and the strengths of the community (IFRC 2004). Qualitative feedback from quantitative ecosystem services and viceversa, as well as human well-being outcomes can be used to evaluate assumptions about indirect drivers (MA 2005a). In socio ecosystems in existing conditions provide negative feedbacks. Ecological resilience is linked to environmental sustainability proving that the booming cities around the world present greater risks for the future (Isenhour, 2011).

The resilience of the sustainability of any ecological system is influenced by sustainable social determinants. Ecological resilience can not be separated from social systems as both society and environment are coupled and interacting in non-linear manner. The concept of social resilience is relevant to understand other forms of resilience that can be individual, group, organizational and community resilience, including the psychological resilience at all levels. There are some developed tools to achieve psychological resilience as a form of vital and authentic life (Wagnild, 2010) and recovering from stress by increasing resistance (Bonanno et al, 2006; Fergus and Zimmerman, 2005).

Community resilience is a relevant aspect of social resilience, although it is usual to derive the notion from the pshychological resilience. Community resilience is defined as as the capacity to anticipate, minimize and absorb stresses and destructive forces through adaptation and resistance; as well as to manage and maintain basic functions and structures during disastrous events, and recover or ‘bounce back’ after an event (Twigg, 2009). The factors influencing community resilience are emerging cohesion, connectedness, community empowerment, collective efficacy, social justice, assessment, etc.

Institutional and organizational resilience is the recovery after disturbances and disruptions emerging from unespected harmful events, risks, stress and strain (Vogus and Sutcliffe, 2007). Organizational resilience is the capacity to unfold, respond and recover from unexpected events and external disturbances absorbing the extreme changes and impacts (Linnenluecke et al. 2012). Building organizational resilience aims to adjustments under challenging conditions from where the organization emerges strengthened and more resourceful (Vogus and Sutcliffe, 2007).

A resilient ecological system absorbs exogenous shocks and disturbances without changing its processes. Loosing resilience results in changes even from the small-scale disturbances (Witten et al, 2011).

Economic, social and ecological decline may be the result of disfunctional or lacking governance and leads downward to environmental conditions, welfare and human well-being (Folke et al., 2010). External disturbances resulting from storms, floods, etc., have structuring effects (Johnson & Miyanishi, 2007) and random internal effects pressure and drive change and instability. Food supply is experiencing ecological instability, reduction in biological diversity and agroecological unputs, climate change, biosecurity risks, transgenic drifts and crops genetically modified, risks of transboundary diseases, increasing of prices, etc.

The renewal capacity in dynamic environments generates an ecological protection against management failures of the system and allowing the managers to learn and change. These changes pose a major constraint to economic development, ecological needs, health and livelihoods. Healthy socio-ecological system increases the economic efficiency and reurns from supporting activities more focused on wealth creation. Restoring degradation of urban ecosystem resilience reduces vulnerability to natural disturbances and disasters, enhance the ecological and social networks and improves the quality of life.

Eco-innovative initiatives target at clean and renewable technologies to reduce impacts on the socio ecological system aimed to enhance resilience to environmental disturbances and to contribute to sustainable development. Eco-innovations on development of resilient cities, eco-innovative solutions are related to waste management, drinking fresh water, sustainable building materials and insulation (Eco-innovation action plan, 2011). Evolving policies fostering eco-innovations that boost efficiency, resource productivity and competitiveness safeguarding the environment (Eco-innovation action plan, 2011).

Resilience is an ecological concept to describe sustainability as an inherent property of the system. The fundamental properties for sustainable design of resilience systems in both engineered and larger systems are the diversity, adaptability, cohesion and ecological efficience. The resilient socio-ecological system functions on a broad spectrum of possible states created by disruptions, disasters and perturbations, gradually tending through evolution and adaptation to return to an equilibrium states. Under certain conditions, the resilient socio-ecosystem may shift to a different new equilibrium state with new structural and functional changes.

In sustainable urban planning, ecological policies for green interventions are implemented to improve urban ecosystems services quality, the environmental sustainability and to instrument the measure of the ecological value through the use of ecological indexes. Resilience can be measured at different scales: regional, city, infrastructure, neighboring, building. Environmental commitments recommended by international organizations such as the World Bank Group are being attended and to certain extent are being fulfilled. Adaptive ecological planning, management and governance assume that the ecological processes can be changed framed by the uncertainty (Peterson 2005).

Urban planning and design principles guide the land-use configurations to support the ecosystem processes and urban resilience. Protection and enhancement of urban ecosystems provide opportunities to increase urban resilience and promote public health and education by addressing climate change. The benefits of urban ecosystems can cantibute to build urban resilience by maximizing the qualities of robustnessresourcefulness and redundancy. Urban resilience enables to learn the best practices and opportunities to achieve synergies by mitigation cutting carbon pollution abd responde with adaptation to climate impacts.

The qualities of urban resilience are to be reflective learning and leveraging from past experiences; robustness of physical assets; redundancy, flexibility, resourcefulness, inclusiveness fir briad consultation, integrated processes aligning systems for consistency and enable them ri function and responde collectively. Urban spatial planning and design must have in the agenda the reliance building to avoid local extintion of species and eradication of native fauna and flora (McKinney, 2002). Manipulation of species composition to change the provisioning of ecosystem services may reduce the resilience of regulating services, increase the effects of extreme events and decrease future supply of ecosystem services.

The MA Scenarios is a step further the global ecological scenario analyses of ecosystem services and their ecological implications (Cumming et al. 2005, Raskin 2005). Maintenance of regulating services insures the adaptability against severe ecological changes and the human action that can decrease regulating services while increasing the ecosystems vulnerability. People tend to value resource provision and cultural values, but tend to undervalue regulating services, ecosystem processes and supporting ecosystem services. Ecosystem components that generate regulating services may undermine the supply of ecosystem services. The capacity of socio–ecological systems to cope with, and adapt to, varios types of disturbances and dissasters is related to regulating ecosystem services.

The possibilities for ecosystem services trajectories are dependent on access to data assimilated into the models to be assessed and projected. One example is the climate changes, one of the drivers of the ecosystem services which models only can be predict only the incremental but not the crucial changes that may transform socio-ecosystems (Smith 2002). This is one of the reasons why ecosystem services are uncertain, ambiguous, complex and difficult to predict (Walley 1991) and the range of possibilities are unknown.

The Millennium Ecosystem Assessment (MA) (MA 2003) has developed four MA ecological scenarios to address future ecological changes in ecosystems management, in the flows of ecosystem services, the trade-offs faced when making decisions on the different options and in their consequent changes in human well-being. Changes in ecosystem services and their trade-offs with poverty reduction and alleviation offer potential risks, costs and benefits. However, the capacity to substitute ecosystem services can be limited due to the costs or lacking availability of technology (Postel and Carpenter 1997). Nevertheless, technology may shape the trade-offs among ecosystem services (Rodriguez et al. 2006). For example, energy technologies have a potential for ecosystem services.

The MA scenarios incorporate detailed ecological dynamics (Raskin 2005, MA 2005a). The Millennium Ecosystem Assessment (MA) scenarios analyze the complex ecological dynamics implications of ecosystem services in human well-being and their trade-offs conections with poverty reduction and life quality of urban communities. The supply of ecosystem services eroded by poverty reduction makes more difficult the poverty alleviation.

Methodologies to support the MA scenarios had emerged from the interview, such as the analisys of green technology and TechnoGarden, locally based learning and Adapting Mosaic, security and Order from Strength (Cork et al. 2006). A quantitative analysis using models are based on a limited subset of ecosystem services have strong limitations because uncertainties and ambiguities are difficult to quantify if not impossible (MA 2005). An MA scenarios analysis involving both quantitative and qualitative results are cross-checked to find harmony with additional iterative analyses to improve the results. In fact, MA scenarios can provide cross-cutting insights to explain the ecosystem services dynamics.

Management strategies formulation and implementation to support the resilience of socio-ecosystems are crucial for the production of goods and environmental services for social systems. Policies, strategies and interventions should be designed to influence the evolution and behavior of socio-ecological systems and environmental resilience protection to enhance the heath and wellface of the overall socio ecosystem.

Ecological policies can be directed towards several ecological goals such as the reduction of energy consumption and use of renewable energies and towards green interventions such as water treatment, waste management, absorption of polluntants, etc. Material and energy use is resulting in growing emissions, pollution and waste materials. Public engagement of local authorities should develop the structures and develop the best management practices to connect urban population with nature awareness and ecological literacy and enable their implementation.

Design practices of systems resilience has developed many useful techniques. The Resilience Alliance (RA) is a research organization created and developed to join and collaborate with resources and efforts of a transdiciplinary group of practitioners and scientists aimed to explore the dynamics of socio-ecological systems. Members of the RA usually come from social, environmental and ecological sciences using theorethical and empirical frameworks of rigorous testing methodology in natural resource management, scenarios and model development, adaptive management techniques and partcipative approaches, self-organization, optimization and resilience systems, among other methods. The RA develops conceptual, theoretical and practical knowledge on biodiversity, resilience, adaptation and transformation of socio-ecosystems and sustainable development policy making and implementation.

The symbiotic relationships develop between large and small facilities in industrial ecology focusing on ecological efficiency. The methodology of BASF combines the ecological impacts of the life cycle with the economic analysis to find the eco-efficiency. The energy flows in industrial ecological systems develop sustainability indicators based on thermodynamic analysis where useful energy is a comparative assessment method of ecological efficiency in industrial processes.

The essence of resilience of any business company is to generate strategic options making sense of its environments in order to realign its resources taking advantage of its rivals (Hamel, Valikangas, 2003). Resilience has implications for the sustainability of business companies to develop beyond their own boundaries an intricated system for continuous renewal and innovation capable to ensure long term resilience. Within the supply chain of the manufacturer, renewable materials and energy have an impact on the economic and socio-ecology systems. Social responsibility should be an attribute of the company in continuos adaptation to achieve ecological integrity with improved quality of life through sustainable design principles.

Greening programs, community green areas and gardens managed by local authorities, as well as other local government initiatives are a source of civic engagement and community participation, a sense of an identity, transmiting and educating ecological knowledge. Resource users with local knowledge sharing the management and decision making may be more supportive for formulating and implementing strategies and policies. Urban green spaces have positive effects on the attractiveness of urban landscapes based on the interrelation between building features and other green elements (De Lotto, R. &M.L. Di Tolle 2013).

The different functions of land use are inserted in buildings shapes with high coverage ratio, while other functions are more specific for building typologies with lower coverage ratio. Ownership fragmentation of lots or buildings is related to the difficulty in finding agreed solutions.

City resolutions should facilitate urban farming and agriculture indicating to public owned property the suitability of land or the local restrictions for rooftop gardens and greenhouses (Brannen 2011). Any practice modification of urban agriculture and farming must begin with the socio economic boundary conditions (Lansing, 1991). Private and public gardening benefits the urban microclimate and change the gray contexts into green environments and can be incentivated by deducting accommodation and maintenance costs. A collective system intervention is the purpose to reduce the greenhouse emissions. Historic centers in urban contexts require applications to integrate natural and artificial solutions to increase the ecological quality and ecosystem resilience.

Local populations affected by any type of air, water, soil pollutions may be enable to mobilize in defense of the right to better environment and ecological resilience Environmental disputes adjudication synergistically links up democratic and ecological processes. The transformative power of ecological activists, environmental lawyers and the civil society organizations adviced by experts must fight back to deliver ecological justice on environmental outcomes and catalyze resilience though legal actions of regulating and monitoring institutions. The contributions to the resilience system should be assessed in terms of performance outcomes and intrinsic characteristics. The resilience of related systems is accomplished through design protocols.

Socio-ecological feedbacks intensify modifications of socio-ecosystems and changes the flow of ecosystem services received from nature, which in turn, increase the vulnerability of people to further cahnges (Cumming et al. 2005).

Biological diversity or biodiversity

The concepts of biodiversity, redundancy or ecological variability, multiple equilibrium adaptation, hierarchy of interactions between spatial scales and temporal responses are elements that give support to the ecosystem resilience. Biodiversity icreases the suitability between species and particular conditions (Chapin et al., 1995; Isbell et al., 2011). Biological diversity retains structural controls and provides functional redundancy when the system is facing disturbance.

Biodiversity conservation and natural resources principles must be included into sustainable governance and resilience policy initiatives. Conservation and enhancement of biodiversity can maintain the flows of ecosystem services and reduce socio ecological vulnerability. Diversification in socio-economic systems is aimed to reduce risk and is accomplished through the biodiversity maintenance and economic diversification.

Resilience is determined by preparation, response and recovery, representing the overall risk management efficiency and effectiveness. Resilience, vulnerability and criticality are all related with the notion of risk integrating causes and consequences and explanations of pre and post events (Philley, 2006; Shahriar et al, 2012). The risk index relates the components of critical infrastructure with the environment in preparation to react in case of disaster or crisis. The resilience index combines instruments of innovation and risk assessment simplifying the large scales areas of components and comparing the resilient capabilities of each component accourding to the different stakeholders and users. Risk monitoring and assessment based on the resilience index serve for warning, information processing and risk mitigation planning.

The resilience capacity to adapt to the ecosystem is based on the biodiversity, redundancy is ecological variability, cycles of adaptation to multiple equilibrium states, hierarchical interaction between spatial scales and temporal responses. Resilience is affected by biodiversity depending on the organization of species, response diversity, time and place scaling of ecosystem processes and spatial patterns. Response diversity is linked to resilience of the ecosystem services through biodiversity, in such a way that any change in species affects.

Other kind of response diversity is the spatial pattern (Elmqvist et al. 2003). A resilient city reacts to environmental dysturbances by protecting natural biodiversity and ecosystems. A resilient city for resilient people is related to a shared decision on developing framework. Building socio–ecological resilience through regulating biodiversity and ecosystem services moderate extreme events.

It is usual that local planning authorities have limited knowledge on biological conservation and biodiversity maintenance and management of natural resources in urban development settings in congruence with other biodiversity approaches (Sandstrom et al., 2006; von Haaren and Reich, 2006). Coordination among state-level agencies and city-level agencies may likely be the reason why planning urban farming and agriculture is related to the quality of the local food system, although it is required to design a strategy for harnessing the supporting resources.

The ecological land-use complementation benefits the biodiversity building from the land uses in urban green areas (Colding, 2007). Knowledge on the interactions between land-use changes and biodiversity is more abundant than the influence of landscape design in landscape functions in some specific contexts (Hobbs, 1993, 1997). Land uses have synergistic effects on supporting processes that are essential for the development of biodiversity. Land uses analysis based on ecological premises support biodiversity and ecosystem services. The ecological premises of ecological land use complementation spatially arranged as they are determinants of biodiversity protection. The ecosystem resilience can be promoted by adopting ecological land-use complementation in new urban areas supported by ecosystem services and respone diversity.

Decisions on supply of different ecosystem services involve trade-offs (Rodriguez et al. 2006) such as clearing the forest land to be used for agriculture improves the supply of food but leads to declines in biodiversity, climate regulation and water purification. Provision of some ecosystem services such as the production of food may reduce the supply of other ecosystem services such as water while removing income sources.

Trade-offs among ecosystem services have a substantial impact on the future, yet they are difficult to anticipate. Proper accounting for the ecosystem uncertainties drives the ecosystem services to low levels of discount rates and increasing the value of future benefits. Overexploitation of ecosystem services undervalue future benefits (Ludwig et al. 2006). An overexploitation of ecosystem services may degrade the regulating of other ecosystem services and decrease the yield of provisioning services, and increases environmental variability and vulnerability. Agrobiodiversity management and conservation of crop genetic resources, wild relatives and traditional seed varieties are a relevant factor for disaster risk reduction and recovery. There are some studies on post-disturbance ecosystem recovery (Connell and Slater, 1977; Odum, 1969).

Adaptive cycle

The general theory of adaptive cycles has been developed to apply the concept of resilience to socio management ecosystems under the argument that exhibit similar patterns of increasing connectedness, decreasing resilience, slow accumulation of resources and crisis, transformation and renewal periods. The behiovioral quadrants differ in the degree of connectivity and the amount of capital.

Community resilience encompases disaster management process cycle and does not excludes psychological resilience dimension. adversities and disturbances. Community resilience manifests in the population mental and behavioural health, functioning dimensions and quality of life (Norris et al, 2008). Disaster management integrates the network if adaptive capacities considered as resources with dynamic attributes to achieve adaptation after. Regime in any dynamic system follows a given trajectory unles it is disturbed. Regime shifts can be found in different types of socio-ecosystems (Beisner et al., 2003).

Any scenarios address a set of assumptions concerned with ecosystem services. An analysis using the MA scenarios evaluates the changes of the regime shifts, its consequences and risks on ecosystem services and on human health and well-being. Ecosystem services must be considered in the MA scenarios in the context of global socio-ecosystems changes and their reciprocal feedbacks. The feedbacks producing ecosystem degradation and poverty are difficult to explain, but the poverty alleviation is dependent upon the access to supply of ecosystem services (Martinez-Alier 2002). One of the cross-cutting challenges emerging from the scenarios is the connection between ecosystems services and poverty, including the trade offs.

Interventions on the patterns of adaptive cycles enable to manage change of the system dynamics. Rigid structures prevent reorganization, while perturbations compromise the exploitation of the adaptive cycle (Biggs et al., 2010; Pelling & Manuel-Navarrete, 2011). Urban land uses are in continues flux of change governed with decisions at local government level (Theobald et al., 2000) but driven by no anticipated non-local drivers (Altieri et al., 1999).

The human action and government policies may enable people to decrease the risks of regime shifts and build resilience and create better conditions to develop ecosystem services. Urban sustainable planning policies implemented through adaptation strategies are able to mitigate climate change effects and manage the environmental impacts on urban socio ecosystems resilience of human communities and settlements.

Green economic growth

Green economy is aimed to improving social equity and human wellbeing while reducing environmental and ecological risks and scarcities (UNEP, 2010). The green economy concept is related to the principle of think globally, act locally. Economies must develop and strengthen the capacities to reduce the use of natural and environmental resources used by a growing green economy. The results sought are to reduce the levels of natural resources use, as well the levels of emissions and pollution in times when population, economic growth and consumption growth.

Green economic growth reduces environmental stress ensuring that the basic needs are met while increases competitiveness and profits. For example, ocean natural resources management can be a source of green and inclusive economic growth. However, thos reduction of stress may have other impacts. The removal of predators in coastal areas has an impact on the degradation of resilience of these coastal ecosystems increasing vulnerability to storms and sunamis (Jackson et al. 2001; Adger et al. 2005).

Traditional production systems are moving to most modern production systems changing the lifestyles of humankind, supported by new technologies and mineral materials towards more industrial and urban oriented systems and away from the use of biomass, natural and agricultural resources. Growth of financial, manufactured, human and social capital has been degradating natural capital and ecosystem services. Ecosystem services and human wellbeing may suffer irreversible severe declines if natural capital is not built and enhanced at the same time that financial, manufactured, social and human capital. However, many countries are experiencing dramatic changes in agricultural and biomass systems and away from urban/industrial systems and mineral materials. Adapting the mosaic approach emphasizes the multi-scale and cross-sectoral efforts to sustain ecosystem services.

The ability to transform the economic growth in economic green growth by taking the opportunities of an evolving policy landscape. The transition from traditional economy activities to green economy must be supported by effective, fair and inclusive governance. Greening of economic growth should be supported by integrated targets, strategies and indicators, aimed to give relevant policy data on systemic change for growing green. Greening economic growth strategies support integrated changes of the socio ecosystem. Green growth strategies strengthened through specific policies play a significant role in addressing the roots of persistent poverty and achieve reduction.

Global green economic liberalization requires investments in public goods and policies to reduce poverty and inequality reduction. Emerging green economies are experiencing industrialization, urbanizations and restructuration processes aimed to achieve better standards of welfare and living. These processes have changed the production, distribution and consumption systems, reduced the agricultural labor force and motivating the use of fossil-fuel-based energy systems which have enable and reinforced large-scale urbanization.

Low-income economies are experiencing activities and practices that usually have an intensive water resource usage and high degradation of the quality of water despite the technical improvements in water practices and systems and technologies fostering an effective use of water and higher economic added value. Technological innovation determines the ecosystem management and governance to increase the availability and to improve efficiency of supply and allocation of ecosystem services. Technology plays a relevant role for the provision of ecosystem services and have an impact on other connected ecosystems. However, these activities and practices are far away from the green economic growth perspective. Technological development and property rights for ecosystem services are co-evolving and augmenting the abilities and capacities to manage and monitor the ecosystems.

Green economic planning and design of urban greening elements create the opportunities to develop a smarter urban resilience and provide the additional benefits of a more sustainable city. Community economic greening programs allow residents to participate and take ownership and management developing a stewardship culture of urban natural resources and spaces. Poor urban and rural communities are vulnerable to negative impacts. Green economic growth policies may ensure a just transition for all the stakeholders in a community, ensuring mitigation of regressive impacts. Some specific measures on green growth can strengthent the synergy poverty reduction strategies, although green economic growth policies cannot be a substitute of social policies addressing the causes of poverty.

To enable green growth is essential to create productive partnerships between the efforts of the different stakeholders for adaptive community co-management of natural resources. Relationships of cooperation between the different stakeholders dealing with interlinked challenges and aimed to close the gaps of green economic and social development as well as sustianble environment may contribute to achieve better quality of welfare.

Green economic growth initiatives require to be supported by an economic incentives framework. The green economic rationale is provided by investments in environmental improvements and protection. Green economic growth investments developing a time gap between short-term costs and long term benefits require collaborative action between public and private sectors.

A relationship between technical components and urban policies is critical to encourage investments in green interventions for improving urban environmental quality and efficiency. This collaborative action overcomes the financial risks and barriers allowing capital flows into investing in urban green sectors. Initiatives, investments and stimulus of green growth requires financing and economic mechanisms implemented through systemic reforms. Green growth achievements by initiatives, investments, and stimulus must be underlyed by financing mechanisms and economic forces.

Reduction of the price gap between the economic value and market prices of ecosystem goods, enhances and improves the investments in green economic sectors and reduces large scale environmental pressures. Green economic growth investments deliver large long term benefits after significant costs. Market failures should be corrected through the costs internalization of social and environmental externalities with negative impact by improving green investments and financing to achieve better natural resources efficiency and environmental protection.

New green jobs are demanded by skilled labor sectors that demand updated and scaled up skills training.

An economic green growth and urbanization resource-intensive processes are in transition from and agrarian to industrial-based resources increasing the demand for materials and energy. The transformation of urban land use is dynamic and therefore the benefits that the population receive from the ecosystem services, the regulated services, cultural services and the supporting services. The quality of all these services lead to the ecosystem resilience and environmental options (Folke et al., 2004).

The study of the ecosystem services feedbacks and regime shifts as part of a global system is relevant to change development paths (MA 2005) despite the difficulties to reduce uncertainties and the unexpected ecosystems phenomena in the projection os ecosystem services, a pattern that is likely to continue by the adoption of unexpected events (Bennett et al. 2003). For example, the vulnerability of drylands has increased with overcultivation and changes in rainfall, decreasing in the capacity of ecosystems to regulate and store water flows and maintain vegetation, leading to loss of resilience to external driven changes and invasive species (MA 2005c). **Urban hydrological cycles represent a fundamental factor in providing and accumulating water, prevent soil loss and erosion, nutrient sequestration and recycling, remove toxins and sediments from water.**

The new policies scenario is part of the commitment made by local governments related to renewable energy demand and subsidie reductions of fossil fuel and gass emission.

The reserved urban land also known as the urban greenbelts are the result of zoning planning for economic green growth used to protect areas that are environmental sensitive from urban development and control agricultural activities. Access to green spaces are linked to improving physical and mental health and reduce mortality.

Conclusions

As we have seen, the redundancy together with the defense of the ecological balances present in urban ecosystems, constitues fundamental elements for building resilient cities. In general, this means integrating aspects of planning policies that take into account the advantages of urban growth based on the needs of native species, with the aim of keeping intact the ecosystem services that benefit the population, through the conservation of the local biodiversity. This can be done through some techniques, in particular the pursuable model of the BEF, together with the presence of ecological corridors to allow the species to migrate.

It would be possible to restore ecosystems to their own conditions of origin, limiting the introduction of non-native species, which in many cases lead to the breakdown of equilibria, resulting in plundering of the resources of the territory to the detriment of the other species that in some cases risk disappearing. Resilience in urban ecosystems is something that can be increased through planning. However, this is not just a physical planning of land use. First, it is about changing the paradigms of relationship with the territory, use of resources, and between human beings. To obtain long-term benefits, sustainable green growth must be able to count on resilient cities that grow in harmony with the rest of the territory. The biggest challenge is not to create islands of order in seas of entropy, that is, not to pour all the externalities produced by the city elsewhere.

To achieve this goal, it is necessary to organize economic activities, favoring a transition from lifestyles based on consumption and industrial activities, to restricted productive value chains, possibly organized in the local territory. This could help to reduce the economic dependency mechanisms, favoring the resilience of citizenship in the face of external economic shocks. It is equally important to integrate ecology experts into institutions that are involved in planning the development of cities, to limit informal or unauthorized construction.

Finally, it will be possible to advance educational programs that from the schools up to politics, concern themselves with forming an active citizenship in the environmental defense of their own territory, with the aim of building a greater social and community resilience.

All this represents the background on which it would be possible to pursue a slow transition from traditional economic activities towards a green economy, supported by an effective, fair and inclusive governance.

References

Adger, W. N., T. P. Hughes, C. Folke, S. R. Carpenter, and J. Rockstrom. (2005). Social–ecological resilience to coastal disasters. *Science* 309:1036–1039

Alberti, M. (2006). *Advances in Urban Ecology. Integrating Humans and Ecological Processes in Urban Ecosystems.* New York: Springer.

Altieri, M., Nelso Companioni, A., Ca˜nizares, K., Murphy, C., Rosset, P.,Bourque, M., Nicholls, C.I., (1999). The greening of the "barrios": urbanagriculture for food security in Cuba. *Agric. Human Values* 16, 131–140

Bennett, E. M., S. R. Carpenter, G. D. Peterson, G. S. Cumming, M. Zurek, and P. Pingali. (2003). *Why global scenarios need ecology*. Frontiers in Ecology and the Environment 1:322–329.

Berkes, F., Colding, J., Folke, C., (2003). *Navigating Social–Ecological Systems: Building Resilience for Complexity and Change.* Cambridge UniversityPress, Cambridge (United Kingdom).

Beisner, B. E., C. L. Dent, and S. R. Carpenter. (2003). Variability of lakes on the landscape: roles of phosphorus, food webs, and dissolved organic carbon. *Ecology* 84(6):1563–1575.

Biggs, R., Westley, F. R., & Carpenter, S. R. (2010). Navigating the back loop: Fostering social innovation and transformation in ecosystem management. *Ecology and Society*, 15(2), Article 9.

Bonanno, G. A., Galea, S., Bucciarelli, A., and Vlahov, D. (2006): Psychological Resilience after Disaster: New York City in the Aftermath of the September 11th Terrorist Attack. *Psychological Science 17* (3): 181–186

Brannen, S. (2011). *Food works: A vision to improve NYC's food system*. New York, NY: The New York City Council.

Calkins, M., 2005. Strategy use and challenges of ecological design in landscapearchitecture. *Landsc. Urban Plann*. 73, 29–48.

Cardinale, B. J., A. R. Ives, and P. Inchausti. (2004). Effects of speices diversity on the primary productivity of ecosystems: extending our spatial and temporal scales of inference. *Oikos* 104:437– 450.

Carpenter, S.R., Folke, C., (2006). *Ecology for transformation*. Trends Ecol. Evol.21, 309–315

Center for Clean Air Policy (2011). *The value of green infrastructure for urban climate adaptation*, available at www.ccap.org

Chapin, F.S., III, Shaver, G.R., Giblin, A.E., Nadelhoffer, K.J. &Laundre, J.A. (1995). Response of arctic tundra to experimentaland observed changes in climate. *Ecology*, 76, 694–711

Colding, J. (2007). Ecological land-use complementation for building resilience in urban ecosystems. *Landscape and Urban Planning* 81 (2007) 46–55

Collins, E.M., and Kearins, K. (2010): Delivering on Sustainability's Global and Local orientation. *Academy of Management Learning & Education* 9(3): 499–506.

Connell & R. 0. Slatyer. (1977). Mechanisms of succession in natural communities and their role in community stability and organization. *Amer. Naturalist* 111: 1119-1144. Cooper, W. S. 1926. The fundamentals of vegetational change. Ecology 7: 391-413.

Conway-Cranos, L. L. (2012). Geographic variation in resilience: an experimental evaluation of four rocky intertidal assemblages *Mar Ecol Prog Ser Vol*. 457: 67– 83, 2012doi: 10.3354/meps09715

Cork, S. J., G. D. Peterson, E. M. Bennett, G. Petschel-Held, and M. Zurek. (2006). Synthesis of the storylines. *Ecology and Society* 11(2): 11. [online] URL: http://www.ecologyandsociety.org/vol11/ iss2/art11/.

Cumming, G.S., Child, M.F., (2009). Contrasting spatial patterns of taxonomic andfunctional richness offer insights into potential loss of ecosystem services. *Philosophical Transactions of the Royal Society* B 364, 1683–1692

Cumming, G. S., J. Alcamo, O. Sala, R. Swart, E. M. Bennett, and M. Zurek. (2005). Are existing global scenarios consistent with ecological feedbacks? *Ecosystems* 8:143–152.

Daniel, D. C. (2011). *A Formal Theory of Resilience*. Dissertation. Master of Science in Geoinformatics, University of M¨unster, Germany.

Daniel, D. and Ortmann, J. (2011). *Disambiguating Resilience*. In Schwering, A., Pebesma, E., and Behnke, K., editors, Geoinformatik 2011 - Geochange, volume 41 ofifgiprints, pages117–125, Heidelberg, Germany. AKA Verlag.

de Lotto, R., Esopi, G. & Sturla, S. *Sustainable policies to improve urban ecosystem resilience*

De Lotto, R. &M.L. Di Tolle (2013). *Elementi di progettazione urbanistica-rigenerazione urbana nella città contemporanea*, Maggioli Publisher, 2013.

Douglas, I., Goode, D., Houke, M., Wang, R. (2011) *The Routledge Handbook of Urban Ecology*. New York: Routledge.

Dunning, J.B., Danielson, B.J., Pulliam, H.R., (1992). Ecological processes thataffect populations in complex landscapes. *Oikos* 65, 169–175.

Eco-Innovation Action Plan (2011). *Innovation for a Sustainable Future*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. [assessed 2014-10-03]http://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=JBJhJh7RB5n2T7nTdZLLVLGRlJPCFRnTGM7ZvF8Wh H9TJryvnsvL!1821898924?uri=CELEX:52011DC0899

Elmqvist, T., Folke, C., Nystr¨om, M., Peterson, G., Bengtsson, J., Walker, B., Norberg, J., (2003). Response diversity, ecosystem change, and resilience. *Front. Ecol. Environ.* 1, 488–494.

Fergus, S., and Zimmerman, M. A. (2005): Adolescent resilience: a framework for understanding healthy development in the face of risk. Annual review of public health 26 (1): 399–419.

Folke, C., S. R. Carpenter, B. Walker, M. Scheffer, T. Chapin, and J. Rockström. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* 15(4): 20. [online] URL: http://www.ecologyandsociety.org/vol15/iss4/ art20/

Folke, C., S. Carpenter, B. Walker, M. Scheffer, T. Elmqvist, L. Gunderson, and C. S. Holling. (2005). Regime shifts, resilience and biodiversity in ecosystem management. *Annual Review of Ecology Evolution and Systematics* 35:557–581.

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunder-son, L., Holling, C.S., (2004). Regime shifts, resilience, and biodiversityin ecosystem management. *Annu. Rev. Ecol. Evol. Syst*. 35, 557–58.

Groffman, P. M., J. S. Baron, T. Blett, A. J. Gold, I. Goodman, L. H. Gunderson, B. M. Levinson, M. A. Palmer, H. W. Paerl, G. D. Peterson, N. L. Poff, D. W. Rejeski, J. F. Reynolds, M. G. Turner, K. C. Weathers, and J. A. Weins. (2006). Ecological thresholds: the key to successful environmental management or an important concept with no practical application? *Ecosystems 9* (1):1–13. (Online.) URL: http://springerlink.com/(mw0hzsfu fbpawv2rf24i3szk)/app/home/contribution.asp?referrer= parent&backto=issue,1,12;journal,2,60; linkingpublicationresults,1:101552,1.

Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy: Understanding transformations in human and natural systems.* Washington, DC: Island Press, 507.

Hamel, G.; Valikangas, L. (2003). The Quest for Resilience. *Harvard Business Rev.* 2003, September, p 52.

Hobbs, R.J., (1993). Can revegetation assist in the conservation of biodiversity inagricultural areas? *Pac. Conserv. Biol*. 1, 29–38.

Holling, C. S. (1996). Engineering resilience versus ecological resilience. In P. C. Schulze (Ed.), *Engineering within ecological constraints* (pp. 31–44). Washington, DC: National Academy Press.

IFRC (International Federation of Red Cross and Red Crescent Societies) (2004) World *Disasters Report: Focus on Community Resilience*. International Federation of Red Cross and Red Crescent Societies, Geneva, Switzerland, 231 pp.

International Energy Agency (2010). *Energy Performance Certification of Buildings: a Policy Tool to Improve Energy Efficiency,* France, 2010.

Isbell, F., Calcagno, V., Hector, A., Connolly, J., Harpole, W.S., Reich, P.B.et al.(2011) High plant diversity is needed to maintain ecosystem services. *Nature*, 477, 199–202

Isenhour, C. (2011): How the Grass Became Greener in the City: On Urban Imaginings and Practices of Sustainable Living in Sweden. *City & Society* 23(2): 117–134. 2011.

Jackson, J. B. C., M. X. Kirby, W. H. Berger, K. A. Bjorndal, L. W. Botsford, B. J. Bourque, R. H. Bradbury, R. Cooke, J. Erlandson, J. A. Estes, T. P. Hughes, S. Kidwell, C. B. Lange, H. S. Lenihan, J. M. Pandolfi, C. H. Peterson, R. S. Steneck, M. J. Tegner, and R. R. Warner. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293:629–638.

Johnson, E. A., & Miyanishi, K. (Eds.). (2007). *Plant disturbance ecology: The process and the response*. Burlington, MA: Academic Press.

Kennedy, C., Pincelt, S., Bunje, P. The study of urban metabolism and its applications to urban planning and design. *Environmental Pollution 159 (2011) 1965-1973*

Kuhn, W. (2003). Semantic reference systems. *International Journal of Geographical Information Science*,17(5):405–409.

Lansing, J. S. (1991). *Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali;* Princeton University Press: Princeton, NJ, 1991.

Linnenluecke, M. K., Griffiths, A., and Winn, M. (2012). Extreme Weather Events and the Critical Importance of Anticipatory Adaptation and Organizational Resilience in Responding to Impacts. *Business Strategy and the Environment* 21: 17–32.

Loreau, M., N. Mouquet, and A. Gonzalez. (2003). Biodiversity as spatial insurance in heterogeneous landscapes. *Proceedings of the National Academy of Sciences* 100:12765–12770.

Ludwig, D., W. A. Brock, and S. R. Carpenter. (2006). Uncertainty in discount models and environmental accounting. *Ecology and Society* 10

MA (Millennium Ecosystem Assessment), (2005). *Ecosystems and Human Well-Being: Synthesis.* Island Press, Washington, DC.

MA. Millennium Ecosystem Assessment. (2005c). *Ecosystems and human well-being: policy responses.* Island Press, Washington, D.C., USA.

MA Millennium Ecosystem Assessment. (2003). *Ecosystems and their services. Chapter 2 in Ecosystems and human well-being.* Island Press, Washington, D.C., USA.

MacArthur, R.H., Wilson, E.O., (1967). *The Theory of Island Biogeography*.Princeton University Press, Princeton, NJ.

Martinez-Alier, J. 2002. *Environmentalism of the poor: a study of ecological conflicts & valuation.* Edward Elgar, Northhampton, Massachussetts, USA.

Masolo, C. and Borgo, S. (2005). Qualities in formal ontology. *InFoundational Aspects ofOntologies (FOnt 2005)* Workshop at KI, pages2–16.

May, R. M. (1974). *Stability and Complexity in Model Ecosystems*. Princeton, NJ: Princeton University Press

McKinney, M.L., (2002). Urbanization, biodiversity, and conservation. *Biol. Sci.5*2, 883–890

Norris, F.H, Stevens, S.P., Pfefferbaum, B., Wyche, K.F., and Pfefferbaum, R.L. (2008): Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness.*American Journal of Community Psychology* 41(1-2): 127–150.

Nyström, M., and C. Folke. (2001). Spatial resilience of coral reefs. *Ecosystems* 4:406–417.

Odum, E. P. (19699. The strategy of ecosystem development. – *Science* 164: 262–270.

O'Rourke, T. (2007). Critical Infrastructure, Interdependencies, and Resilience. *The Bridge* 37 (1): 22–29.

Pelling, M., & Manuel-Navarrete, D. (2011). From resilience to transformation: The adaptive cycle in two Mexican urban centers. *Ecology and Society*, 16(2), Article 11. Retrieved from http://www.ecologyandsociety.org/vol16/iss2/art11/

Peraboni, C., (2010). *Reti ecologiche e infrastrutture verdi*, Maggioli Publisher: Milan, 2010.

Peterson, G. D. (2005). Ecological management: control, uncertainty and understanding. Pages 371– 395 in K. Cuddington and B. Beisner, editors. *Ecological paradigms lost: routes of theory change.* Elsevier, Academic Press, Oxford, UK. [online] URL: http://www.elsevier.com/wps/find/bookdescription. cws_home/705214/description#description.

Peterson, G., C. R. Allen, and C. S. Holling. (1998). Ecological resilience, biodiversity, and scale. *Ecosystems* 1:6–18.

Philley, J. (2006). *Collar hazards with a bowtie: Chemical Processing*. Putman Media, January. [accessed 2010-04-22], <
http://www.nxtbook.com/nxtbooks/putman/cp0106/index.php?startid=27>.

Pope, S.E., Fahrig, L., Merriam, H.G., (2000). Landscape complementation andmetapopulation effects on leopard frog populations. *Ecology* 81, 2498–2508.

Postel, S., and S. R. Carpenter. 1997. *Freshwater ecosystem services*. Pages 195–214 in G. Daily, editor. Nature's services. Island Press, Washington, D.C., USA.

Raskin, P. D. (2005). Global scenarios: background review for the Millennium. *Ecosystem Assessment. Ecosystems* 8:133–142.

Reich PB, Tilman D, Isbell F, Mueller K, Hobbie SE, Flynn DF, Eisenhauer N. (2012). Impacts of biodiversity loss escalate through time as redundancy fades. Science. 2012 May 4;336(6081):589-92. doi: 10.1126/science.1217909.

Rodriguez, J. P., T. Beard, Jr., E. Bennett, G. S. Cumming, S. Cork, J. Agard, A. P. Dobson and G. D. Peterson. (2006). *Ecology and Society* 11 (1):28. [online] URL: http://www.ecologyandsociety. org/vol11/iss1/art28/.

Sandstr¨om, U.G., Angelstam, P., Khakee, A., (2006). Urban comprehensiveplanning—identifying barriers for the maintenance of functional habitatnetworks. *Landsc. Urban Plann.* 75, 43–57.

Shahriar, A., Sadiq, R., and Tesfamariam, S. (2012): Risk analysis for oil & gas pipelines: A sustainability assessment approach using fuzzy based bowtie analysis. *Journal of Loss Prevention in the Process Industries* 25(3): 505–523.

Smith, L. 2002. What might we learn from climate forecasts? *Proceedings of the National Academy of Sciences* 99:2487–2492.

Theobald, D.M., Hobbs, N.T., Bearly, T., Zack, J.A., Shenk, T., Riebsame, W. E., (2000). Incorporating biological information in local land-use decisionmaking: designing a system for conservation planning. *Landsc. Ecol*. 15,35–45.

Twigg, J. (2009*): Characteristics of disaster resilient community–a guidance note.* [accessed 2014-0-01] http://discovery.ucl.ac.uk/1346086/1/1346086.pdf

UNEP (2010): United Nations Environment Programme Green Economy Report. [assessed 2014-10-03] <http://www.unep.org/greeneconomy/GreenEconomyReport>.

United Nations DESA (2019): World Urbanization Prospects: the 2018 Revision. Key Facts: [assessed 2019-24-05]< https://population.un.org/wup/Publications/Files/WUP2018-KeyFacts.pdf>

Vogus, T.J., and Sutcliffe, K.M. (2007): The impact of safety organizing, trusted leadership, and care pathways on reported medication errors in hospital nursing units. *Medical Care 4*1(10): 992–1002.

von Haaren, C., Reich, M., (2006). The German way to greenways and habitatnetworks. *Landsc. Urban Plann.* 76, 7–22.

Wagnild, G.M. (2010): *Discovering Your Resilience* Core [interactive]. [accessed 2014-10-03]. <https://www.pobal.ie/Publications/Documents/Discovering_Your_Resilience_Core.pdf

Walker, B. H., A. P. Kinzig, and J. Langridge. (1999). Plant attribute diversity, resilience, and ecosystem function: the nature and significance of dominant and minor species. *Ecosystems* 2:95–113.

Walker, B., and D. Salt. (2012). *Resilience Practice: Engaging the Sources of Our Sustainability*. Washington, DC: Island Press.

Walker, B., & Salt, D. (2006). *Resilience thinking: Sustaining ecosystems and people in a changing world*. Washington: Island Press.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society*, 9(2), Article 5.

Walley, M. P. (1991). *Statistical reasoning with imprecise probabilities*. Chapman and Hall, London, UK

Witten, I.H.; Frank, E.; Hall, M.A. (2011). *Data Mining: Practical Machine Learning Tools and Techniques.* Morgan Kaufmann, San Francisco, CA, USA.