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ENSURE E-LERNING TOOL

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Does reducing vulnerability always lead to enhance resilience?

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See References in ENSURE Deliverable 2.2

1 Does reducing vulnerability always lead to enhance resilience?

The resilience concept, although investigated since 1970s, has gained prominence in the disaster field after the Hurricane Katrina occurred in August 2005, when a lack of resilience was largely complained. Nevertheless, the term is mentioned in many of international reports devoted to risk reduction and sustainability initiatives published in the last 15 years.

- knowledge, innovation and education represent a need for building a culture of safety and resilience at all level;
- the development and strengthening of institutions, mechanisms and capacities is a strategic goal for building resilience to hazard.

the influences that it received from the Complexity and Sustainability theories.

This paragraph raises a key question for the Ensure Project: is it possible to state that reducing vulnerability always leads to increase the resilience of communities and territories?

To answer such a question, in the following paragraphs some case studies will be provided in order to highlight that:

- mitigation measures addressed to reduce one or more aspects of vulnerability can increase other aspects of vulnerability or the same one in relation to a different hazard;
- mitigation measures addressed to reduce one or more aspects of vulnerability can be ineffective for enhancing resilience or, even, should result in a decrease of the resilience;
- mitigation measures addressed to increase the resilience of the community may led to reduce some aspects of vulnerability of the settlements.

For what concerns mitigation measures aimed at reducing vulnerability to individual hazards, this topic has been already faced in deliverable 2.3, where examples of social changes or mitigation actions aimed at reducing physical vulnerability enhancing vulnerabilities to other hazards are provided. Here two examples and a synthetic table are provided, while the topic related to mitigation measures aimed at reducing specific aspects of vulnerability but decreasing resilience has been more in depth investigated.

2 Mitigation measures addressing the reduction of vulnerability of specific elements or systems to individual hazards (BRGM)

The paragraph provides two examples of structural mitigation measures addressed to reduce vulnerability of specific elements or systems to one hazard which result in an increasing of the vulnerability of the same elements or systems to other ones. The concrete examples of hazard-oriented measures which had led to higher damage facing earthquakes are the Bam earthquake (December 26th 2003) and the Kobe seismic event (January 17th 1995).

On December 2006, an earthquake struck the South-East province of Kerman in Iran, next to Bam city. The magnitude of the seism was 6.6 on Richter scale and 80 after-shocks followed in the days after. More than 31.000 people were killed during the earthquake (Spence, 2006) and 40.000 to 60.000 were homeless. Indeed a large number of typical constructions were destroyed during the earthquake and the damages were even visible on satellite images. The typical houses were built in adobe, “derived from an appropriate response to the climate of Southern Iran, with high diurnal temperature swings” (Spence, 2006) but they were very vulnerable to earthquake.

During the earthquake of Kobe on January, 17th 1995, more than 5500 people were killed, nearly 94.000 buildings collapsed and 106.000 were partly damaged. It has to be noticed that mainly traditional buildings were destroyed because of their heavy roofs. Those roofs constructed with mud and tiles were designed to resist typhoons (Menoni, 2001). “Failures in these buildings were typically caused by large inertial loads from the heavy roofs exceeding the nominal lateral-load-resisting capacity of the supporting walls” (Scawthorn and Yanev, 1995). The table 1 synthesizes examples of hazard-oriented mitigation measures, preventive or corrective, which lead to the increase of the vulnerability of the same element to another hazard. The two major hazards taken into consideration are earthquakes and floods, but example of other hazards (landslides, volcanoes, hurricanes and heat or cold waves) are included when possible.

Table 1: Inconsistency between some hazard-oriented mitigation measures

		Phenomena			Climate	
Elements	**Typology**	**Earthquakes**	**Floods**	**Landslides/ Volcanoes**	**Typhoons / Hurricanes**	**Heat wave / Cold wave**
Buildings	*Pilotis / stilts /piles*	Pilotis and soft storeys to be avoided	Pilotis raise the height of the building and limit water entry in the building (UN ISDR, 2004)			
	Height / number of levels	High buildings may be more vulnerable in some cases depending on the soil conditions	- High buildings with many levels allow to move valuable items out of the water (UN ISDR, 2004) - Reducing the ground surface reduces flooded surface and thus drying and cleaning periods			
	Walls	- Non-homogeneous wall construction to be avoided - Rigidity of construction materials have to be homogenous on all the height of the building (to avoid the flexible level effect)	Different materials to be used (e.g. materials with low permeability up to 0.3m) (UN ISDR, 2004)			
	Roofs	Heavy roofs favour collapse (Coburn et al., 1993)		Roofs designed to support heavy loads from Tephra falls (e.g. R.C. roofs)	Heavy roofs avoid them to be blown off	
					For hurricanes, 4-slope roofs with maximal pitch of 30° are recommended (MEEDDAT, 2009)	For snowy episodes, 2- slope roofs with important pitch are recommended
	Localisation	Avoid building near a slope and on site with known site effects (Bouchut, 2006)	Better to build on high grounds; out of reach of floods	Avoid building near a slope (landslide)	Building near a slope or a cliff can protect buildings from winds	
	Mass	Light structures are less vulnerable (Spence, 2006)	The building shouldn't be too light in order not to float and not to be too vulnerable to debris and currents		Light structures are more vulnerable to winds	Light structures reduce thermal isolation
	Mass repartition	- Mass repartition should be as homogeneous as possible - Avoid putting mass high up	Important device and installation should be put high up (MEEDDAT, 2009)			
	Shape	- T- or L-shape to be avoided (Bouchut, 2006) - Avoid elevation irregularities (Bouchut, 2006)	L-shape buildings can concentrate streams			
	Walls materials	- Structure should be tied (Coburn et al., 1993) - Bricks or concrete blocks structures are identified as the most dangerous ones and must be chained horizontally and vertically	- Drying quickly: engineering bricks, concrete blocks and gypsum plasterboards (UN ISDR, 2004) - Engineering bricks also limit water entry during flood events (UN ISDR, 2004) - Steel of reinforced		Balconies or external roofs should not be tied to the rest of the structure	Bricks provide high thermal isolation

			structures is vulnerable to salt corrosion in case of coastal flooding			
		Wood buildings are quite resistant to earthquakes	Wood structure are vulnerable to floods (ex: Sri Lanka)		Wood structures are vulnerable to strong winds (Coburn et al., 1993)	
		Adobe construction to be avoided (Coburn et al., 1993)	Adobe construction is to be avoided (not resistant)			Adobe construction generally react well to extremes temperatures weather
	Basements	Deep foundations provide better earthquake response	Basements are vulnerable		Basements are very resistant and constitute shelters to strong winds	Basements provide thermal isolation for extreme weather
	Openings	Better to minimize openings	Openings may be a way to let the water enter and to save the structure	Better to minimize openings in order to slow the ingress of hot gases, together with a reduction of the fire load (Pyroclastic flows)	Better to minimize openings (MEEDDAT, 2009)	Large openings result in less thermal isolation
Infrastructures (roads, pipelines…)	*Electric networks*	Underground lines are less vulnerable (ERDF, 2008)	Underground lines are vulnerable to floods (ERDF, 2008)		Underground lines are less vulnerable to wind (ERDF, 2008)	Underground lines are more vulnerable to heat waves (ERDF, 2008)
	Bridges	Particularly vulnerable to earthquakes	Raising roads on bridges or piles can be a solution to preserve roads serviceability from floods			
	Pipelines	Less vulnerable when built underground	Underlines pipelines may be more vulnerable to floods			
Other elements: Embankments, levees, slopes	*Slopes*	Toe weight would destabilize the slope even more (wave trapping)		Toe weight stabilizes the slope (landslide) (Bouchu t, 2006)		

3 Mitigation measures addressing the reduction of specific aspects of vulnerability

In this paragraph some case-studies, aimed at highlighting that measures addressed to reduce one or more aspects of vulnerability can, sometimes, lead to a decreasing of territorial system resilience, rather than to a direct improvement of the resilience itself. This may happen because: the mitigation actions aimed at decreasing some vulnerability features of territorial systems increase other aspects of vulnerability which may induce, in turn, a decreasing of the resilience of the system as a whole; mitigation measures, acting on specific aspects of vulnerability or on other risk components, influence negatively resilience dimensions of territorial systems, or trigger chains of events that produce unexpected new vulnerabilities or a new system state characterized by a lower level of resilience. These causes often overlap, making difficult their clear identification in the case-studies; moreover, the complexity of the relationships among vulnerability aspects and resilience dimensions sometimes belies what clearly arises from other cases and contexts. Therefore, in this paragraph some examples rather than a strict classification, aimed at highlighting specific aspects of such complex relationship, are provided.

A first consideration refers to the often conflicting relationships among social and physical vulnerability and to the outcomes that such a struggle may have on the resilience of a community. Very often a change of building typologies and features corresponds to the improvement of economic and social conditions of communities. Generally, due to an increase of economic wealth, the traditional and poor houses are replaced by more stable buildings made with materials and construction techniques unconnected with local traditions. This process starts from an improvement of social vulnerability conditions and may have two different outcomes:

- a higher vulnerability to some types of hazards of the new buildings (due to the loss of local traditional building techniques and to the construction of buildings sized on major hazards);
- a lower physical vulnerability of buildings and, in the meanwhile, a lower resilience of the system due to a lower rapidity in re-building after the event.

Many of the houses re-built after floods or earthquakes by NGO have specific aspects of traditional buildings which, although often characterized by high levels of vulnerability, are examples of remarkable adaptation to hazards (Jigyasu, 2008), due to the traditional local materials and to the ease of rebuilding. Social vulnerability reduction and the consequent physical vulnerability reduction not always lead to an improvement of community resilience. This is clear when the improvement of social and economic conditions of communities is promoted and implemented by intentional – for example the Chinese urbanization policies – or spontaneous migrations from country to city related to the opportunities of social and economic improvement provided by the city. The moving of a huge amount of population produces, in many cases, urban settlements, frequently illegal, localized in hazard prone areas and characterized by high levels of physical vulnerability: for example, thousands of people living in the *favelas* all around Rio de Janeiro, placed on steep slopes prone to flash floods. In such a case, people cannot build up their houses in safer areas due to poverty, social conditions and high land prices (Cannon, 2008).

The relationship between physical and social vulnerability can be analyzed from a different perspective: in many cases, indeed, physical vulnerability mitigation measures are characterized by great difficulties in their implementation, due to the social and economic conditions of the community. Physical vulnerability mitigation measures are generally expensive and not so feasible in low income communities. For example, the mitigation program promoted by NGO and Red Cross in Caribbean islands and aimed at reducing physical vulnerability of residential buildings to hurricanes, through incentives for the structural reinforcement of the roofs, was largely opposed by the population: "why spend money on a roof that will be proof against hurricane winds that may never happen, when each and every day the household has to cope with an inconvenient and unhealthy kitchen? When faced with this dilemma, the Red Cross society decided to help people to improve both" (Cannon, 2008). It is necessary to act in a integrated manner on the physical vulnerability and on the social conditions of the population to achieve a comprehensive improvement of resilience of a territorial system.

A first relevant contradiction arises from case-studies: measures aimed at improving social and economic living conditions may produce an improvement of physical vulnerability and, on the contrary, measures aimed at decreasing physical vulnerability may result as scarcely feasible without such an improvement. In both cases, the actions aimed at reducing social, economic or physical vulnerability, do not necessarily imply an improvement of resilience. On the contrary, there are examples of mitigation measures aimed at mitigating single aspects of vulnerability which have positive influences on others. In scientific literature there are many cases, indeed, of mitigation measures addressed to reduce physical vulnerability of buildings in which relevant economic activities are located that produce lower damages and a shorter recovery time phase after the event. The case of the mitigation program of the Van Nuys brewery in California (CSSC, 1999) highlights that after the 1971 earthquake, this building was damaged and suffered a large business interruption. From the early 1980s, a structural mitigation program allowed the retrofitted buildings and equipment to suffer only low damages during the Northridge earthquake in 1994. The brewery quick returned to fully operation (in only 7 days) and had benefits exceeding the cost of mitigation program. This example highlights the role of some key-dimension of resilience such as the memory of past events and the capacity to learn from them (learning capacity) which, in this case, triggered the activation of mitigation measures. These latter, reducing the physical vulnerability of buildings and equipments, produced a lower economic vulnerability of the community, being this activity relevant for the local economy. Nevertheless, also the relevance of memory and learning capacity in order to support the implementation of mitigation measures aimed at reducing specific aspects of vulnerability is not always proved. For example, with reference to the California case, Godschalk (2003) argues: “Comfort (1999) showed how emergency managers learned to adapt and improve their disaster response activities over the course of three earthquakes: Whittier Narrows, Loma Prieta, and Northridge. Following each disaster, their response management improved as they adapted their community practices”. On the contrary, similar outcomes did not take place in other areas affected only by a big earthquake: “after earthquakes in Ecuador in 1987 and Armenia in 1988, there was little change in community mitigation practices. Comfort (1999) called these “non-adaptive” systems, low on technical structure, flexibility, and openness to new information and methods”.

While some resilience dimensions play a central role to promote and support the implementation of vulnerability mitigation measures, the community have not always such social, economic and organizational characteristics that allow resilience dimensions to activate themselves, although they are intrinsic properties of complex systems. Moreover, memory, which has a relevant role in building up learning capacity, depends more on the frequency of calamitous events than on their intensity. Further remarks arise from case-studies related to mitigation measures aimed at reducing specific aspects of vulnerability or other risk components – as hazard or exposure – which negatively influence some resilience dimensions or, vice versa, from cases referred to measures aimed at increasing specific resilience dimensions which lead to a vulnerability improvement. A typical example of the first case is related to structural mitigation measures, always considered as a decisive factor in natural risk reduction and for the improvement of disaster resilience of communities. The reduction of physical vulnerability obtained through building codes or spread reinforcement of the building stock has often induced in the population a false sense of safety or even the certainty that, in case of event, building damages would be negligible. This certainty often led to neglect other not structural measures – which may play instead a decisive role in the hazardous event response and recovery – and to promote a further growth of exposure in prone hazard areas. Structural measures, both hazard or physical vulnerability oriented, may have relevant limits and produce higher losses in case of hazardous events (Alexander, 2000). Moreover, during the recent Abruzzo earthquake or the Kocaeli earthquake, most of the collapsed buildings were built after 1980s, according in theory to anti-seismic codes: the main reason for such a failure was related to the miss-implementation of the existing building codes. Another example of mitigation measures which may have negative outcomes for resilience can be identified in the risk transfer mechanisms due to insurances. The spread use of assurances, particularly if it is not well regulated, may lead to a reduced attention for the static improvement of buildings and for an effective emergency preparation, since the risk has been transferred to insurance companies. Such a mechanisms can produce a decrease of the resilience and the inhibition of cultural and learning processes which determine the adaptation to adverse events. The re-building fund after the disaster is a similar mechanism: why to worry about the risk if someone will pay for repairing damages?

Examples of spread risk mitigation measures that, in many cases, have negative outcomes are related to the resettlement of exposed population and assets towards safe locations. First of all, such measures are difficult to be implemented since the resistance of local communities which generally prefer to continue their live in the same place, even though aware of the risk conditions. In other cases these measures induce degenerative processes of the communities, increasing other vulnerability factors, especially economic and social ones. The work of Gaillard (2007) about the resettlement of populations due to volcanic phenomena provides some relevant examples and interesting ones can be identified in Italy too: for example, the failure of the recent measures aimed at stimulating the decreasing of building and population density in the Vesuvius' area through a voluntary delocalization of the population. Unfortunately, even in this case population, although aware of the risk, prefer not to leave their houses. This choice seems to show a low learning capacity and a rootedness that is opposite to the rule of evolution towards more resilient systems (Baker, 2009). Therefore, also in this case, measures aimed at reducing the exposure of vulnerable assets, rather than supporting an evolution of settlements and communities towards lower risk conditions and higher resilience, maintain or improve risk conditions.

Furthermore, it seems to be useful to think about the outcomes of some preventative structural measures for some natural hazards. For example, measures aimed at preventing flooding through dikes, channels and levees addressed to change the characteristics of natural watershed are very spread. In some cases, such measures produce relevant changes in eco-systems which, in turn, can induce relevant modifications in the livelihoods of local communities (fishing, tourist activities, etc.). Hence, the impacts of such consequences induce relevant changes in their social structure. Such changes produce, in many cases, new vulnerabilities also related to a weak social structure which make the community less resilient. These circumstances, quoted in scientific literature (Weichselgartner, 2005; Klein et al., 1998; Wisner et al., 2004), are largely verifiable in some territorial contexts and especially in developing countries where hazards may be a resource, although this assumption can be paradoxical. A typical example is represented by the Delta of MeKong river in Vietnam where “flood policy has to minimize the adverse impacts of flood damage and disruption as well as to maximize the productive use and conservation values of the floodplains” (Weichselgartner, 2005). The case of Bangladesh (Wisner et al., 2004) is representative too; the estimated damages caused by the mitigation measures (dikes, channels, etc.) are, indeed, much bigger than the expected ones caused by floods: in this case, mitigation measures cause relevant changes and potential losses in fishing activities, which represent the main livelihood of the poor population. Therefore, new vulnerabilities arise, the existing ones increase and the resilience of local community decrease.

Another example of complex relationship between vulnerability and resilience is provided by a study related to the vulnerability mitigation measures defined by experts, government and NGO after the 1999 Chi-Chi (Taiwan) earthquake (Lin et al., 2006). The report singles out the different effects of such measures in different territorial contexts, highlighting that in some poor villages prone to frequent mud-flows and floods triggered by earthquakes, these measures caused an improvement of vulnerability at local scale. The work identifies as main root of such a failure the lack of interface between science and practice. In detail, the study considers two villages, singling out both the types and the chains of hazards to which they are prone to and their connections with human activities, both the process of knowledge sharing and the institutional organization. This comparison brings out that the first community (Pu-li) has a better science-practice interface because the knowledge is included in its social texture and this changed the community from vulnerable to resilient; the second one (Song-ho) demonstrates the science-practice interface to be a failure due to the disregard of multiple nature of hazards as well as social capitals (Lin et al., 2006). In this example, mitigation measures caused an improvement of vulnerability at local scale due to weaknesses in some resilience dimensions.

It is worth underlining that in many cases the efficacy of mitigation measures depends not only on the type of actions but also on the features of the decision process and on the way in which such measures are implemented, especially the structural ones: “when the management of a resource or facility is shared by a diverse group of stakeholders (e.g., communities with varying economic conditions, government, or business community), decision making is better informed and more options exist for testing policies” (Prasad et al., 2009). Nevertheless, decision processes are not always efficient: in many cases a breakdown happens in the chains of control, which particularly paralyzes the emergency management activities, as in the Kobe earthquake in 1995, when the un-awareness of decision makers in Kobe (indeed in Osaka and Hyogo Prefecture) about the size of the event made a quick response impossible. Moreover, many mitigation measures need a high level of participation and a decision process shared by the whole community in order to be effective. For example, the enforcement and effectiveness of land use zoning mitigation measures are largely dependent on the inclusionary and consensual nature of the decision making process. Tompkins and Adger (2004) argue that key vulnerable groups are often excluded and frequently largely ignored when infrastructures are being designed to reduce vulnerabilities due to the poor living conditions in risky areas (Cutter et al., 2000; Pelling, 2003). When collaborative planning is ignored, the sustainability of plans and their implementation come into question (Tompkins and Adger, 2004). Therefore, some resilience dimension, such as collaboration, cohesion or networking are very relevant in order to guarantee the effectiveness of mitigation measures addressed to reduce different aspects of vulnerability.

4 Mitigation measures aimed at enhancing resilience

Several case-studies show that mitigation measures aimed at increasing some resilience dimensions may result in an improvement of some aspects of vulnerability.

These cases are often focused on the self-organization of communities. For example, mitigation or reconstruction programs based on the social cohesion, participation and self-organization of communities that, in practice, lead to an increase of the physical vulnerability since population do not have cultural and technical capacities to fairly implement them. Moreover, some mitigation measures, particularly the ones related to the emergency management, are based on, or aim at increasing, the self-organization capacity of communities. Unfortunately self-organization, interpreted in scientific literature as a key factor of resilience, may have negative outcomes too. In communities hit by earthquakes, for instance, the population often go back spontaneously to their damaged houses before the experts have assessed the real safety conditions of buildings, or create improvised and temporary “settlement” near the hit buildings to be close to their own houses, without taking into account the possible collapse of these buildings (Sapountzaki and Dandoulaki, 2006). These behaviors show that the self-organization capacity of individuals or groups, in some cases, do not improve the resilience of the community as a whole, increasing on the contrary the risk conditions.

In some cases, mitigation measures acting on different aspects of resilience may have negative outcomes, since these aspects may clash with each other: for example, the relationship among measures aimed at preserving natural resources, decisive to prevent or mitigate the impacts of some natural hazards, and the ones aimed at achieving a social and economic development, which are also relevant to improve the resilience of communities. Therefore, unbalanced local development need to be oriented: “the means of enhancing both social and ecological resilience may in some cases be found in supporting communities in traditional management approaches” (Tompkins and Adger, 2003). Another example provided by Baker (2009), quoting the work carried out by Barbier (2007), is related to the relationship between social and economic wealth related to tourist development and to changes induced in coastal eco-systems by deforestation of mangrove trees which amplified the tsunamis impacts in Asian countries in 2004.

Finally, it has to be noticed that the information provided by local authorities and media about new infrastructures development, safeness of buildings, efficacy of emergency management tools and procedures and so on, has to be careful considered. In some cases, indeed, if the communities believe that they are prepared, a false sense of security can be created which can significantly increase some aspects of vulnerability. For example, Etkin (1999) highlights how reliance on structural flood defenses increases vulnerability over the time through the so-called “risk transference”. These defenses generally produce a short term flood risk decreasing and a long-term flood risk improvement, transferring the risk into the future. People exposed to floods in this time loose the correct perception of the risk and feel a false sense of security, while with their actions increase vulnerability.