Linear infrastructure assets as a territorial system for flood disturbances control.

Lorenzo Tinti - Orcid Id: 0000-0001-7170-373X

DA, Università degli Studi di Ferrara / Italy
DOI:

Abstract- *Flooding is a cyclical environmental disturbance with implications on ecosystems structure and physical environment (White and Pickett, 1985). Risk management is an increasingly pressing issue within spatial planning that is perhaps the most effective approach to preventing the increase in flood risk through active controls on territorial transformations (Sayers et al., 2013; Meng et al., 2020). At the same time, the development of linear infrastructures is essential to ensure adequate accessibility to services, goods and facilities (Srinivasu and Rao, 2013). Since infrastructure works are territorial-scale interventions with a considerable potential on shaping spatial forms (Strang, 1996) and on directing environmental processes, including alterations on surface hydrology (Raiter et al., 2018) the integrated exploitation of these two implications would allow a widespread territorial intervention able to implement resilience against flood. As linear infrastructures developments are complex works in complex environments (Di Giulio, Emanueli, Lobosco, 2018) there is considerable uncertainty about timing and economic feasibility that arise from the management of public/private interests, the multiplicity of issues involved and the management of huge financial budgets. The aim of this contribution is to discern the limitations and potentials of a multidisciplinary strategy by following a 'research-by-design' approach for the development of a rail transport infrastructure in the Lezhë district in Albania with a specific focus on the integration of flood risk reduction design within infrastructure track layout planning. Through a radical rethinking of territories, this work increases territorial resilience and propose new hybrid ecosystems, making them simultaneously devoted both to functionalist engineering and ecological renovation.*

Keywords: Landscape architecture; Territorial transformations; Flood risk reduction; Linear infrastructures; Ecosystem resilience.

1. Linear infrastructure and flooding: a possible relation.

Flooding is a cyclical environmental disturbance with implications on ecosystem structure and physical environment (White and Pickett, 1985) which is becoming increasingly important due to climate change (Kundzewicz et. al., 2014). Since biological diversity depends on natural disturbances and urban apparatus must reduce risk exposure it is necessary to operate in symbiosis rather than block or nullify those events moving from 'risk prevention' to 'risk management, 2006; Merz et al., 2010; Liao, 2012; Rossano, 2015; Morel, 2022). Risk management is an increasingly pressing issue within spatial planning that is perhaps the most effective approach to preventing the increase in flood risk through active controls on territorial transformations (Sayers et al., 2013; Meng et al., 2020).

At the same time, the development of linear infrastructures is essential to ensure adequate access to services, goods, and, facilities (Srinivasu and Rao, 2013). Since infrastructure works are territorial-scale interventions with considerable potential for shaping spatial forms (Strang, 1996) and directing environmental processes,

Fig.1/ Valli Grandi Veronesi . Source/ Archivio Luigi Ghirri, 1989

including alterations on surface hydrology (Raiter et al., 2018) the integrated exploitation of these two implications would allow a widespread territorial intervention able to implement resilience against flood. Specific attention should be paid to the ancillary systems of infrastructure, i.e. all those elements that are complementary to the primary function of the infrastructure and which are often not taken into account from a perceptive and design point of view, such as waste areas, technical equipment or, track protection elements. The combination of these disengaged elements that accompany linear infrastructures is left to their own devices, finding themselves in a blurred condition ''Fig. 1 Valli Grandi Veronesi (Source: Archivio Luigi Ghirri, 1989)''.

Important design experiences regarding linear infrastructure development have shown how combining landscape design with infrastructure engineering can substantially improve the aesthetic and ornamental qualities of the areas involved . Assuming that the construction and operation of infrastructure is one of the main drivers of environmental change (Doyle and Havlick, 2009; Bélanger, 2013;) it is possible to identify hybrid design practices that straddle landscape and infrastructure, such as the exploitation of earthworks to create water reservoirs and the subsequent creation of artificial wetlands, which would stabilize environmental conditions in flood risk areas.

Based on previous planning and design methodologies, this contribution aimsdiscern the limitations and potentials of a multidisciplinary strategy for the development of rail transport infrastructure in the Lezhë region with a specific focus on the integration of flood risk reduction design within infrastructure track layout planning.

apparatus must reduce exposure to risk, it is necessary to operate in symbiosis rather than block or nullify those events moving from 'risk prevention' to 'risk management' (Werritty, 2006; Merz et al., 2010; Liao, 2012; Rossano, 2015; Morel, 2022). Risk management is an increasingly pressing issue within spatial planning that is perhaps the most effective approach to preventing the increase in flood risk through active controls on territorial transformations (Sayers et al., 2013; Meng et al., 2020).

At the same time, the development of linear infrastructures[1] is essential to ensure adequate accessibility to services, goods and facilities (Srinivasu and Rao, 2013). Since infrastructure works are territorial-scale interventions with a considerable potential on shaping spatial forms (Strang, 1996) and on directing environmental processes, including alterations on surface hydrology (Raiter et al., 2018) the integrated exploitation of these two implications would allow a widespread territorial intervention able to implement resilience against flood. Specific attention should be paid to the ancillary systems of infrastructure, i.e. all those elements that are complementary to the primary

1 Based on UNEP definition linear infrastructures includes roads, railways, pipelines, i.e. systems for transporting people, energy, raw materials and water.

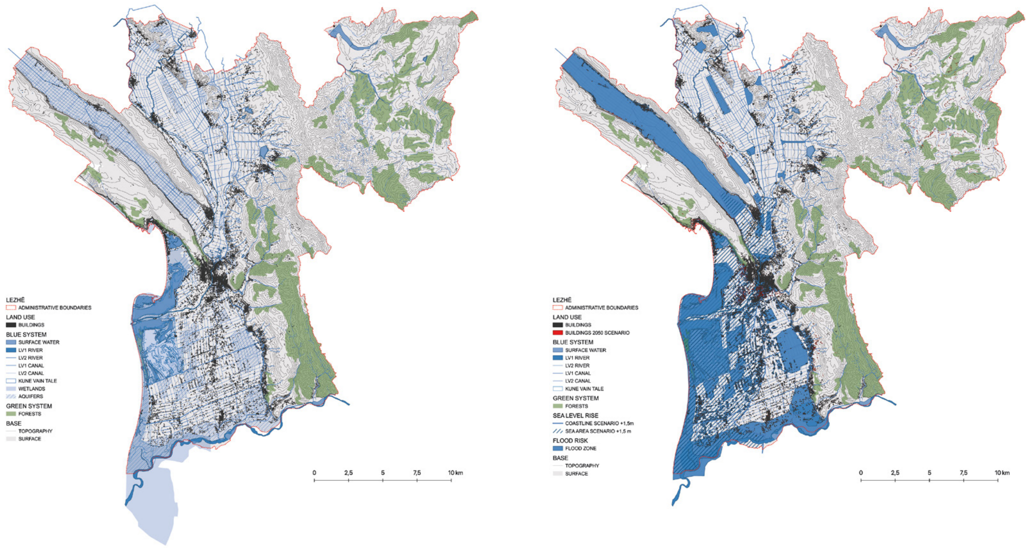

Fig.2/ Lezhë actual conditions and risk scenario. Source/ Author, 2021

function of the infrastructure and which are often not taken into account from a perceptive and design point of view, such as waste areas, technical equipment or track protection elements. The combination of these disengaged elements that accompany linear infrastructures are often left to their own devices, finding themselves in a blurred condition "Fig. 1 Valli Grandi Veronesi (Source: Archivio Luigi Ghirri, 1989)".

Important design experiences regarding linear infrastructure development have shown how combining landscape design with infrastructure engineering can substantially improve the aesthetic and the environmental qualities of the areas involved[2]. Assuming that the construction and operation of infrastructure is one of the main drivers of environmental change (Doyle and Havlick, 2009; Bélanger, 2013;) it is possible to identify hybrid design practices that straddle landscape and infrastructure, such as the exploitation of earthworks to create water reservoirs and the subsequent creation of artificial wetlands, which would stabilise environmental conditions in flood risk areas.

Based on previous tested planning and design methodologies, the aim of this contribution is to discern the limitations and potentials of a multidisciplinary strategy for the development of a rail transport infrastructure in the Lezhë region with a specific focus on the integration of flood risk reduction design within infrastructure track layout planning.

2 For a more in-depth analysis see the projects in the archive of the Biennal Internacional del Paisatge Barcelona, available at http://www.arquitectes.cat/iframes/paisatge/projectes, specifically see infrastructure project tipologies.

2. When infrastructure meets landscape design. The case study of Lezhë.

Lezhë district is a region of 479 km2 located in the north of Albania and present a large diversity ecosystem (Gencer, 2014), its environmental and landscape features are of considerable importance and constitute intrinsic characters of the region itself. Multiple hazards are present over the territory and their impact extends beyond the administrative boundaries, revealing the need for an integrated local local-to-national-to-regional reach to build resilience, as a response to uncertainties. This contribution focuses on the reduction of flood risk through the integration of nature-based environmental actions and linear infrastructure development within a multidisciplinary design strategy. The research process followed a 'research-by-design' , using the design process as a validation tool (Deming and Swaffield, 2011). Furthermore, to guarantee correct projection toward horizons, the scenario-based methodology was adopted as a basis for determining factors linked to alternative landscape transformations (Steiner, 2000) induced by climate change.

2.1 Environmental conditions as a starting point

Where physical and economic settlements are present, flood risk combined with a high level of vulnerability is consequently followed by physical and economic losses (Brochier and Ramieri, 2001; Frasheri and Pano, 2003; Pojani and Tola, 2011). Floods

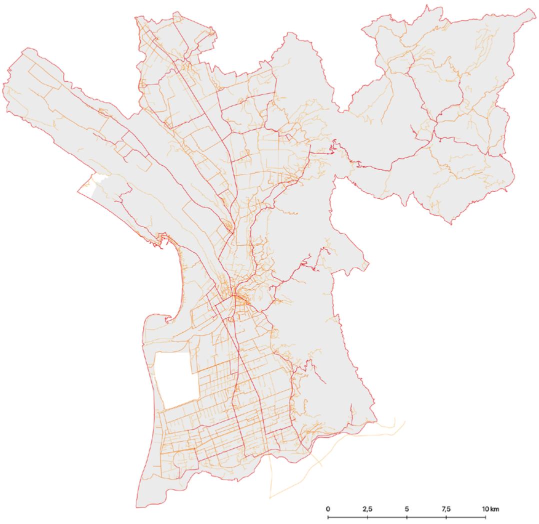

Fig.3/ Lezhë linear infrastructure system analysis . Source/ Author, 2021

caused by surface water and sea level rise are one of the main problems in the Lezhë district and the possibility of at-risk areas being affected increases as climate change intensifies (Milly et al., 2002). The environmental and ecological conditions of the district were analyzed focusing on the hydraulic situation of the area: the identification and representation of the water system characterised by all the specific elements as well as the anthropic footprint allowed the construction of a territorial mosaic (McGarigal, 2006) from which the projection of scenarios was then started ''Fig. 2 Lezhë actual conditions and risk scenario (Source: Author, 2021)''. By projecting the landscape towards a condition of extreme changes dictated by flood risk and sea level rise , it was possible to extrapolate spatial configurations on which to size strategic interventions (Lobosco, 2019).

2.2 Detection of linear infrastructures

Linear infrastructures almost always overlap in a sterile way on tin areas they cross (Giovinazzi, Giovinazzi, 2010) without providing any significant spatial improvement, but rather require action to minimize and compensate for their environmental effects (Sousa, 2020). The paradigm of the negativity of infrastructures must be overturned and transformed into opportunity. Recognition of infrastructures as preponderant mutant actions on the territorial scale would make it possible to trigger strategic actions with direct consequences on landscape, both on a small and large scale (Ugolini, 2020) ''Fig. 3 Lezhë linear infrastructure system analysis (Source: Author, 2021)''.

The territory of the district of Lezhë is characterized as a predominantly agricultural territory brutally crossed by the Rruga shtetërore SH1, an Albanian highway that connects the capital Tirana with the Montenegrin border. Linear logistics and transport infrastructures present very poor conditions there is a total lack in using for il infrastructure. Along the entire flat part of the district, he is the water management infrastructure which, perpendicular to the SH1, connects the Albanian Alps to the Kune-Vain-Tale nature reserve and the Adriatic Sea, as well as supplying all agricultural sectors. In the face of climate change water impact, increasing road traffic and the need for sustainable alternative travel such as rail, there is a clear necessity to strengthen the existing infrastructures exploiting them not only as a purely engineering operation but also as a new performative landscape and environmental system (Bélanger, 2013).

2.3 An integrated spatial transformation

The main design action is the revitalization of the railway line by multiplying its directions of travel. The project proposes to increase the safety buffer zone of the railway line in environmental devices such as accumulation basins, water infiltration zones, and read st infiltration areas . Thanks to the oversizing of the infrastructure ancillary system and the subsequent insertion of water management devices, it is possible to make the infrastructure an environmentally active element capable of impact on a territorial scale thanks to its

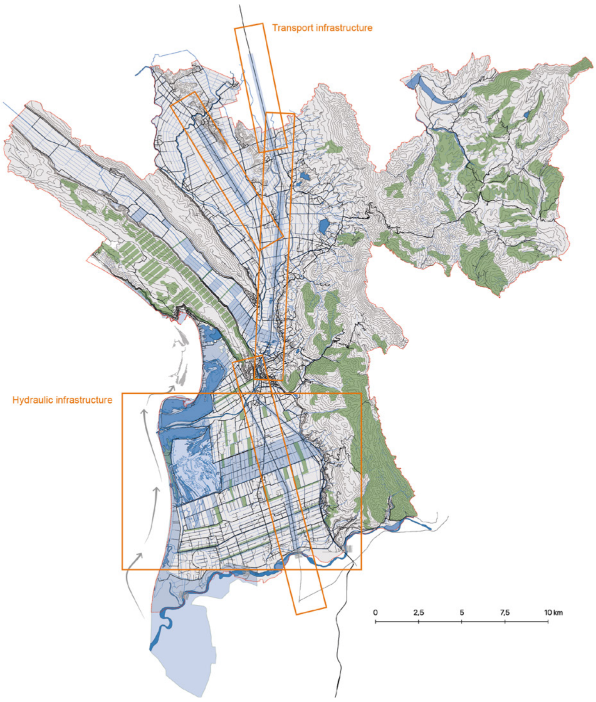

Fig.4/ Lezhë infrastructure and landscape design integration . Source/ Author, 2021

37 km length "Fig. 4 Lezhë infrastructure and landscape design integration (Source: Author, 2021)".

The new landscape is highly dynamic and resilient adaptive capacity is that implemented through the inclusion of new water storage devices that perform adequately in the face of unexpected and extreme flooding. The result is a territory that accommodates different ecosystems with a high adaptation value, shaped by the integration of the design processes of the linear railway infrastructure with spatial operations related to landscape design. In a nutshell, this research proposes a macro-strategy that addresses risk reduction through planning and design actions.

3. Discussion and conclusion

As linear infrastructures developments are complex works in complex environments (Di Giulio, Emanueli, Lobosco, 2018) there is considerable uncertainty about the timing and economic feasibility that arise from the management of public/private interests, the multiplicity of issues involved and the management of huge financial budgets. Similarly, the lack of accurate data concerning environmental structures and predictive detail regarding the future weather events scenarios regarding the Lezhë district implies that the presented study should be intended as a starting point for defining more accurate reasoning and research is methodological proposal addresses design actions related to the development of rail transport infrastructures capable of modifying the territory in its performance and implement its resilience to flooding turbances. In the same way, other types of linear infrastructure networks (roads, pipelines, electricity grids, underground networks, etc.) can also act as risk management devices as they are identified as spatial elements with effective repercussions for landscape and environmental systems.

Combining infrastructure engineering development, landscape design and, risk reduction planning would increase territorial resilience through a radical rethinking of territories, making them simultaneously devoted both to functionalist engineering and ecological renovation.

Bibliography

Bélanger, P. (2013) Landscape Infrastructure - Urbanism beyond Engineering. PhD. Wageningen Universiteit en Research centrum (WUR).

Bélanger, P. (2013) The new geographic landscape. PhD.Ph.Landscape Architecture Frontiers, 1(1), 42-54.

Brochier, F. and Ramieri, E. (2001) Climate Change Impacts on the Mediterranean Coastal Zones. Available at SSRN. http://dx.doi.org/10.2139/ssrn.277549

Carisi, F., Samela, C., Domeneghetti, A., Iacobini, F., Zammuto, A., Castellarin, A. and Brath, A. (2019) A simplified methodological framework for the assessment and management of flood hazard associates with extended linear infrastructure (railways). In: EGU General Assembly 2019, Geophysical Research Abstracts, Vol. 21, EGU2019-17870. Available from 10.13140/RG.2.2.32338.61127 [accessed 22 March 2022].

Di Giulio, R., Emanueli, L., Lobosco, G. (2018) Scenario's evaluation by design. A "scenarios approach" to resilience. Techne - Journal of Technology for Architecture and Environment, 15, 92-100. https://doi.org/10.13128/Techne-22118

Deming, M. E. and, Swaffield, S. (2011) Landscape

Architecture Research: Inquiry, Strategy, Design. Hoboken, N.J.: Wiley.
Doyle, M.W. and Havlick, D.G. (2009) Infrastructure and the Environment. Annual Review of Environment and Resources, 34(1), 349-373. https://doi.org/10.1146/annurev.environ.022108.180216
Frasheri, A. and Pano, N. (2003) Impact of climate change on Adriatic Sea hydrology. Elsevier Oceanography Series, 69, 92-96. https://doi.org/10.1016/S0422-9894(03)80015-6
Giovinazzi, O. and Giovinazzi, G. (2010) Segni nel paesaggio. Re-interpretare le infrastrutture lineari. TeMA-Journal of Land Use, Mobility and Environment, 3(4), 83-94. https://doi.org/10.6092/1970-9870/208
McGarical, K. (2006) Landscape Pattern Metrics. Encyclopedia of Environmetrics. https://doi.org/10.1002/9780470057339.val006.pub2
Meng, M., Dabrowski, M. and, Stead, D. (2020) Enhancing Flood Resilience and Climate Adaptation: The State of the Art and New Directions for Spatial Planning. Sustainability, 12(19), 1-23. https://doi.org/10.3390/su12197864
Merz, B., Hall, J., Disse, M. and Schumann, A. (2010) Fluvial flood risk management in changing world. Natural Hazards and Earth System Science, 10, 509-527. https://doi.org/10.5194/nhess-10-509-2010
Michener, W. K. and, Haeuber, R. A. (1998) Flooding: Natural and Managed Disturbances. BioScience, 48(9), 677-680. https://doi.org/10.2307/1313330
Milly, P. C. D., Wetherald, R. T., Dunne, K. A., and Delworth, T. L. (2002) Increasing risk of great floods in a changing climate. Nature, 415(6871), 514-517. https://doi.org/10.1038/415514a
Morel, P. (2022) De la prévention du danger à la gestion du risque. Tracés.
Kundzewicz, Z.W., Kanae, S., Seneviratne, S.I., Handmer, J., Nicholls, N., Peduzzi, P., Mechler, R., Bouwer, L.M., Arnell, Mach, N.K., Muir-Wood, R., Brakenridge, G.R., Kron, W., Benito, G., Honda, Y., Takahashi, K. and Sherstyukov, B. (2014) Flood risk and climate change: global and regional perspectives. Hydrological Sciences Journal, 59(1), 1-28. https://doi.org/10.1080/02626667.2013.857411
Liao, K.H. (2012) A Theory on Urban Resilience to Floods—A Basis for Alternative Planning Practices. Ecology and Society, 17(4). http://dx.doi.org/10.5751/ES-05231-170448
Lobosco, G. (2019) Scenario thinking in landscape architecture education. ECLAS and UNISCAPE Annual Conference proceedings, 21-23.
Gellert, P. K., Lynch, B. D. (2004) Mega-project as displacements*. International Social Science Journal, 175, 15-25. https://doi.org/10.1111/1468-2451.5501002
Pojani, E. and Tola, M. (2010). The effect of climate change on the water sector with a case study of Albania: An economic perspective. Proceedings of the BALWOIS.
Raiter, P. K., Lynch, B. D. (2018) Linear infrastructure impacts on landscape hydrology. Journal of Environmental Management, 206, 446-457. https://doi.org/10.1016/j.jenvman.2017.10.036
Rossano, F. (2015) From absolute protection to controlled disaster: New perspectives on flood management in times of climate change. Journal of Landscape Architecture, 10(1), 16-25. http://dx.doi.org/10.1080/18626033.2015.1011420
Sayers, P., Li, Y., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y. and Le Quesne, T. (2013) Flood Risk Management: A Strategic Approach. Paris: UNESCO.
Srinivasu, B. and Rao, P.S. (2013). Infrastructure development and economic growth: Prospects and perspective. Journal of business management and Social sciences research, 2(1), 81-91.
Steiner, F. (2000) The Living Landscape: An Ecological Approach to Landscape Planning. McGraw-Hill.
Sousa, P., Gomes, D. and Formigo, N. (2020) Ecosystem services in environmental impact assessment. Energy Reports, 6, 466-471. https://doi.org/10.1016/j.egyr.2019.09.009
Ugolini, M., Varvaro, S., Ripamonti, F. and Gallizioli, C. (2020) Building landscape. A new road infrastructure is an occasion for a multidisciplinary approach to a landscape project. In IOP Conference Series: Materials Science and Engineering, 960(3). IOP Publishing. https://doi.org/10.1088/1757-899X/960/3/032103
Viazovska, A. (2016). Dimensions of Landscape through the Lens of Landscape Infrastructure Practice. ZARCH, 7, 1-10. https://doi.org/10.26754/ojs_zarch/zarch.201671529
Werritty, A. (2006) Sustainable flood management: oxymoron or new paradigm? A?a, 38(1), 16-23. https://doi.org/10.1111/j.1475-4762.2006.00658.x
White, P.S., Pickett, S.T.A. (1985) Natural disturbance and patch dynamics: An introduction. In Pickett, S.T.A. and White P.S. (Eds.) The Ecology of Natural Disturbance and Patch Dynamics (pp. 3-13). San Diego: Academic Press.

IMAGES

Fig. 1 Valli Grandi Veronesi (Source: Archivio Luigi Ghirri, 1989)

Fig. 2 Lezhë actual conditions and risk scenario (Source: Author, 2021)

Fig. 3 Lezhë linear infrastructure system analysis (Source: Author, 2021)

Fig. 4 Lezhë infrastructure and landscape design integration (Source: Author, 2021)