# Application of the DPSIR and Social-Ecological Network Frameworks to analyse social-ecological relationships in AFOLU activities addressed by the LIFE Programme.

*Andriollo, E[1]., Caimo, A.[2], Secco, L.[1], Pisani, E[1].*

[1]*TESAF Department. Università degli Studi di Padova*

[2]*Technological University of Dublin*

*Introduction*

Agriculture, Forestry and Other Land Use (AFOLU) appears as one of the major forces affecting the environmental conditions of ecosystems. AFOLU is directly responsible for "*around 13% of CO2, 44% of methane (CH4), and 81% of nitrous oxide (N2O) emissions from human activities globally during 2007-2016, representing 23% of total net anthropogenic emissions of GHGs (medium confidence*)" (IPCC, 2019: 8). To address environmental challenges, a part of the scientific literature proposes to analyse agricultural systems through the lens of a Social-Ecological Approach (e.g., Lescourret *et al.*, 2015; Rasmussen *et al.* 2018), which makes visible the positive and negative interlinkages between ecological resources and human actions undertaken through the AFOLU activities, which are normally poorly considered in the conventional Ecosystem Service Approach (e.g., Pascual and Howe, 2018).
In the European context, the LIFE Programme (https://cinea.ec.europa.eu/life_it) represents the most important financial tool supporting projects impacting on natural resources and proposed by partnerships of actors characterised by differences in needs and interests but sharing common and forward-looking environmental objectives. As a result, partnerships co-founded by the LIFE Programme are composed of a multitude of stakeholders comprising the environmental governance (Lemos and Agrawall, 2006). Therefore, in the European Union the LIFE Programme represents for AFOLU activities a central financial instrument to foster sustainability transformations by reducing their negative impacts on ecosystems.
This study aims to provide an initial knowledge on the social-ecological relationships undertaken in the context of AFOLU activities and tackled, in terms of a response strategy, through LIFE projects. Specifically, we want to clarify the social-ecological nature and structure of LIFE projects by identifying:

- causal social-ecological relationships underpinning objectives and activities of LIFE projects in the realm of AFOLU activities (*Research objective 1*, *RO1)*,
- structural social-ecological relationships emerged through the creation of partnerships and specification of environmental issues addressed (*Research objective 2, RO2)*.

We analyse causal SES interactions addressed by the LIFE projects through the DPSIR Framework (e.g., Gary et al., 2015). The Framework distinguishes *Drivers* forces (e.g., intensive agriculture), exerting *Pressures* (e.g., nitrate pollution) on ecosystems leading to changes to the *States* (e.g., high concentration values of NO3). From pressures on states emerge *Impacts* on the environment (e.g., water eutrophication), determining a *Response* (R) (e.g., sustainable technologies in fertilisation).
The combination of the DPSIR and SES framework is here conceptualised as the continuous interactions between the social and ecological components of the SES, which is practically operationalised through the DPSIR framework by the *social* drivers and pressures affecting the *ecological* state, which determine an impact firstly affecting the ecological component but also, in the long run, the social component of the SES. The unsustainable effect is counterbalanced by a response, which in this context is represented by a LIFE project proposing an innovative solution to respond to the specific challenge determined by human action (fig.1).
Consequently, we analyse the structural SES relationships through the analysis of social-ecological network (SEN) emerged from the implementation of LIFE projects (fig.1) where multiple actors

composing partnerships aim to address environmental issues through interventions (e.g., air, biodiversity, soil, water). A SEN analyses social and ecological processes in environmental management as networks constituted by social and ecological nodes, focusing on how its structure affects the environmental governance, its processes, and the social and environmental outcomes (Sayles et al., 2019). Specifically, in this study we aim to identify what actors categorised for (i) type of LIFE project, (ii) geographical area, (iii) level of governance:

- relates to every specific environmental theme,
- connect activities concerning different environmental themes.

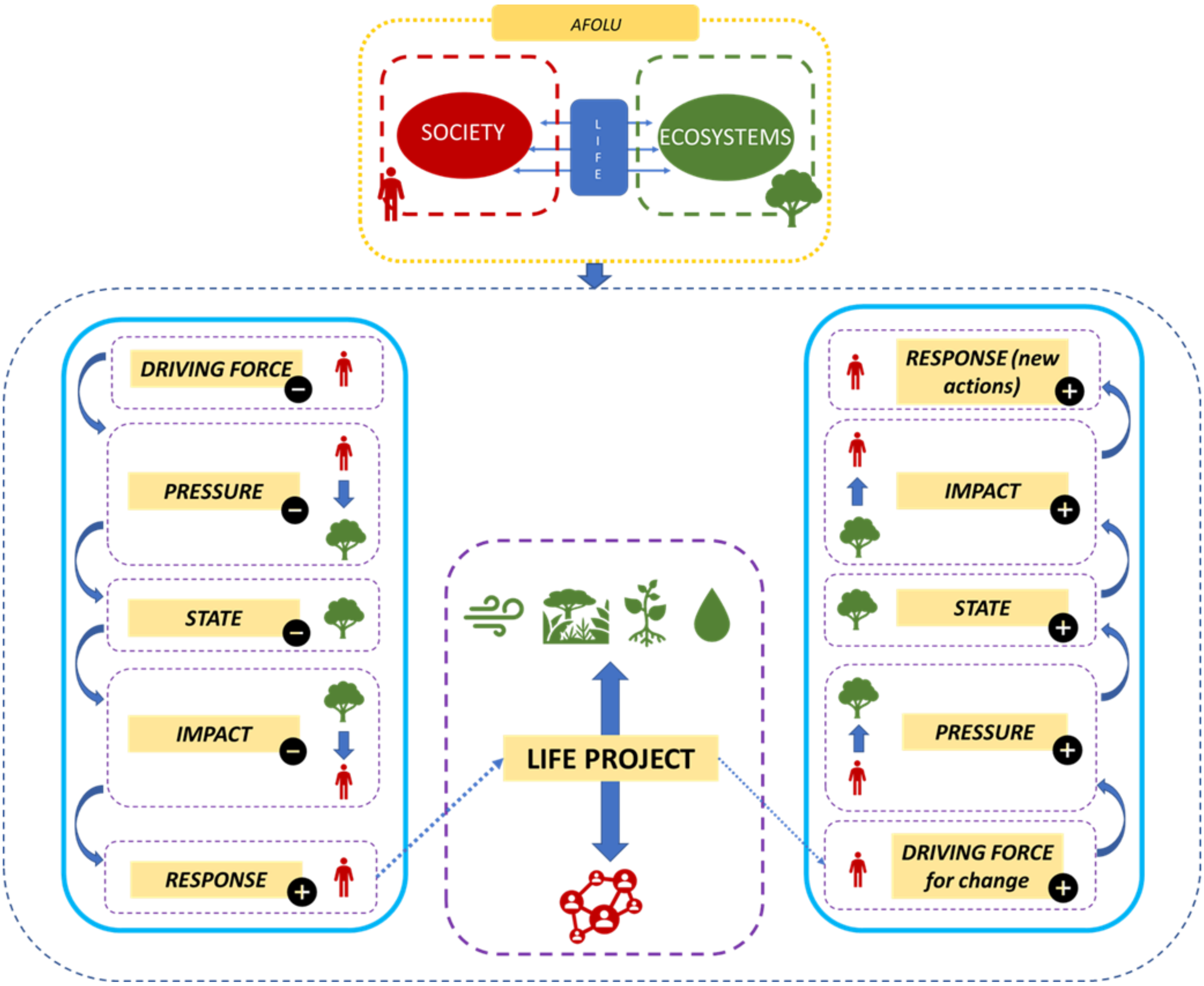


*Fig.1: Social-ecological relationships analysed through the DPSIR and SEN Frameworks*
*Source: own elaboration*

*Methods*

We collect data related to LIFE projects through the online database of the LIFE Programme where information about projects is available. We select projects focused on AFOLU activities and implemented in the last programming period (2014-2020) through the "theme" option, selecting the theme "Agriculture-Forestry", which allows us to select all projects concerning AFOLU activities, specifically agriculture, forestry, livestock, and grazing.
In relation to the RO1, we refer to sections related to *project description* and *environmental issues addressed* extracting information needed for the DPSIR framework using specified codes to analyse

causal SES relationships. After then, we synthesise their relationships through a graphic representation using the Sankey diagram composed of scales (i.e., Drivers, Pressures, States, Impacts and Responses) and levels (i.e., variables related to scales).
In relation to the RO2, we refer to the *environmental issues addressed* and *beneficiaries composing the project partnerships* sections to analyse structural SES relationships through Social Network Analysis (SNA). The former section is analysed to identify what environmental theme is addressed by projects (i.e., ecological nodes); the latter is used to identify all beneficiaries of LIFE Projects who concretely implement actions (i.e., social nodes). After identifying social and ecological nodes, we create the SEN, connecting: (i) all actors composing a partnership and (ii) every actor with the ecological nodes addressed by its projects. Consequently, we use SNA to calculate network statistics: density, degree centrality and betweenness centrality (Borgatti et al., 2013).

*Discussions based on results*

By selecting LIFE Projects having as theme "Agriculture-Forestry" in the LIFE database, 56 projects are selected.

The Sankey diagram (fig.2) shows causal SES relationships established through the DPSIR Framework. Specifically, selected LIFE Projects focused on AFOLU activities are especially related to the food chain, mainly on intensive agriculture practices and adaptation and mitigation to climate change. The analysis shows that LIFE projects try to reduce impacts of agricultural activities due to the:

- use of fertilisers and pesticides in intensive agriculture impacting especially soil and water,
- management of waste from agricultural activities impacting especially soil and air quality,
- GHG emissions from livestock and mechanisation impacting especially air quality,
- climate change impacting significantly on biodiversity.

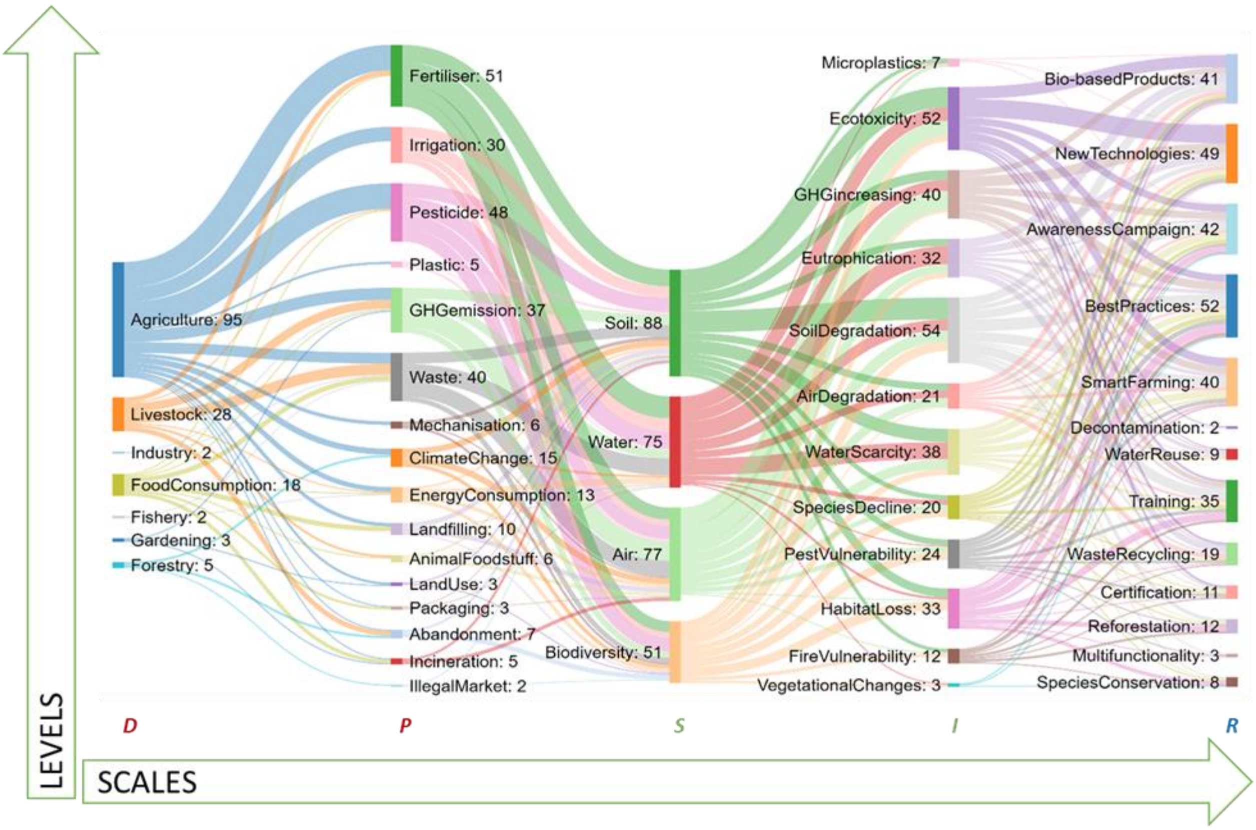


*Fig.2: Social-Ecological interaction addressed by the LIFE Projects.*

The SEN analysis allows us to understand the network structure of LIFE projects concerning AFOLU activities. Figure 3 shows that projects concerning water, soil and air are more connected than projects facing biodiversity challenges, this is confirmed by network statistics (tab.1), especially the number of actors having positive values of betweenness centrality. Nevertheless, projects related to water are characterised by a low number of relationships and, consequently, a low value of density. Tab.2 shows that most actors is financed through a LIFE-ENV project, especially considering projects related to soil and water. Moreover, actors are mainly from Spain and Italy. Tab.2 shows that German and Portuguese actors tend to implement projects related to biodiversity, conversely Greek and Dutch actors tend to implement project related to water. In all environmental themes actors mainly work on national scale. In addition, actors acting as bridges between different environmental themes are national authorities and universities located in Mediterranean countries working especially on LIFE-ENV projects related to soil, air, and water.

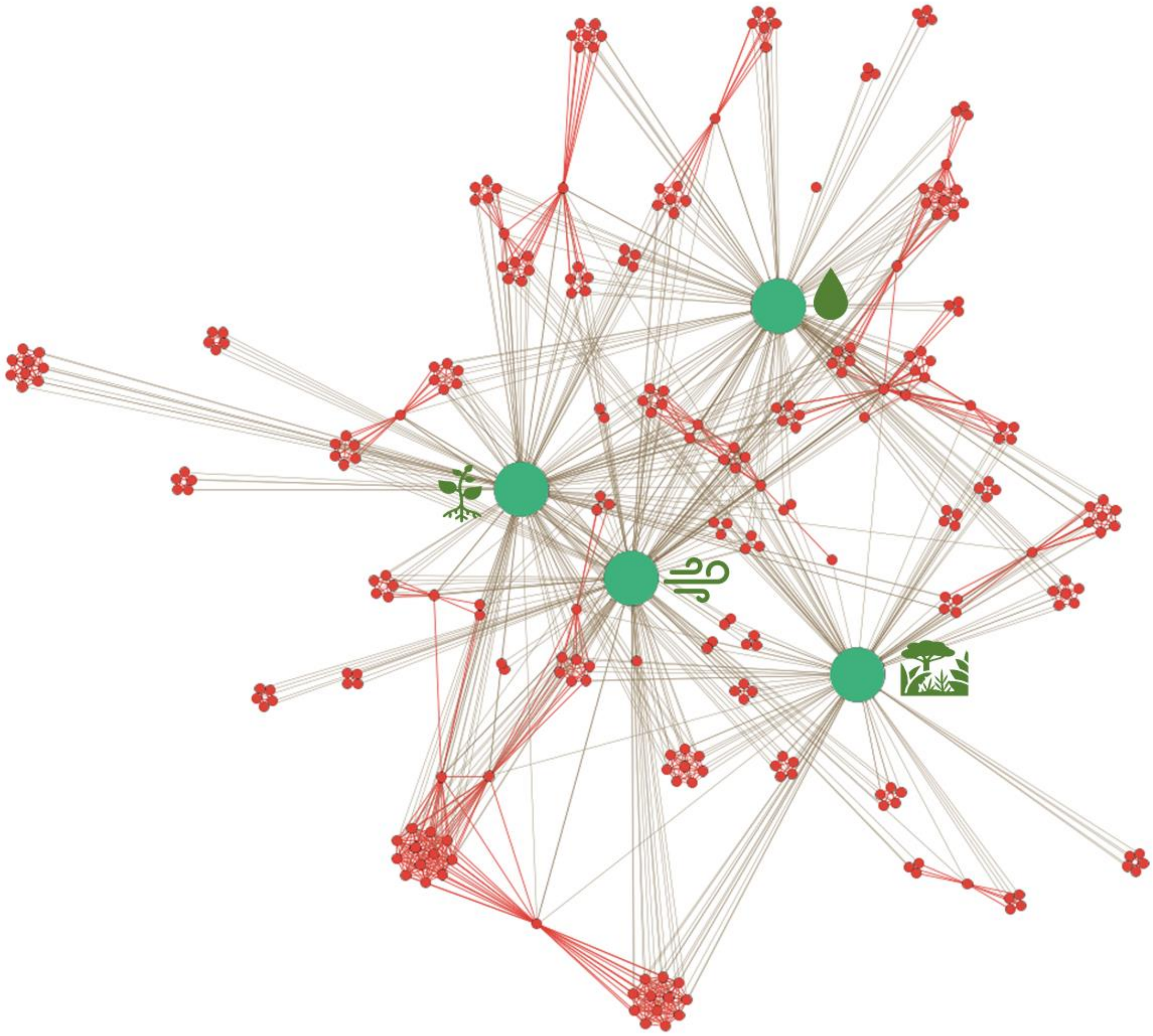

*Fig.3: Social-ecological network of LIFE projects related to AFOLU activities.*

| Theme | Projects | Nodes | Edges | Density | Av. Degree centrality | Nodes with Betweenness centrality >0 |
|---|---|---|---|---|---|---|
| **Air** | 15 | 142 | 497 | 0,05 | 7 | 8 |
| **Biodiversity** | 22 | 111 | 312 | 0,051 | 5,622 | 2 |
| **Soil** | 30 | 157 | 487 | 0,04 | 6,204 | 10 |
| **Water** | 30 | 140 | 367 | 0,038 | 5,243 | 8 |

*Tab.1: Network statistics of SEN.*

| | AIR | BIODIVERSITY | SOIL | WATER |
|---|---|---|---|---|
| *Type of LIFE project* | | | | |
| LIFE-ENV | 40,8 | 56,8 | 80,9 | 97,1 |
| LIFE-NAT | 0,0 | 5,4 | 0,0 | 2,9 |
| LIFE-GIE | 0,0 | 10,8 | 5,7 | 0,0 |
| LIFE-CCM | 2,8 | 0,0 | 2,5 | 2,9 |
| LIFE-CCA | 14,8 | 25,2 | 13,4 | 5,7 |
| LIFE-GIC | 0,0 | 3,6 | 2,5 | 0,0 |
| *Geographical area* | | | | |
| Austria | 1,4 | 1,8 | 1,3 | 0,0 |
| Belgium | 3,5 | 0,0 | 0,6 | 0,0 |
| Croatia | 0,0 | 0,0 | 0,6 | 0,0 |
| Cyprus | 3,5 | 0,0 | 2,5 | 2,9 |
| Denmark | 0,7 | 0,9 | 0,6 | 0,0 |
| France | 5,6 | 6,3 | 5,1 | 2,9 |
| Germany | 4,9 | 9,9 | 3,8 | 2,1 |
| Greece | 7,0 | 0,0 | 6,4 | 6,4 |
| Hungary | 1,4 | 1,8 | 0,6 | 0,7 |
| Ireland | 0,7 | 0,0 | 0,0 | 0,0 |
| Italy | 12,7 | 18,0 | 26,1 | 17,1 |
| Latvia | 0,0 | 0,0 | 0,0 | 0,7 |
| Luxembourg | 0,7 | 0,0 | 0,0 | 0,0 |
| Netherlands | 4,9 | 3,6 | 5,1 | 8,6 |
| Poland | 0,0 | 0,0 | 0,0 | 0,7 |
| Portugal | 3,5 | 9,0 | 3,2 | 2,1 |
| Slovenia | 0,0 | 0,0 | 0,6 | 0,0 |
| Spain | 48,6 | 47,7 | 42,0 | 54,3 |
| United Kingdom | 0,7 | 0,9 | 1,3 | 1,4 |
| *Level of governance* | | | | |
| International | 12,7 | 47,2 | 23,9 | 16,2 |
| National | 15,3 | 43,2 | 25,2 | 16,2 |
| Regional | 12,7 | 45,9 | 25,5 | 15,9 |
| Local | 20,7 | 40,0 | 25,0 | 14,3 |

*Tab.2: Actors (%) subdivided by environmental theme addressed.*

*Conclusions*

This study is a first attempt to clarify the social-ecological nature of LIFE projects evidencing that actions sustained by the LIFE Programme are characterised by both a social and ecological meaning to be converted in specific impacts on the social and ecological domain. Even if LIFE projects have a central environmental perspective in their objectives and outcomes, this study shows that they are fostered also by social needs and could be improved considering the social structure of networks composed of partnerships. In addition, in the long run, environmental outcomes could lead to positive social effects, such as increasing public awareness on environmental challenges, creating a new collaborative coalition, and developing new technologies.

*References*


Borgatti, S.P., Everett, M.G., Johnson, J.C. 2013. Analyzing Social Networks. SAGE Publications.

Gari, S.R., Newton, A., Icely, J.D. 2015. A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems. Ocean & Coastal Management 103, 63-77. http://dx.doi.org/10.1016/j.ocecoaman.2014.11.013

IPCC, 2019: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems https://www.ipcc.ch/site/assets/uploads/sites/4/2021/02/210202-IPCCJ7230-SRCCL-Complete-BOOK-HRES.pdf

Lemos, M.C., Agrawal, A. 2006. Environmental Governance. Rev. Environ. Resour. Vol.31 pp.297–325. https://doi.org/10.1146/annurev.energy.31.042605.135621

Lescourret, F, Magda, D., Richard, G., Adam-Blondon, A-F., et al. 2015. A social–ecological approach to managing multiple agro-ecosystem services. Current Opinion in Environmental Sustainability, 14:68–75. http://dx.doi.org/10.1016/j.cosust.2015.04.001

Pascual, U. & Howe, C. in Ecosystem Services and Poverty Alleviation: Trade-Offs and Governance 3–21 (Routledge, Oxon, 2018).

Rasmussen, L.V., Coolsaet, B., Martin, A., Mertz, O.,1, Pascual, U., Corbera, E., Dawson, N., Fisher, J.A., Franks, P., Ryan, C.M. 2018. Social-ecological outcomes of agricultural intensification. Nature Sustainability. https://doi.org/10.1038/s41893-018-0070-8

Sayles, J.S., Mancilla Garcia, M., Hamilton, M., Alexander, S.M., Baggio, J.A., Fischer, A.P., Ingold, K., Meredith, G.R., Pittman, J. 2019. Social-ecological network analysis for sustainability sciences: a systematic review and innovative research agenda for the future. Environ. Res. Lett. 14 093003 https://doi.org/10.1088/1748-9326/ab2619