Watescapes Sustainable Management: Enabling Contexts for Eco-Innovative Solutions

Maria Cerreta,

PhD, Professor of Environmental assessment and evaluation, Department of Architecture (DiARC), University of Naples "Federico II", Italy

Pasquale Inglese,

GeoSpatial Solutions Developer, Department of Architecture (DiARC), University of Naples "Federico II", Italy

Chiara Mazzarella,

PhD Candidate, Department of Architecture (DiARC), University of Naples "Federico II", Italy

1. INTRODUCTION

The environment is naturally liable to hazards and related disaster risks for human safety, but from XX century natural risks have significantly increased due to man-made hazards. The effects of pollution on the natural and urban environment derives from heavy industrialization first, and consumer society too. Indeed, the urban environment is the place where man-made unresponsible activities manifest their direct damages to human health. Over the centuries cities, that were established to organize communities and defend them from external threats, have become vulnerable places with high man-made risk exposure.

Waste is the first man-made hazard for the environment and human beings' health, and virtuous waste management is a central theme in the prevention of environmental disasters and related risks to health and quality of life. Well-being for all and environmental protection are two of the main global challenges of our time, and a central idea in the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015) and disaster-related targets of the United Nations Sustainable Development Goals (SDGs) (UN, 2015).

In particular, the health issue is relevant and can be considered a challenge and a priority with poverty eradication, education, food security and nutrition, and sets out a wide range of economic, social and environmental objectives.

Indeed, the New Agenda (UN, 2015) in the *Article 34* recognizes that sustainable urban development and management are crucial to the quality of life, promoting community cohesion and personal security and stimulating innovation and employment, but also reducing the negative impacts of urban activities and of chemicals which are hazardous for human health and the environment. This awareness means including through environmentally sound management and safe use of chemicals, but also the reduction and recycling of waste, in order to minimize the impact of cities on the global climate system.

In particular, *Goal 3. Ensure healthy lives and promote well-being for all at all ages*, one of the seventeen SDGs, underlines the need to reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution contamination by 2030.

Furthermore, *Goal 12. Ensure sustainable consumption and production patterns* considers the need to: implement the 10 Year Framework of Programmes on Sustainable Consumption and Production Patterns; achieve the sustainable management and efficient use of natural resources by 2030; achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment by 2020; reduce waste generation through prevention, reduction, recycling and reuse by 2030.

Waste management is deeply linked to disaster risk, taking into account that a risk-based framing approach conceptualizes the risks arising from the overlapping of hazards, exposure and vulnerability, leading to impacts that provide feedback to socio-economic processes. This concept of risk was derived from a rich set of literature on risk (including risk perception and risk management) and requires approaching disaster risks in the context of the full spectrum of the risk profile that societies face. Indeed, the World Health Organization (WHO) underlines that improper waste management and illegal waste shipments can have negative impacts on both the environment and public health. Negative impacts can be due to different handling and disposal activities resulting in soil, water and air pollution. Inadequately disposed of or untreated waste may cause serious health problems and hazards for populations surrounding the area of disposal (WHO, 2015).

Moreover, WHO underlines that uncontrolled or mismanaged waste disposal affect citizens negatively determining relevant impacts at the local level, such as landscape deterioration, local water and air pollution, and that managing waste properly and in an environmentally and sustainable sound approach is essential for health reasons.

Taking into account the above considerations, European Union waste management policies aim to reduce the environmental and health impacts of waste and, at the same time, improve Europe's resource efficiency. The main goal is to turn Europe into a recycling society, avoiding waste and using unavoidable waste as a resource, achieving much higher levels of recycling and minimising the extraction of additional natural resources.

According to the Europe 2020 strategy, suitable waste management is a key element in ensuring resource efficiency and the sustainable growth of European economies (EC, 2010).

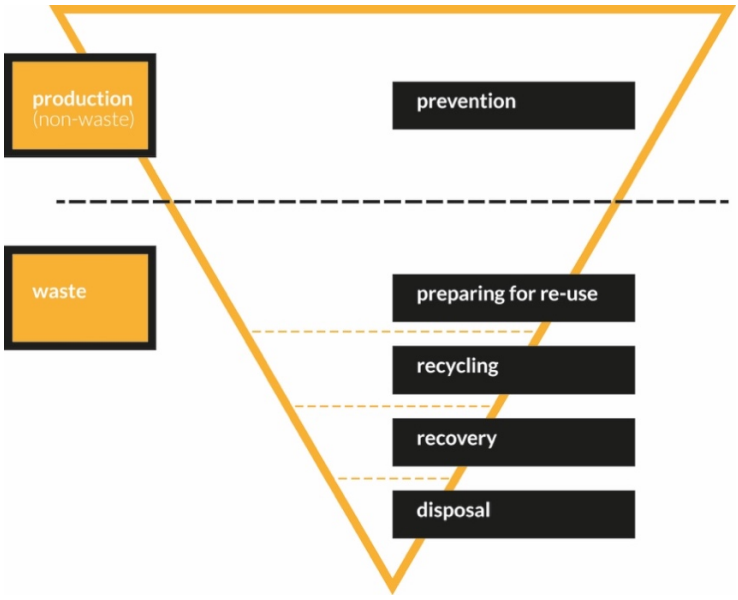

Figure 1. EU waste management hierarchy

The revised Waste Framework Directive of 2008 (EC, 2008) introduced a five-step waste hierarchy applying a priority order in waste prevention and management legislation and policy (Fig. 1), where (a) prevention is the best option, followed by (b) re-use, (c) recycling and (d) other forms of recovery, with (e) disposal such as landfill as the last resort.

The waste hierarchy identifies measures to encourage the options that deliver the best overall environmental outcome and may require specific waste streams departing from the hierarchy supported by life-cycle thinking on the overall impacts of the generation and management of waste. Consistent with this hierarchy, the 7th Environment Action Programme (EAP) (EU, 2014) has a special focus on turning waste into a resource, with more prevention, re-use and recycling, and sets the following priority objectives for the EU waste policy: 1) reduce the amount of waste generated; 2) maximise recycling and re-use; 3) limit incineration to non-recyclable materials; 4) phase out landfilling to non-recyclable and non-recoverable waste; 5) ensure full implementation of the waste policy targets in all EU Member States. The EAP identifies also human health and wellbeing as a key challenge, with specific attention to air and water pollution, excessive noise, and toxic chemicals, considering the effects of the different types of waste.

Taking into account that the WHO underlines that environmental factors could be responsible for up to 23% of all deaths in Europe (Prüss-Üstün and Corvalán, 2006), and taking into account that this percentage is increasing over time considering also the existing linkage between climate change, air pollution and health (WHO, 2018), human health deeply depends on environmental salubrity (EEA/JRC, 2013).

The EAP recognizes that specific efforts are needed to reduce waste generation (per capita and in absolute terms), limiting energy recovery to non-recyclable materials, phasing out landfilling of recyclable or recoverable waste, ensuring high-quality recycling, without adverse environmental and/or human health impacts. At the same time, hazardous waste needs to be managed, minimising significant negative effects on human health and the environment, supporting prevention, recycling and re-use, affecting health and behaviour directly and indirectly, including extended producer responsibility and moving towards a lifecycle-driven Circular Economy (CE), with a cascading use of resources and residual waste that is close to zero (EU, 2014).

Saffron et al. (2003) carried out a literature review of the health impacts of incineration, landfill, composting, landspreading sewage sludge and sewage discharges, underlying the possible health hazards and the related health outcomes, defining an interesting framework to consider in order to analyse the different critical issues (Fig. 2).

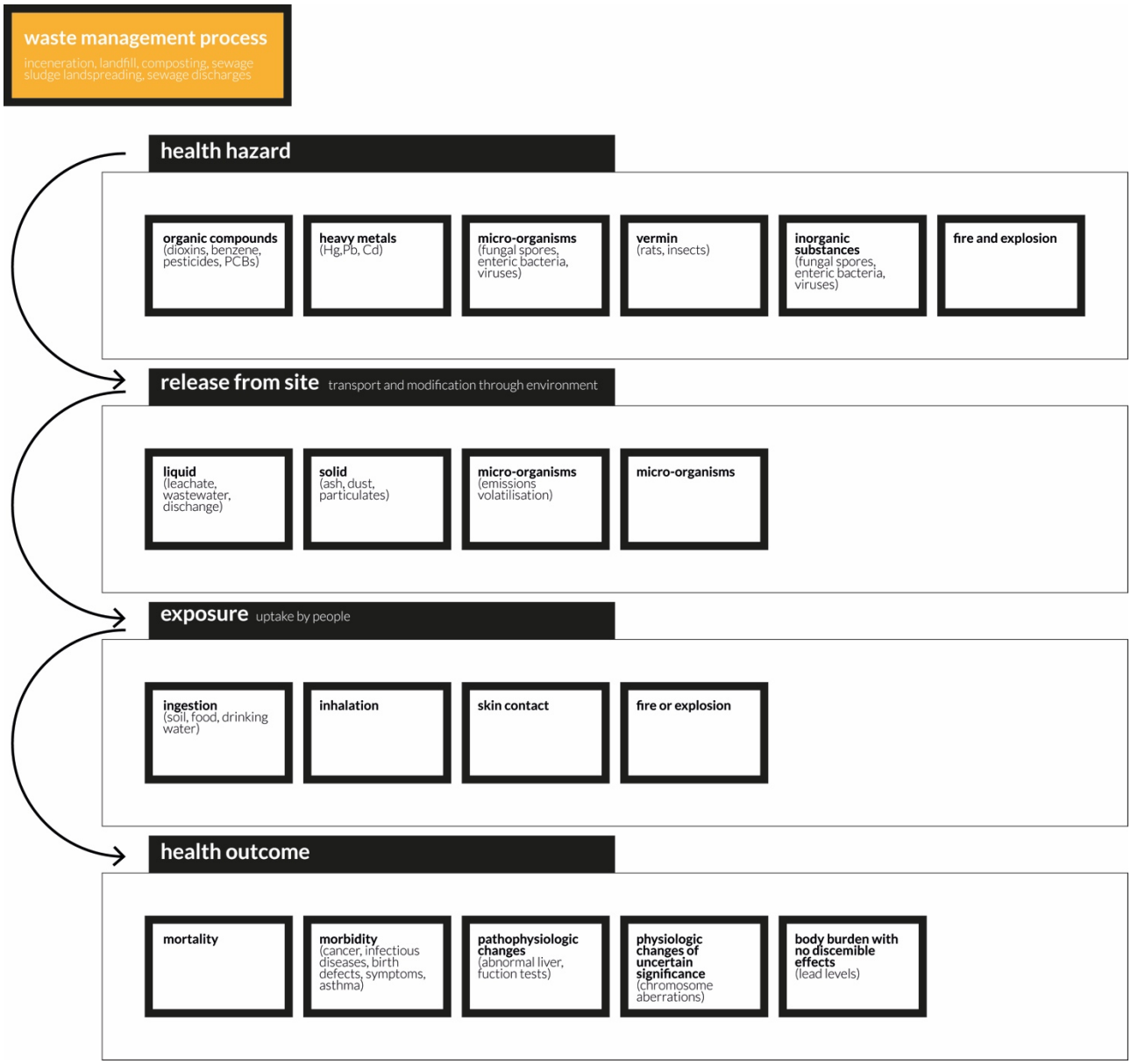

Figure 2. Pathways from health hazards to health impacts (Source: Saffron et al., 2003, author's elaboration)

In recent years the European Union has progressively increased systems of programmes and measures to promote the CE in waste management and obtain benefits for both the environment and the economy starting from the wastes issues (WHO, 2018).

The European Commission has adopted its proposal "Closing the loop – An EU action plan for the Circular Economy" (EC, 2016a; EC, 2016b), which includes legislative proposals to amend current EU waste legislation, including the Waste Framework Directive, the Landfill Directive and the Directives on packaging and packaging waste and electrical and electronic waste in order to stimulate a transition towards a CE, which can contribute to improving global competitiveness, fostering sustainable economic growth and generating new jobs.

The transition to a CE can have significant health benefits if takes account of the health implications and effects

(ESA, 2016), and according to EEA (2016) includes the potential for wider social benefits, providing opportunities to create well-being, growth and jobs, while reducing environmental pressures and combining regulation, information and research. The specific action is related to the informal waste sector in the collection, treatment and disposal, and the illegal flows of hazardous waste. The proposed actions of the CE EU Action Plan will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and provide benefits for both the environment and the economy.

In Italy, waste management has globally improved over the last decades, but the country has to face a complex legacy of pollution and critical management, due to official and unofficial processes that have not ended yet.

The waste emergency in the Campania region, which ended in 2009, has left, to the so-called "Terra dei Fuochi" region ("Land of Fires" region), a legacy marked by land to be reclaimed, a lack of recycling facilities and extensive landfills authorized and not, whose proximity to residential areas has provided irreversible damage to the health and quality of life of the inhabitants (Marfe et al., 2016). Indeed, Campania region has been affected by a long waste management crisis and has been hugely polluted with any kind of special waste from all Europe producing, year by year, serious damages on human health, environmental conditions and socio-environmental conflicts (De Rosa, 2018). For the above reasons, further efforts are necessarily able to face different kinds of crucial issues as critical governance, negative waste management, eco-mafias, lack of recycling plants, the absence of awareness in communities. In particular, the informal activities around the waste collection, sorting, treatment and disposal, as well as the illegal flows and trafficking of hazardous waste represent a critical issue and a serious challenge. In many cases, informal waste management activities provide income and support the livelihoods of families and local communities, but the price in terms of direct health impact for those involved is very high. So, while many grassroots movements were fighting a 'waste war' for their health rights, as many worldwide movements for environmental justice, another part of the same population was involved in illegal waste disposals in Campania lands through infiltration in municipal councils (De Rosa, 2018; D'Alisa et al., 2012). Indeed, effective waste regulations and close monitoring of the territory can reduce illegal waste disposal phenomenon (D'Amato et al., 2018). Implementation and enforcement of national and international legislation and conventions, but also of the local governance process, is key to tackling this relevant phenomenon (WHO, 2015). Health inequality and environmental justice are two crucial issues related to informal waste management, that need suitable data and information on the problem and decisive policy action of remediation to face and solve the extreme exposures and inequities conditions of local communities.

In this context, the Horizon2020 project "REPAiR, REsource Management in Peri-urban AReas. Going beyond Urban Metabolism" (http://h2020repair.eu/), consisting of a consortium of universities, public and private bodies, that involves 18 partners from six countries (Italy, Netherlands, Germany, Belgium, Hungary and Poland), investigates the flows of material looking for those dysfunctions of urban metabolism that determine landscapes of waste, so-called "wastescapes", in order to identify suitable and feasible eco-innovative solutions. The Italian partner is the Department of Architecture (DiARC) of University of Naples "Federico II" in cooperation with the Campania Regional Authority (CRA), and explores simultaneously wastescape and waste flows, by the support of a Decision Support System hybrid methodology, able to combine soft and hard approaches and tools.

REPAiR framework puts in relationships different approaches creating enabling contexts (Choo and Alvarenga Neto, 2010) and, in this way, aims to operationalize CE improving waste management and wastescapes remediation. Co-creation is an integrate and iterative process (Mauser at al., 2013) and the framework that links researchers, actors, stakeholders and decision-makers to identify site-specific eco-innovative solutions. This process objective is enhancing collaboration and cooperation, that are considered the most effective tools to build back better integrating disaster risk reduction measures (UNISDR, 2015).

Aim of this paper is describing the decision-making process elaborated in the REPAiR project, where the waste management is a central issue, introducing the Italian case-study and describing the decision-making process implemented in the so-called "Terra dei Fuochi" region, an example of "wastescape" where the waste management is a crucial point.

Section 2 introduces materials and methods, describing the methodological approach of the REPAiR project; Section 3 presents the Italian case study, and Section 4 discusses some results about the methodological process and conclusion.

2. MATERIALS AND METHODS

2.1 WASTESCAPES AND HEALTH RISK

According to the principles of CE, wastescape can be considered an innovative resource for the regeneration of territories in crisis, and allow a change of paradigm able to determine multiple and different environmental, economic, social and cultural implications.

During the last decades' cities' sprawl produced peri-urban areas, that are a common condition of most of contemporary urban settlements. REPAiR project focuses on remediation and regeneration of territories in peri-urban areas of the case-study cities. Peri-urban areas are hybrids territories in between, highly

fragmented, where rural and urban patterns alternate and clear boundaries are not easily identifiable (Russo et al., 2017).

American urban literature has recognized these fragments of the indeterminate landscape as *drosscape*, grey areas, brown fields, fragments of abandoned sites after deindustrialization phenomena, neglected areas (Berger, 2006).

According to Berger analysis, drosscape are not voids in between, but an integral essence of the landscape. Drosscapes are not a natural context, like third landscape (Clément, 2005) but a *dark side of men's cultural landscape* (Shannon, 2006). This concept involves the inner potential to turn them into cultural landscapes. Part of drosscapes are the wasted lands, scarred and polluted lands and sites.

Considering drosscape areas related to waste flows, and the waste lands a waste product themselves, the operational landscape of waste (Brenner, 2014) have to be observed in the REPAiR project. Operational landscapes can be mines and infrastructures, and all those functional sites whose work sustains urban life. They generally are not perceived as part of the city because of the lack of relations with the urban settlements, but incinerators, landfills, big waste treatment and waste disposal plants, waste-recycling plants, waste-water processing plants are often located in peri-urban areas, and their position is in the centre of public debate of urban planning.

In this framework, in the Spatial Analysis Glossary of the REPAiR Deliverable 5.1 PULLS Handbook, a specific definition of wastescape has been elaborated, considering as patches of landscape related to waste-cycles by functional relations and identified as "wasted-lands" (Russo et al., 2017). Indeed, REPAiR project defines six categories of wastescapes that are considered as innovative resources to be reintegrated in the metabolic dynamics to improve the quality of the investigated peri-urban areas. These six categories are grouped into five Drosscapes and one Operational Infrastructure of Waste (Fig. 3):

1. Degraded lands (W1). This category considers lands that have lost some degree of their natural productivity due to human-caused processes and includes: polluted (W1.1), bare (W1.2) and artificial soils (W1.3).
2. Degraded water and connected areas (W2). This category includes both properly degraded water bodies; elements functionally related to them; and territories in crisis for hydraulic reasons. The following subcategories are distinguished in W2.1 with water bodies, degraded for quantitative or qualitative reasons (i.e.: polluted, draining up, overflowing, etc.) as: rivers, canals, basins, streams, ditches, water pipes, culverts, wells, etc.; W2.2 with banks, shores, tanks, plants, and other elements linked to W2.1; W2.3 with flooding zones.

3. Declining fields (W3). This category addresses vacant or under-used fields, vacant parcels, and vulnerable soils. The subcategories are Abandoned fields and parcels (W3.1), and Vulnerable lands (W3.2).
4. Settlements and buildings in crisis (W4). The subcategories are Vacant/underused, neglected or obsolescent buildings and settlements (W4.1), and Unauthorized, confiscated, buildings and informal settlements (W4.2).
5. "Dross" of facilities and infrastructures (W5). This category includes: dismissed or underused Infrastructures (W5.1) and Facilities (W5.2) as well as - both active and dismissed - areas connected to them (W5.3).
6. Operational Infrastructure of Waste is the facilities dedicated to waste storage and management. They are not spread in the peri-urban areas.

REPAiR project, through a hybrid decision-making process, aims to recover wastescapes and operationalize CE to improve urban metabolism of these areas. Compared to a general drosscape as a brown field, a wastescape has a stronger impact on the economic, social and ecological health of the territory around it. Waste flow analysis and management are core issues in the REPAiR research as they determine wastescape generation, and improve urban metabolism, operationalizing CE is the goal to reach through the project eco-solutions.

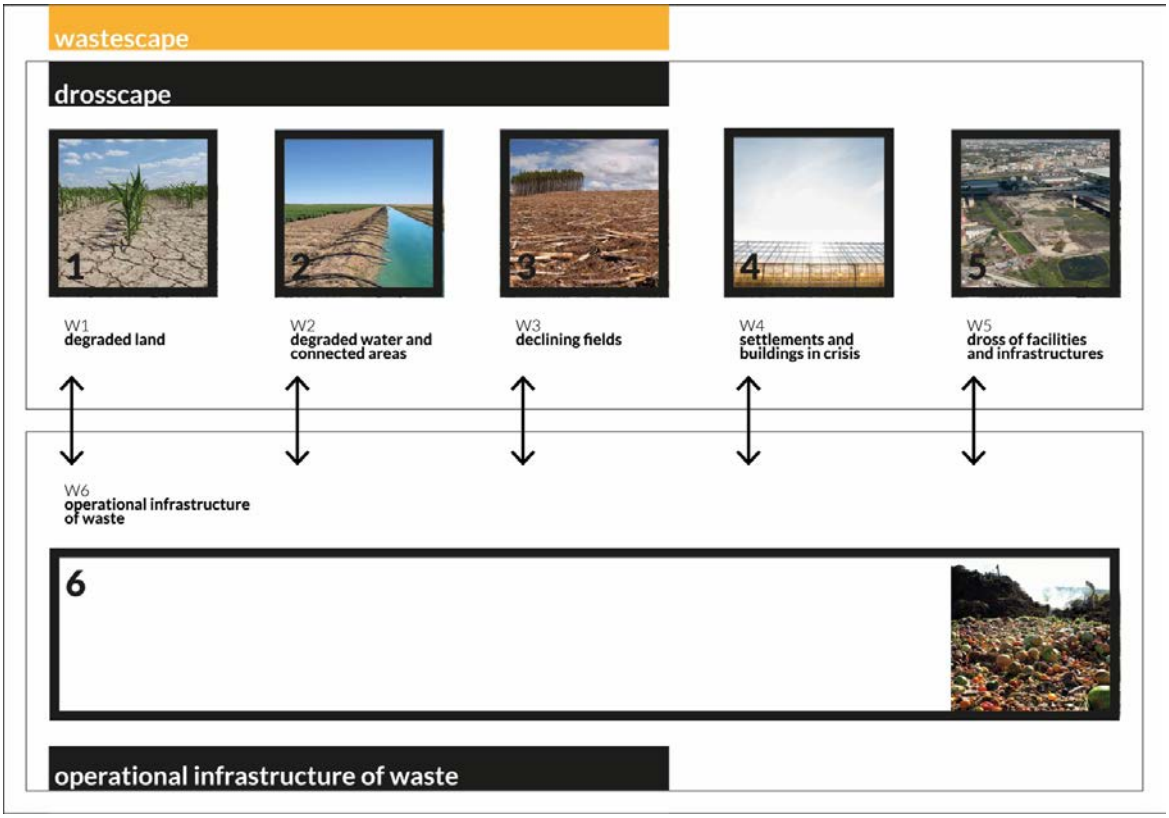

Figure 3. Examples of wastescapes.

The last report from Italian Waste Cadastre of Superior Institute for the Environmental Protection and Research (ISPRA) estimates that in 2016 in Campania region the production of special waste is about 7,1 millions of tonnes, 5,3% of national production, whose 94% (almost 6,7 millions of tonnes) is composed of non-hazardous waste.

The main types of waste produced are waste from construction and demolition operations (41.1% of total regional production) and waste from waste and wastewater treatment (38.5%) (ISPRA, 2018). Some studies (WHO, 2015) have provided evidence of an association between residence near legal landfills and different health risks. In most of the available studies, the distance from the landfill is used as a proxy of exposure. It has been noted that this measure may reflect and integrate different routes of exposure, as contamination of air, soil and groundwater in the vicinity of the plant. Recent work carried out in Italy as part of the ERAS project has proposed the combined use of the geographical distance and the estimated concentrations through a model chain (LandGEM Model as per US EPA, 2005) and Lagrangian model dispersion. The concentrations of hydrogen sulphide (H2S) emitted from waste is used as an indicator of the air contamination, while distance can be used as an indicator of pollution of water and soil matrices, under the assumption that the contamination occurs mainly in the area adjacent to the landfill. The possible health effects related to residential proximity to landfills have been studied in several papers underline that they mainly concern cancer (e.g., pancreas, larynx, liver, kidney), non-Hodgkin lymphoma and respiratory diseases (Porta et al., 2009; Mattiello et al., 2013; Jarup et al., 2002; Aatamila et al., 2011; Heaney et al., 2011; De Feo et al., 2013; Mataloni et al., 2016) (Fig. 4).

Several other studies addressed birth outcomes: negative effects were observed for toxic waste, with significant elevated risks found for all congenital malformations, neural tube defects, abdominal wall defects, surgical correction of gastroschisis and exomphalos, and low and very low birth weight for births to people living within 2 km of the sites, both of hazardous and non-hazardous waste (Elliott et al., 2009).

The different studies and researches underline that waste production, management and disposal involve a variety of complex activities, with a great potential to affect health directly and indirectly, through many pathways and mechanisms, only partly understood (WHO, 2015). As already highlighted the health effects include an increased risk of cancer and mortality, respiratory disease, congenital malformation and low birth weight, and affecting also well-being and quality of life-related to neurological disorders and annoyance due to odour. As part of peri-urban areas, wastescape remediation results relevant for economic, social and environmental regeneration. Indeed, a preliminary selection of transdisciplinary impact categories were made to assess wastescapes according to the three pillars of sustainability: society, environment and economy. In

particular, the social pillar includes human health and human well-being, and especially for human health, the selected indicators are related to human toxicity, environmental health, particulate matter formation and occupational health.

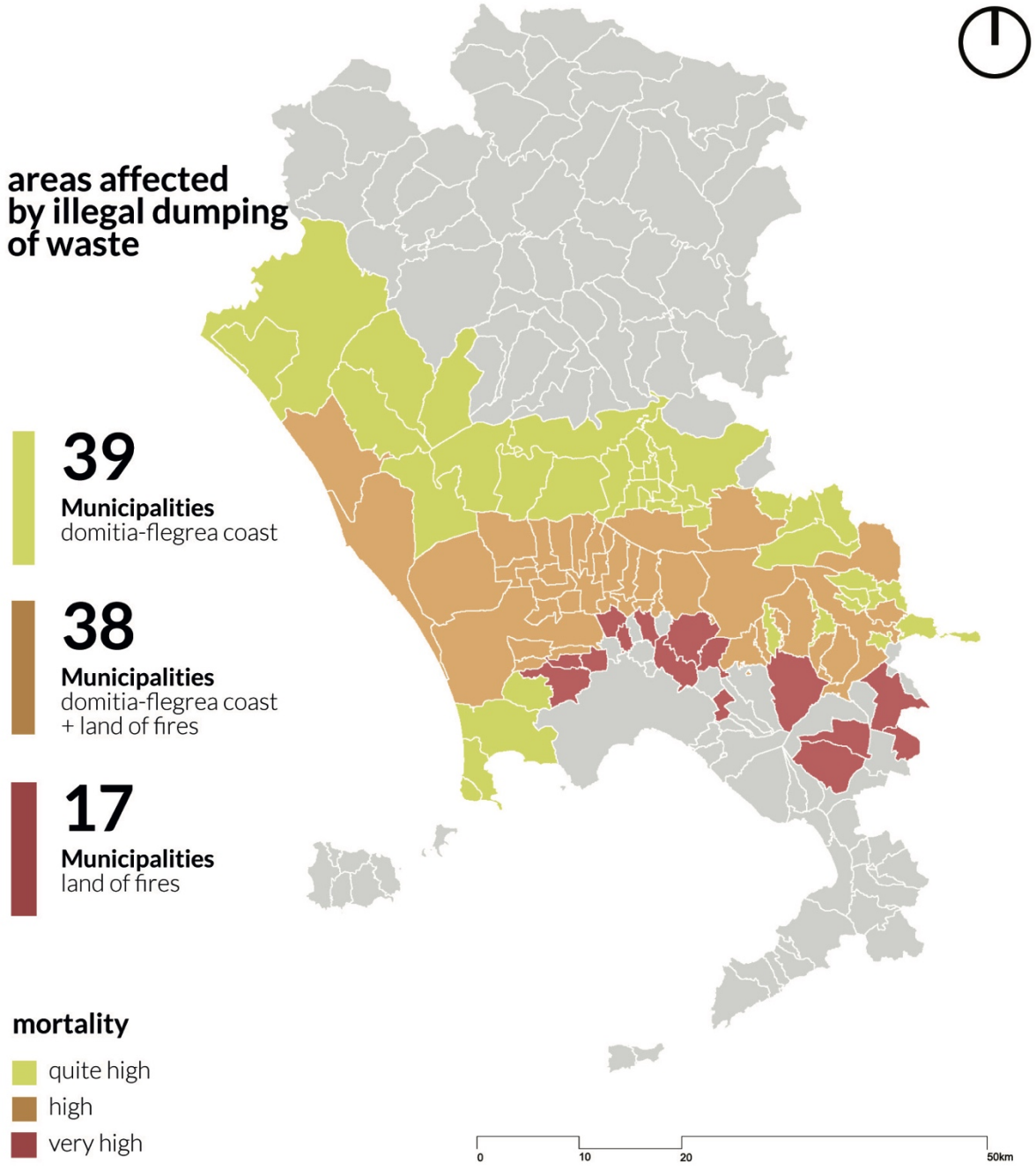

Figure 4. Areas affected by illegal dumping of waste and level of mortality (adapted from ISS)

2.2 THE REPAiR PROJECT

The REPAiR project, exploring approaches and synergistic techniques to tackle and manage change

and transition, focuses on the characteristics of waste landscapes and on potential opportunities for transformation and regeneration, also considering waste, in particular organic waste and construction and demolition waste, as an instrument for activate new models of sustainable use of territorial resources, based on the principles of CE.

Waste is understood as a potential resource, taking a positive meaning from the point of view of circularity and recycling by eco-innovative and place-based development strategies.

Starting from the European policies and regulations on waste management (2008/98/CE, 2018/851/CE), and taking into account the recent ISPRA (ISPRA, 2018) reports on urban waste and special waste, it is possible to identify the specifics of wastescapes, also in relation to the flows of materials, energy and type of waste, and define if, when and where they can become a productive resource for Urban Metabolism (UM).

The REPAiR's approach is oriented to develop strategies that strengthen CE and make it operative and builds on the collaboration of different expert teams from industrial ecology, economy, spatial planning, environmental policies, involving stakeholders from six selected regions. This approach calls for a methodology facilitating regular inter-team interaction in a real-world environment. In this way an interdisciplinary team of expert, local actors and decision-makers are working together informing policies for wastescape regeneration and improvement of Urban Metabolism. To do that, REPAiR team is implementing an open-source GIS platform, where decision-makers can test and evaluate different alternatives of Eco-innovative solutions. Accordingly, the REPAiR team elaborated a methodological process oriented to:

1. understand the decision needs of key actors in the study areas;
2. specify the concept of Urban Metabolism to describe the crucial processes in the study area;
3. generate manifold ideas for possible changes and engage future users, local stakeholders as well as thematic experts in strategy development;
4. develop a framework of indicators to assess these ideas against the current situation, according to SDGs framework;
5. develop data management structures and user interfaces for the Geodesign Decision Support Environment (GDSE) to enable decision makers to assess their decision alternatives quickly.

As mentioned, the key challenge for REPAiR project is to integrate models and methods according to an interdisciplinary approach, both on a software and process level in order to regenerate wasted lands in peri-urban areas.

The decision-making process is structured by interactive parts of the three main frameworks where

the main steps are developed in each framework context as in the following scheme (Fig. 5): A. wastescape/waste cycle selection; B. integrated spatial analysis, material flow analysis and social analysis; C. end-of-life scenarios; D. eco-innovative implementation; E. local/global impact assessment; F. suitable scenario selection.

The integrated models and methods aim to apply three different approaches (Fig. 5):

- GeoDesign Decision Support Environment (GDSE) (Steinitz, 2012) is the central approach, and the platform where hard and soft data converge and interplay, and useful to develop and assess alternative strategies in the field of material and waste management (Arciniegas and Janssen, 2012; Arciniegas et al., 2013; Arciniegas et al., 2016; Campagna, 2014);
- Life Cycle Assessment (LCA), with specific attention to Life Cycle Impact Assessment (LCIA), is the approach used to assess the different impacts (Guineé et al., 2002; Rebitzer et al. 2004; Taelman et al., 2018);
- Peri-Urban Living Lab (PULL) (Eriksson et al., 2005; Feurstein et al., 2008; De Bonis et al., 2014; ENoLL, 2016) is the approach used to interact with the real-life context, where knowledge is shared and where co-design process becomes effective using GDSE platform.

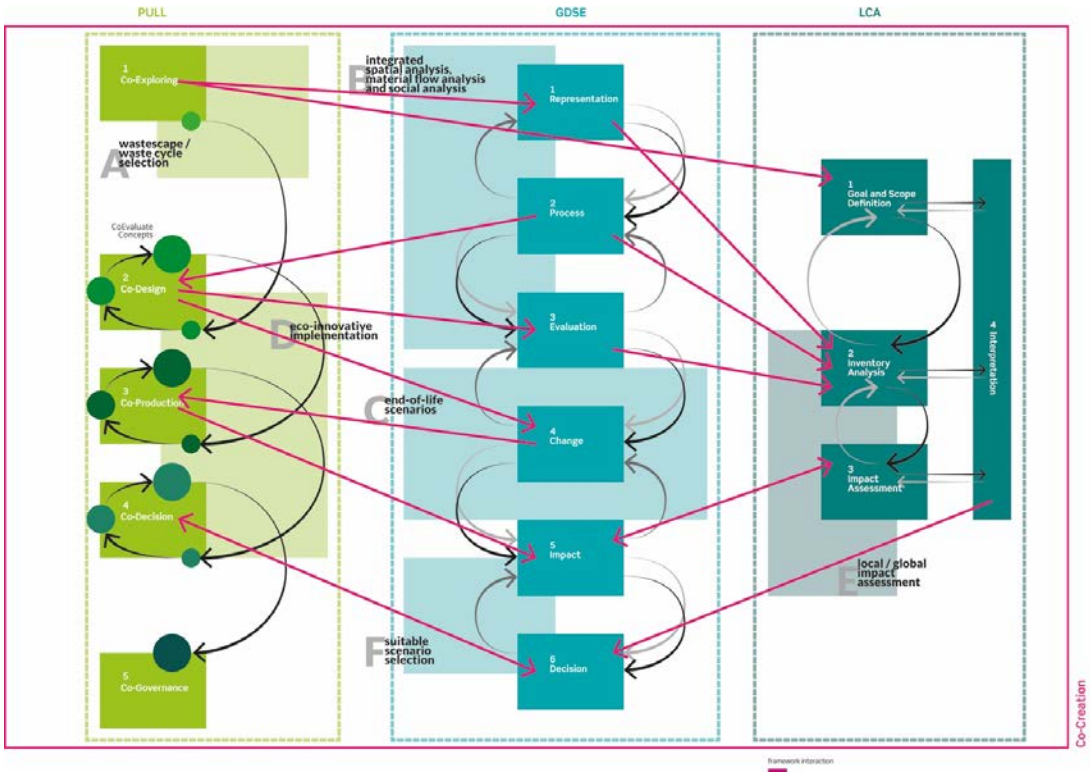

Figure 5. The REPAiR methodological approach (Source: REPAiR D3.3, 2018)

The methodological approach aims at making operational the concept of Urban Metabolism according to the CE principles, deepening the dynamics between energy flows, waste, information and people and

identifying ecological and innovative solutions deriving from a win-win-win approach, considering the environmental, social and economic impacts of the transformations and the benefits deriving from the intrinsic relationships inherent in metabolic systems. REPAiR project identifies the following objectives:

1. To provide decision-makers with comparative assessments of different integrated spatial resource management strategies;
2. To develop an understanding of resource management systems by analysing the relations between waste flows, environmental and spatial quality, allocation and governance in peri-urban areas;
3. To interpret the link between metabolic flows and urban processes;
4. To implement Living Lab approach in peri-urban areas, the so-called Peri-Urban Living Lab (PULL) in order to develop, test, implement and assess place-specific Eco-Innovative Solutions for waste management;
5. To understand decision-making frameworks and processes in the case study areas with regard to interests and priorities of different stakeholders to add transparency to the decision-making process.

These general objectives, common for all the European partners of REPAiR project, face very different scenarios of waste management and wastescapes regeneration, where they are being applied, identifying Eco-Innovative Solutions, conceived as elementary and site-specific responses to problems, based on the environmental principles of Reduce-Reuse-Recycle-Recover. They have been classified according to the PESTEL framework following the dimensions that they can take, as: Political/organisational (P), Economic (E), Social (S), Technical (T), Environmental (E) and Legal (L) (D5.3, REPAiR, 2018). The complexity of waste management issues and wastescape regeneration find the opportunity, in the Peri-Urban Living Labs phase of interaction (D5.1,REPAiR, 2017), and through Eco-Innovative Solution shaping, of sharing knowledge and creating mutual trust between the actors involved. This is the core of the methodological process: to create the conditions to activate an enabling context to implement the Eco-Innovative Solutions, defined according to the term "eco-innovation", as defined by the European Commission, that refers to forms of innovation, technological and non-technological, aimed at fostering development opportunities and safeguarding the environment, optimizing the use of resources (EC, 2012) and therefore referred to both product and process actions.

3. THE CASE STUDY

3.1 WASTESCAPES EMERGENCY IN CAMPANIA: THE "TERRA DEI FUOCHI" SITE

Metropolitan Area of Naples (MAN), in particular "Terra dei Fuochi" area, in Campania Region, Italy, is

one of the REPAiR project pilot cases, a clear example of wastescapes context, studied through the proposed above described methodology, that provides for the interdisciplinary interaction between the Geodesign, the Living Lab and the Life Cycle Assessment approaches.

MAN is a highly dense area (around 3.0 million inhabitants), its peri-urban areas have natural and built environments highly degraded, and many problems are due to the significant influence of criminal organisations.

At the same time, the Campania Region potentially has 2551 contaminated sites. These are landfills and areas of uncontrolled waste deposit. 15.8% of the entire region is polluted, a total of 2,157 km2 (ARPAC, 2008). The main challenges related to waste management in MAN focus area aims to improve waste governance and people behaviour, and, thus, avoid illegal dumping, that create the most of the health and security risks. Setting up a suitable environment for knowledge creation can improve health risk management in the "Terra dei Fuochi", and support the co-creation of situated Eco-Innovative Solutions.

The REPAiR Italian Focus area is composed of 11 selected municipalities (Acerra, Afragola, Caivano, Cardito, Casoria, Casalnuovo di Napoli, Cercola, Crispano, Frattamaggiore, Napoli, Volla), all composing the "Terra dei Fuochi": an area that has been affected by waste emergency since 2009 and whose legacy is its biggest problem to address (Senior and Mazza, 2004) (Fig. 6).

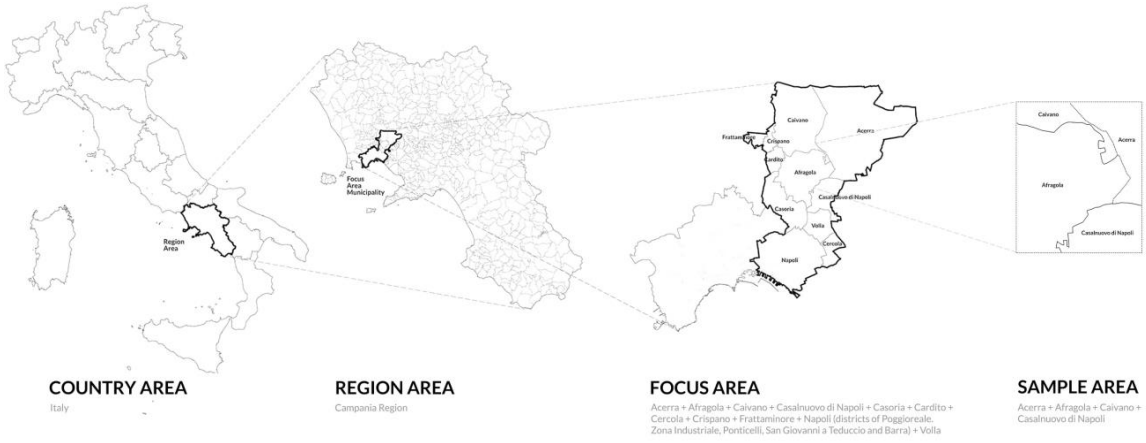

Figure 6. The REPAiR Italian Case Study: Naples Focus Area (Source: REPAiR D3.3, 2018)

The main problem of “Terra dei Fuochi” pollution is due to illegal dumps of last decades, that have gradually filled lands, quarries, infrastructures. Criminal organisations, acting in a silent context, have tombed any kind of a special waste. Indeed, special waste constitutes the most important part of the produced waste, that is a very relevant cost for companies. At the same time, eco-mafias have been acting along decades all over

South of Italy in Campania, Sicily, Basilicata and Puglia, with the silent accord of stakeholders and a part of governance.

Waste emergency in Campania cannot be analysed without considering the huge dumping of illegal hazardous waste, coming from the North of Italy and Europe plants. But waste emergency in Campania has been produced not only for the eco-mafia role but also for the inefficiency of public governance too.

In 1994, when landfills were full, it has been declared the emergency state. Eventually, a series of short-term top-down measures tried to stem the emergency but did not solve the problem and illegal dumps or toxic open-air burnings. In addition to this crisis, the solution promised with the realization of an incinerator gave rise to a big struggle aimed at blocking its construction. Strong disagreements were about the global consequences of the presence of incinerators on human health; over the kind of emissions generated by plants; and about the technology, of the older or newer generation, used for the plants.

Moreover, the choice of the dump sites, in already socio-economically difficult areas close to Naples, further alienated local populations (Cantoni, 2016).

On May 2008, the decree no. 90 of the Italian Government declared protests in the vicinity of landfills, incinerators or any plant related to waste management as a penal felony. It is possible to say that the waste crisis has been a crisis of democracy (D'Alisa et al., 2010). Media attention to this crisis grew up after demonstration acts of 2004, due to the increase of infant mortality rate and cases of cancer.

In Italy, there are more than 50 national interest sites (NIS) that need remediation, areas where environmental pollution is highly relevant for typology with risks to health. The relationship between environmental pollution and people health in the 44 Italian NIS has been monitored by SENTIERI Project (Mortality study of residents in Italian polluted sites - IPSs, Vv.Aa, 2014) that studies mortality of residents in the sites of national interest for environmental remediation. IPSs are mostly located near industrial areas, both active and dismissed, near incinerators or dumping sites of industrial or hazardous waste. Italy is one of the few European countries with a permanent monitoring programme on epidemiological surveillance of resident populations in polluted sites. In SENTIERI project there is particular attention to illegal waste dumps, providing indications to deep with specific studies.

Italian Superior Health Institute (ISS) ended the upgrade of the health situation of resident people in Terra dei Fuochi area. The research, entrusted by Italian Parliament with Law n°6 of 6th February 2014, to ISS in cooperation with Italian Association of Cancer Registers (Associazione Italiana dei Registri Tumori - AIRTUM) detected that for malignant tumour of stomach, liver, lung, bladder and breast there is an excessive risk-taking for males and females for the used indicators of incidence, mortality and hospital stays in MAN.

The environmental situation in Terra dei fuochi is complex and it is not easy to identify certain causes because of different and not constant sources of contamination, like illegal open-air waste burnings. Anyway, there is the evidence of high mortality for neoplastic diseases and a high prevalence of congenital malformations at birth. Pathologies related to this phenomena are characterized by multifactorial aetiology, and on the base of international literature, it is possible to include the exposition to hazardous and not hazardous waste emissions.

3.2 ECO-INNOVATIVE SOLUTIONS: KNOWLEDGE MANAGEMENT AND CO-CREATION

In REPAiR project, the notion of enabling context is introduced to rationalise the links between spatial analysis and Eco-Innovation Solutions (Geldermans et al., 2018).

According to Sendai Framework for Disaster Risk Reduction 2015-2030, the decision-making process has to be inclusive and risk-informed while using a multi-hazard approach. The social aspect of waste management issue is addressed through co-design phase in the REPAiR project. Eco-Innovative Solutions will outcome from PULLs, where consulting and interactive design process interplays on GDSE platform.

The methodology of eco-solutions design follows five phases: Co-Exploring, Co-Design, Co-Production, Co-Decision, Co-Governance. Stakeholders and actors participating in the decision-making process on environmental issues will be effective in GDSE platform, where the results will arise from Life Cycle Assessment and Material Flow Analysis data linked to GeoDesign process to express actors preferences and, thus, immediately evaluating the best Eco-Innovative Solutions among the expressed preferences.

Co-design process, the second phase of Peri-Urban Living Labs, aims not only at producing Eco-Innovative Solutions to test and evaluate, but it is a tool to transfer knowledge about CE principles, urban metabolism, wastescapes, waste management and urban planning.

Design with actors and stakeholders is the best way to create an enabling context in order to improve knowledge and awareness and operationalize Eco-Innovative Solutions. Considering the result of the Actor-Network Analysis to manage PULLs, we can define 4 main activities that the stakeholders carry out during the process of networking, recalling the work: problematisation, interment, enrolment and mobilisation. People and associations mobilized along time to defend health right are asked to co-create Eco-Innovative Solutions according to available data developed by research groups. In the first phases of problematization and interment, knowledge sharing has been the challenge to run. Eco-innovation can produce DRR as it works for global challenges for sustainability with elementary site-specific actions (REPAiR, D.5.3, 2018). Knowledge management researches highline how the creation of enabling conditions and, eventually, enabling contexts

has the most relevant effects in knowledge transmission and sharing (Choo and Alvarenga Neto, 2010). Enabling conditions to create enabling contexts for knowledge management contribute to the creation of Eco-Innovative Solutions to regenerate wastescapes and define actions to activate circular processes. The four main sets of enabling conditions are:

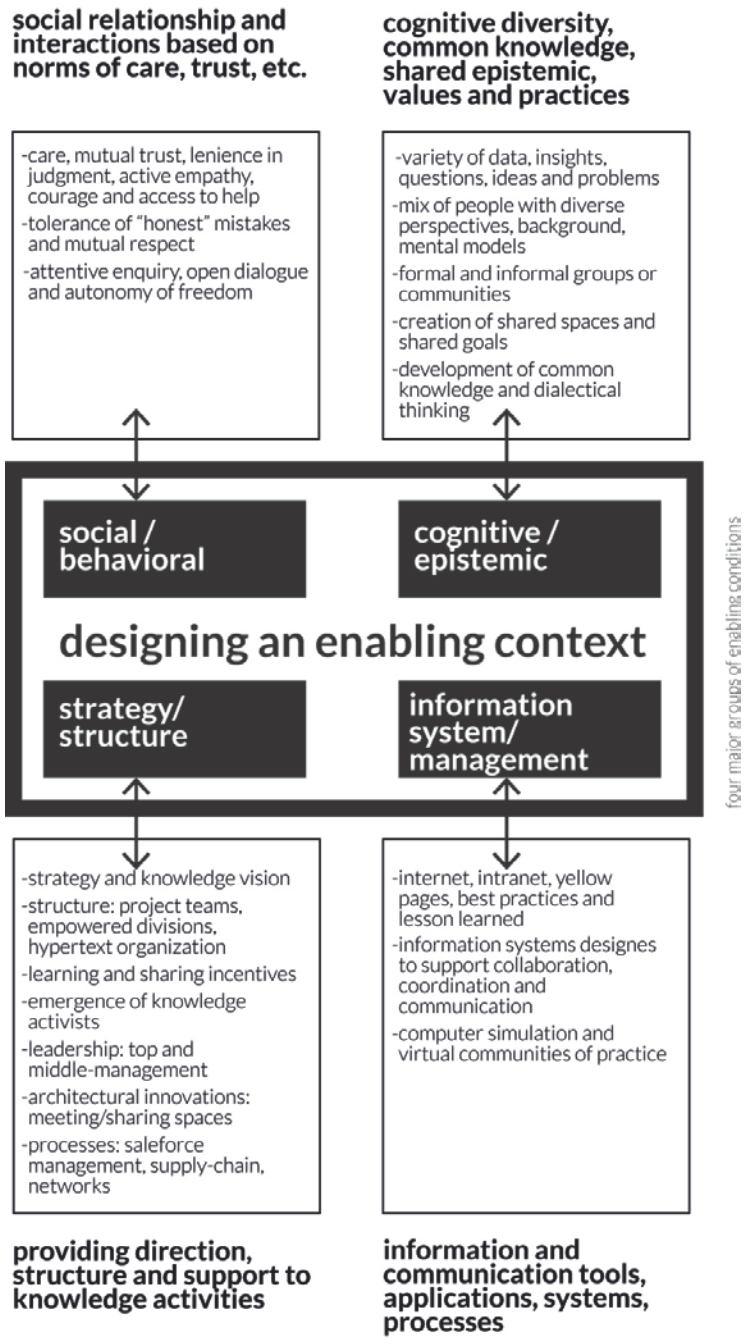

Figure 7. The enabling conditions (Source: Geldermans et al., 2018)

1. Social/Behavioral, based on interactions, that includes care, mutual trust, leniency in judgment, active empathy, courage and access to help, tolerance and mutual respect, attentive enquiry, open dialogue and

autonomy of freedom;

2. Cognitive/Epistemic, based on cognitive diversity and common knowledge, includes a variety of data, questions, ideas and problems, a mix of people with different points of view, groups, the creation of shared spaces and goals, development of common knowledge and dialectical thinking;
3. Strategy/Structure, based on providing structures for knowledge activities, composed of strategy and knowledge vision, structure, learning, leadership, architectural innovations, processes;
4. Information Systems/ Management, made by tools and systems, with the internet, best practices and lessons learned, information systems designed to support collaboration, coordination and communication, computer simulation and virtual communities of practice.

Combining enabling conditions with knowledge process types of creation, sharing and use, and with four interaction levels, individual, group, organizational and inter-organizational, we can have a complete framework for designing an enabling context in knowledge management.

The interactive moments of researchers with local actors during the Peri-Urban Living Labs processes have been complex and unpredictable due to the different points of view of actors involved. The main evidence of wastescape is quite the total absence of care of the spaces.

Relationships between people and their landscape occur at widely varying scales. Humans engage with environmental phenomena at a particular scale of landscape surroundings. That is the human "perceptible realm" (Gobster et al., 2007). Interactions within this "realm" give rise to aesthetic experiences, which can lead to changes affecting humans and the landscape, and thus the related ecosystems.

During PULLs, emerged that local actors main unease is mostly due to the inefficiency of degraded infrastructures, lack of connection in the territory and the awareness of vast illegal dumping. The first analysis focused on general issues related to the three waste flows on which the REPAiR project focuses (Organic Waste, Construction and Demolition Waste, and Wastescapes). The main objectives identified want: reversing citizens' distrust in institutions, prevent organized crime implication in waste management, react to the European sanction about the lack of composting plants; preventing the organic waste emergency also through community composting; disposing eco balls; face the issue of abandonment and illegal deposit of waste along the streets; overcoming governance immobilism caused by transition on the management of waste; address the Nimby effect concerning the localization of a composting plant in an urban area; overcoming suspicion on the use of recycled products as compost and CDW; spread knowledge and awareness about environmental issues; shared planning processes, planning measures that allow CE processes to be implemented and become common practices (REPAiR, D.6.3. Arlati et al., 2017).

The Eco-Innovative Solutions (EIS), identified and processed in a co-creation and co-production framework, with stakeholders, communities and local administrations, within Peri-Urban Living Lab activated on the territory, are the result of a recursive process of site-specific strategies, discretized into elementary actions. The context in which the strategies are developed is the periurban territory of the Sample Area: hybrid space, a place of transition between city and countryside, with unstable and fragmented borders that configures new possibilities for adaptive, processual, open planning, redefining new territorial geographies. Through process innovation, which sees the introduction of the short-supply chain as the trigger for combining technological and environmental aspects, we work on two parallel spatial models: "green-infrastructures" and "new soil". Green infrastructures provide eco-systemic services, contribute to CO_2 reduction and increase biodiversity; grey-green infrastructures, as the ultimate product of the process, become a place for waste collection and treatment: in particular, wastescapes, abandoned public areas, areas of priority interest for stakeholders and accessibility conditions, which together have defined enabling context, or areas of transformation of priority importance, in which it is possible to activate the processes of regeneration. The new soils, made following the recycling of inert materials (CDW) and the subsequent naturalization of the soil, through a soil improver produced on site (OW), become an innovative public space, a new porous edge, "of cushion" between the urbanized and rural space. Intervening on open and flexible boundaries, capable of triggering recursive and collaborative processes, leads to the definition of unexpected waste landscapes, comparable to land-art works, synthetic places between artifice and nature.

In such complex scenario, co-creation methodology seeks to let all involved actors be active part in shaping eco-solutions and thus waste management policies, whose creation process evolves from Co-Exploring, through Co-Design, Co-Production, Co-Decision to Co-Governance.

4. DISCUSSION AND CONCLUSIONS

A part of the population living in "Terra dei Fuochi" is exposed to pollution because of waste management inefficiency, due to the vicinity of landfills sites and to the spread illegal hazardous waste dump. Struggle for the health right and social equality take place every time is announced construction of new plants, because of the evidence of the dangerous effects of living near waste treatment plants (Membretti, 2016). NIMBY (not in my backyard) effect can be understood because of the lack of efficiency in waste management policies in these areas. At the same time, a part of the local population is not still consistent with respect to environment care, as shown by many wastescape in Naples peri-urban area, any kind of bulky waste and thrash bags abandoned along roads and common illegal phenomena of open-air waste burning. These actions

produce health risk for the same population of affected municipalities and join illegal bigger dangerous actions, as the recent huge burnings of the separate waste disposal plant of San Vitaliano and of the storage and disposal facility in Pescarola (near Caivano Municipality, Naples) in the area site of waste, both probably arsons occurred in July 2018. The REPAiR project is working on existing dysfunctions of UM, both in improving official waste management and providing peri-urban areas with facilities the lack of which causes many small illegal actions. This sharing work works on getting through mistrust in public governance too. Data of risks due to a residence near landfills, however, are less reliable than those for incinerators, due to the lack of accurate information. Further to these knowledge gaps, the available evidence is becoming less relevant for some countries of the WHO European Region, as the waste industry evolves. Health impacts of different types of waste management have been documented in several instances, mainly in relatively controlled situations where old generation facilities, especially landfills and incinerators, were in operation. Modern technology has greatly reduced noxious emissions and measurable health impacts have in many cases become smaller. All in all, analyses carried out over time, ideally on population cohorts, would be the best option in order to clarify these temporal trends. Old generation facilities are still in operation in many countries, however, and health impacts comparable with those described in the literature are likely to occur; in addition, the nature of the waste flows is changing, for example with e-waste, often informally treated with consequent exposures to hazardous substances. This is but one of the deep differences between countries of the WHO European Region in terms of waste management. In some cases, informal activities of waste collection, treatment and disposal, despite the patchy anecdotal evidence, are known to entail very high exposures to noxious agents, for example through open-air waste burning. More systematic data are needed to understand the extent of these practices in Europe and evaluate the likely health impacts, however, these extreme exposures, typically suffered by disadvantaged groups, must be urgently prevented. Following the adoption of the Sustainable Development Goals (SDGs), growing attention is being paid to sustainability in many domains, including waste. Sustainability introduces further elements of complexity, but it can also be regarded as a guiding principle that can help make policy progress even in the absence of conclusive evidence on specific health effects. Generally speaking, SDGs provide additional support to the EU waste hierarchy, and they can also be of help at the practical level, for example when local authorities are faced with decisions on waste management policies. CE is also an increasingly prominent pursuit, fully aligned with SDGs. By reducing, or ideally eliminating the waste production, by using unwanted outputs from certain production cycles as input for others, the CE has indeed the potential to contribute greatly to long term-sustainability, as well as profitability. Health considerations should be central to the debate, however, given the possibility that adverse effects are inadvertently

introduced, for example by "recycling" toxic substances, compounds or materials, thereby introducing a process of toxification of certain waste streams. Also, experiences in some Member States shows that a profitable industry can be run on waste collection and treatment, provided considerable investments are made. The health effects of waste management and disposal activities are partially understood, and updated evidence would be needed for better informing the policy debate, especially in consideration of the fast-evolving technology. Estimating the effects of exposures deriving from old generation facilities would be important, so as to estimate the extent of local health impacts. Similarly, much better and more complete data are needed on informal waste management activities and illegal operations, given the likely substantial magnitude of the health burden suffered by the people involved. Data on hospital admissions, including for emergencies and acute cases, should be considered as a potential source of valuable information in this respect. In general, methods and resources for cost-efficient health surveillance should be developed, as this might help remediate and prevent further instances of such situations.

The methodological approach of REPAiR project aims at making operational the concept of UM according to the CE principles, deepening the dynamics between energy flows, waste, wastescape, information and people and identifying ecological and innovative solutions deriving from a win-win-win approach, considering the environmental, social and economic impacts of the transformations and the benefits deriving from the intrinsic relationships inherent in metabolic systems, thus address health risk exposure too. The value of the interaction informs the whole methodological process in its hybrid structure, gathering researchers, public administrators, local actors and stakeholders, working together to shape Eco-Innovative Solutions for waste management improving and wastescape regeneration, and to share knowledge and awareness, all necessary conditions to activate an enabling context. Setting up a suitable environment for knowledge creation can contribute to improve health risk management in the Terra dei Fuochi, and support the co-creation of situated Eco-Innovative Solutions, where innovation is related both to the process and the result.

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