Climate Change, Landslide Risk Assessment and Adaptation Policies: The Urban Area of Ancona Municipality

Article · August 2015

DOI: 10.1007/978-3-319-09048-1_159

Daniele Spizzichino
Institute for Environmental Protection and Research (ISPRA)

A. Capriolo
Institute for Environmental Protection and Research (ISPRA)

Climate change, landslide risk assessment and adaptation policies: the urban area of Ancona municipality

Spizzichino Daniele[1], Capriolo Alessio[1], Di Gioia Fiorina[2]

[1] ISPRA - GEOLOGICAL SURVEY OF ITALY, Via Vitaliano Brancati 60, 00144, Rome, Italy

[2] Comune di Ancona. U.O. SIT – Settore Informatica e Innovazione

Adaptation, together with mitigation, is one of the two complementary actions that preferably must be undertaken jointly to cope with the problem of climate change. As stated by the IPCC (Intergovernmental Panel on Climate Change), mitigation aims at avoiding the unmanageable impacts, while adaptation aims at managing the unavoidable impacts and increasing the resilience of natural and human systems to current and future impacts of climate change. Starting from this idea, the scope of the present work is to describe the methodological approach adopted to run a geological (quantitative) risk assessment, including an economic valuation, for slow landslide and develop a cost-benefit analysis of adaptation measures at local level in the urban area of Ancona municipality (Marche Region, Italy). Such activity has being carried out within the framework of the Life Project "ACT" (Adapting to Climate change in Time), that deals with the development of Local Adaptation Plans based on predictable climate scenarios and environmental, social and economic impact assessment of climate change on some of the most vulnerable urban areas in the Mediterranean basin.

Keywords: Adaptation, Climate Change, Landslide Risk, Mitigation.

1. Theoretical background and rationale

Climate change has a significant impact on the hydrological cycle and all its related phenomena. In Italy, between 1279 and 2002 A.D., the AVI catalogue [1] had been recording 4521 extreme events in terms of damages. In the same period we had 13.8 victims per year due to landslides and 49.6 victims per year due to floods [2]. These phenomena in the environmental and anthropogenic settings resulted in significant economic losses and casualties (e.g. Piemonte 1994, Versilia

1996, Campania 1998, Golfo Ligure 04/02/2003, Bari 23/10/2005, Vibo Valentia 3/7/2006, Cagliari 22/10/2008, Giampilieri (ME) 01/10/2009, Veneto Region 01/11/2010). At present, it is quite difficult to define a strong correlation between current climatic trend, natural and anthropogenic impacts and forecasting model. The correlation should consider the relationship between meteorological trigger mechanisms (still not very well associated to climate change) and related impacts for different types of phenomena. Natural hazard represents a conflicting interface between natural-physical system and social and development setting, and consequently determines a fundamental imbalance for population safety. The likely increase in frequency and intensity of extreme weather events [3], especially in the Mediterranean area, might lead to an increase in economic, environmental and social damages if no preventive action is taken.

2. Methodological approach and dataset

The present impact methodologies and risk assessment has been proposed and developed by ISPRA [4], while the data for the implementation has been provided by Ancona municipality and carried out through spatial analysis with GIS tools.

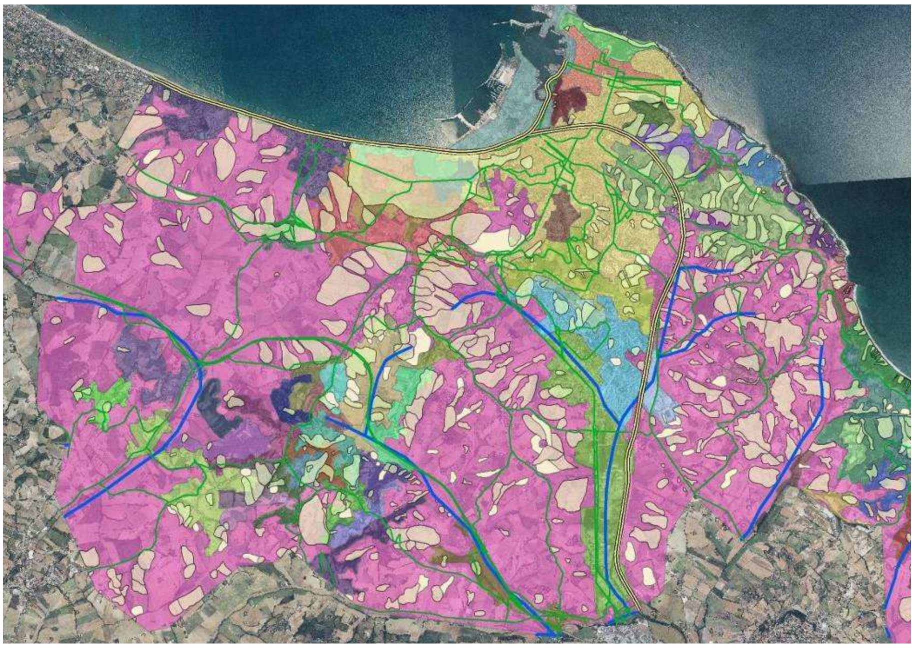

Figure 2.1. Spatial intersection between slow landslide (IFFI) and Land Use (CLC 2006) along the Ancona municipality

The work followed two main approaches:

1) Site scale approach for the Ancona landslide - through the definition of triggering thresholds for the landslide displacements and related stability model for the risk assessment (developed by Ancona Municipality with the technical support of University of Rome and supervision of ISPRA);

2) Municipality approach scale:

- looking at the 2011 assessment developed by GIS tool, it overlays potential slow landslide [5] hazard areas and exposed elements (e.g. population, land use, road network, urban settlement), in order to define the actual landslide local risk assessment (see Figure 2.1);
- looking at the 2050 – 2100 scenario, a GIS buffer analysis has been used to take into account the increases of future climate trends (ISPRA and Municipality, joint simulation).

The Local Impact Assessment has been carried out through the use of the following dataset: CLC2006 project, The Italian Landslide inventory (IFFI project) [6], and the municipal geo database.

3. Slow Landslide Risk Assessment

A spatial analysis has been implemented in order to create future scenarios starting from the actual landslide area (area affected by slow landslide in 2011).

The analysis shows that the landslide susceptibility changes in a range that goes from 21,6% to an estimated landslide susceptibility equal to 30,5% (with an average increase to year 2100 for all the Corine Land Cover codes equal to 30%, and a more than 50% for commercial and industrial area).

The impact assessment, developed for specific exposed elements (e.g. population, barracks, railways, schools and Roads network), has been carried out for two different Future Landslide Scenario (year 2100 scenario A and scenario B) with precipitation varying from 10% to 40% [7].

The residents in unstable area changes from 10% to 14% in the worst case scenario. Railways increase their vulnerability moving from 12,3% to 18,7% (of the total length). Nursery and primary schools in the future seem to be less resilient than secondary and high schools.

Tab.3.1. Summary table for the impact with the respect of investigated exposed elements.

		Year 2011		Year 2100 FLSA		Year 2100 FLSB	
Exposed elements	total	affected by landslide	%	affected by landslide	%	affected by landslide	%
Resident	102.926,00	10.301,00	**10,0**	11513,00	**11,2**	15.333,00	**14,9**
Barracks	14	3	**21,4**	3	**21,4**	3	**21,4**
Nursery	22	2	**9,1**	5	**22,7**	5	**22,7**
Preschool	32	1	**3,1**	6	**18,8**	7	**21,9**
Primary	24	-	**0,0**	2	**8,3**	3	**12,5**
Secondary	12	-	**0,0**	-	**0,0**	1	**8,3**
High	19	-	**0,0**	2	**10,5**	2	**10,5**
Roads and Railways	total (km)	affected by landslide	%	affected by landslide	%	affected by landslide	%
Railways	91.991,00	11.276,89	**12,3**	12.533,29	**13,6**	17.239,49	**18,7**
Municipal	352.880,8	53.159,35	**15,1**	48.483,04	**13,7**	65.459,79	**18,6**
Local affiliated	504,3	372,1	**73,8**	380,09	**75,4**	436,76	**86,6**
Local not affiliated	121.618,50	19.063,90	**15,7**	20.952,01	**17,2**	27.899,68	**22,9**
Private	112.417,93	23.434,49	**20,8**	25.981,63	**23,1**	34.555,14	**30,7**
Provincial	38.554,70	4.349,54	**11,3**	4.785,87	**12,4**	6.264,61	**16,2**
ANAS road	27.355,00	5.648,92	**20,7**	6.051,17	**22,1**	7.111,71	**26,0**

4. Local Adaptation Plan based on a Cost-Benefit Analysis

For the final Local Adaptation Plan an estimation of future costs of inaction on Ancona urbanized area has been developed. The main scope of the analysis is to identify the future spatial distribution of the buildings (in the urban area of Ancona) affected by slow landslide and compare the related costs (mainly economic value of buildings) with the landslide risk reduction costs, in order to plan the due adaptation policies to address future Climate Change.

First, the assessment of CC impacts on geological hazard (slow landslides) was carried out in order to identify future impact scenarios on specific segments of social infrastructure (e.g. residential and commercial buildings) and the best adaptation measures in case of action.

The analysis was based on the collection of the following data:

- Future urbanized area affected by slow landslide (worst case 2100 scenario) in the Ancona urban area (H=landslide spatial hazard);
- Different land use in urban area classified and derived from Corine Land Cover project 2006 (E = Exposed Elements);

- The building vulnerability was supposed constant in this stage (V = Vulnerability =1);
- Building value (estimated cost per m^2) derived by the Italian Real Estate Observatory Market.

In order to estimate the benefit (in terms of total cost avoided), the total direct costs due to the loss of residential and commercial areas because of future landslides (year 2100) has been estimated, considering the urbanized area potentially affected by landslide and the unit cost derived from the main Real Estate Market Observatory. In order to estimate the total cost, the urbanized affected area (depending on the type of destination code) was multiplied by the unit value taken from the Market Observatory, assuming a standard building composed by four floors (ground floor for commercial/office destination).

Tab 4.1. Total loss estimate for residential and commercial building (2100).

Ancona Municipality (surface km^2 = 124,43)		
Corine Land Cover2006	**Urban Area affected by landslide in the 2100 scenario (Km^2)**	**Total loss cost 2100 (€)**
Continuous urban fabric	0,00	18.920.000,00
Discontinuous urban fabric	2,40	19.213.039.792,00
Industrial or commercial unit	0,19	377.111.778,00
Harbor areas	0,07	131.520.000,00
Total	**2,66**	**19.740.591.570,00**
Number of resident	**N of resident in hazard areas**	**%**
102.926,00	15.333,00	15

The adaptation costs were estimated considering the total costs needed for landslide risk reduction (superficial and deep slow landslide restoration works). With regard to the adaptation costs from landslides impacts within the Ancona municipality, a site specific analysis was carried out.

All the technical literature (e.g. regional price list of works, guideline of restoration works and countermeasures) has been taken into account in order to provide the unit cost of measures for slow landslide (type 1 superficial landslide and type 2 deep landslide). Calibration of costs has then been made on real cases available on the ReNDiS [8] [9] project database developed by ISPRA since 1999.

This analysis has identified the costs of measures (per m^2) that can be applied in order to reduce the urban area affected by landslide risk.

Table 4.2 Total estimated cost for landslide risk reduction in the Ancona Municipality

Urban area affected by future landslide (year 2100) equal to 3% of the entire territory	3,5 Km^2
Min estimated cost of measures	254,000,000 €
Max estimated cost of measures	315,000,000 €
Average estimated cost of measures	280,000,000 €

5. Conclusions

From the above analysis it is quite clear that the inaction cost (damage caused by slow landslide in the future) that the municipality of Ancona will have to incur without adaptation plan are much greater than the costs of landslide risk reduction (table 5.1).

Table 5.1 Cost/benefit inaction/adaptation

Expected damage of total exposed elements (year 2100)
€ 19,740,591,570.00
Adaptation costs (risk reduction measures)
€ 315,000,000.00
Percentage of adaptation costs respect to the loss occurring in the inaction scenario
1.6 %

The treatment of the temporal dimension has not considered benefits (avoided costs) as emerging from gradual adaptation during the reference period 2011-2100. The analysis is unable to predict the time when the various landslides would be triggered and consequently to establish when costs will be avoided over time. However the study provides an estimate, in the presence of different climate scenarios [7] (increase in average seasonal precipitation), of the total perimeter of the surface that in 2100 will presumably slide down.

More in detail the adaptation costs are 1.6 % of the total inaction costs referred to the complete loss of property, giving evidence that adaptation cost are lower than cost of inaction.

Through this simple approach it has been possible to estimate future costs of inaction (expected damage) that such a kind of events will have on the assets taken into account and also the costs (adaptation measures) for risk and vulnerability.

References

[1] CNR-GNDCI web site: The AVI project URL: http://avi.gndci.cnr.it/ welcome_en.htm.

[2] Margottini C., Spizzichino D., Climate change, geological and hydrological hazard and adaptation policy in Italy. Geophysical Research Abstracts Vol. 12, EGU2010-10870, 2010 EGU General Assembly 2010, Wien 2-7 May 2010.

[3] IPCC (2007) Fourth Assessment Report: Climate Change 2007 (AR4).

[4] Capriolo A., Giordano F., Mascolo R. A., Spizzichino D., A.A. 2011. Climate change and adaptation policies in the euro Mediterranean area: Proposed strategies in the LIFE ACT (Adapting to Climate change in Time) project. In: Le modificazioni climatiche e I rischi naturali, Polemio M. (Ed.), CNR IRPI, Bari, 173-177.

[5] Cruden D.M., Varnes D.J. (1996). Landslide types and processes. In: A.K. Turner, R.L. Schuster (eds.) Landslides investigation and mitigation (Special report 247, pp. 36-75). Transportation Research Board, Washington, D.C.

[6] Trigila A., Iadanza C., Spizzichino D. (2008) IFFI Project (Italian Landslide Inventory) and risk assessment. Proceedings of the First World Landslide Forum, 18-21 November 2008, United Nations University, Tokyo, Japan, ICL (International Consortium on Landslides) – ISDR (International Strategy for Disaster Reduction), pp. 603-606.

[7] Desiato F., Toreti A., Fioravanti G., Fraschetti P., Perconti W., A.A: 2010. Baseline climate scenario – Climate Trends and Projections. LIFE ACT Project Deliverable. No LIFE08 ENV/IT/000436 ISPRA 2010 (http://issuu.com/actlife/docs/climate_trends_and_projections?e=1968665/3123603)

[8] Spizzichino D., Campobasso C., Dessi B., Gallozzi P., Traversa F. A.A. 2009– Long Term strategy on "Slope stability mitigation measures", the italian monitoring experience: the ReNDiS project. Geoitalia 2009 - sesto forum italiano di scienze della terra, Rimini 09-11 settembre 2009. in Epitome Volume 3 Sessione B8 p.71

[9] Campobasso C., Delmonaco G., Dessì B., Gallozzi P., Ligato D., Porfidia B., Spizzichino D., Traversa F. and Vizzini G. (2011) Long term strategies and policies for landslide risk mitigation in Italy: the ReNDiS project. The Second World Landslide Forum - Abstract Book, 3-9 October 2011, FAO, Rome, Italy. ISPRA, p. 677.