



European Alliance for Regenerative Agriculture

# Regenerating Systemic Risk

## A Case Study in the Valencia Watershed on the Impact Potential of Regenerative Agriculture

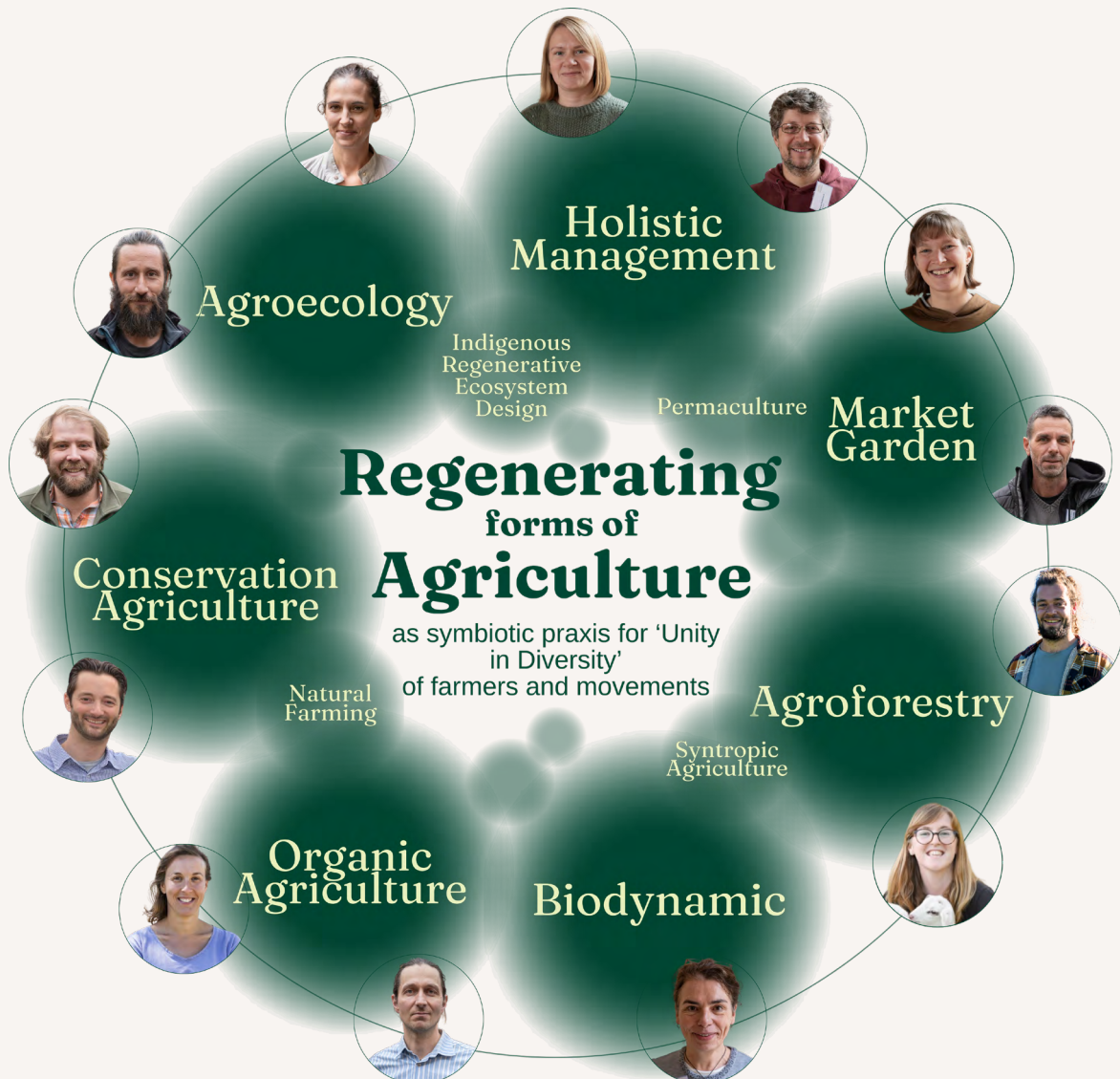
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Valencia

### About the European Alliance for Regenerative Agriculture

The European Alliance for Regenerative Agriculture is the independent, farmer-led coordination, advocacy and collective action organisation of the movement of regenerative agriculture at the European level. EARA is striving to enable the transformation of our agrifood ecosystems through accountable ecologic, economic and social regeneration.

More information can be found on our website at [www.eara.farm](http://www.eara.farm).



## Preface

This case study illustrates how systemic risk arises from degraded landscapes with reduced hydrological functions, manifesting as amplified droughts, desertification and floods. The findings demonstrate the value of addressing these risks through green and blue infrastructure, rather than relying primarily or exclusively on grey infrastructure. While the proposals and results are specific to the Valencian community, the analytical method can be applied to other flood-prone regions. Financial instruments and policies are essential, particularly at landscape scale. But risks of this magnitude ultimately require communities to act strategically and collectively, with shared regeneration as the common goal.

Central to this approach is recognising farmers, private actors, and public institutions as critical parts of the same system, each playing a distinct role in restoring its underlying health. This means all actors, from financiers to administrators, are moving away from viewing land as a distant asset to be managed, and toward seeing themselves as active participants in a living system. Policymakers, citizens, farmers, and the land itself are not separate interests to be balanced against one another. They are interconnected parts of a whole. Holistic, durable solutions depend on treating them as such.

EARA produces this case study to mark the beginning of a broader call to action. We invite farmers, homeowners, municipalities, regional and national governments, lenders, insurers and reinsurers to get in touch so we can deploy our pragmatic, action-oriented network to develop further analyses for your specific context. Degenerating ecosystems, public health pressures and economic stress are accelerating. Coordinated action, everywhere it is needed, is essential to achieving lasting change. Thank you!

## Acknowledgements

We are deeply grateful to the evolving, adaptive and resilient global movement of regenerating farmers, who are stewards of our lands. Their commitment to regenerating ecosystems and supporting rural communities form the essential foundations for the health of our planet and all its inhabitants.

We want to give particular thanks to Utku Berkalp Uenalán and AgriPurpose for supporting the remote sensing analyses contributing to this work.

Similarly, we acknowledge the work of the Asociación de Agricultura Regenerativa Ibérica (ARI, the Iberian Regenerative Agriculture Association), specifically their report written by William Anderson, Peter Ong and Naira de Gracia describing the impact potential of regenerating forms of agriculture on the systemic risks

exposed by the Valencian flood catastrophe of 2024. This report was developed, in part, to support the findings of their report with quantifiable outcomes. We also want to appreciate the visionary work that is being done in Europe and beyond on regenerating landscapes' water functions. Networks such as Regrarians, Water Stories, Water Holistic, Tarun Bharat Sangh, Friends of Seva Mandir or individuals such as Sepp Holzer, Nick Steiner, and countless other field workers and farmers building ponds, swales and other water harvesting earthworks while keeping soils covered, nourished and uncompacted.

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# Executive Summary

Valencia’s floods of October 2024 resulted in over 230 fatalities, and recovery demands exceeding €30 billion<sup>1</sup>, one of the most costly and deadly natural disasters in Spain’s history. While extreme rainfall and flooding triggered the severity of damages, it was compounded by a systematically degraded landscape whose capacity to regulate water has been severely reduced. This increased biogeophysical fragility translates directly to systemic economic risk that extends far beyond the Valencian landscape. This study demonstrates that a transition to regenerative systems would address the root causes of such disasters, while providing a multitude of economic, environmental and social benefits, at a fraction of the cost of recovery.

## Key Findings

<p>A full transition of key agricultural land could be possible within 4-6 years, at less than 5% of the cost of the estimated damages, and only 8.5% of the committed recovery fund.</p>
<p>Building climate resilience in agricultural landscapes is an effective approach for safeguarding lives and assets while reducing the damages incurred by natural disasters, including asset damage, waterway pollution, soil loss, and reduced agricultural production.</p>
<p>Regenerative systems are environmentally and economically resilient, with up to 50% reduced runoff compared to current agricultural land, and a significant mitigation of mudslides during torrential rainfall.</p>

Degraded agricultural landscapes increase the frequency and severity of uninsurable losses, strain public finances through repeated infrastructure maintenance and emergency payouts, undermine farm profitability and supply chain security, and reduce long-term productivity of land, labour, and capital through short-term losses. Together, these dynamics create cascading risks that transcend agriculture into financial stability, food prices, insurance markets, water management, and socio-economic resilience. Increased risk is evident through escalating global catastrophes where rural and periurban areas have suffered environmental and economic damages exacerbated by the surrounding landscape’s inability to regulate extreme weather events. As such, while this report focuses on Valencia, the opportunities available to address these challenges can apply to contexts across the globe.

This report shows that strategically transitioning toward regenerative agricultural systems is a key cost-effective response to these systemic risks, while delivering a host of other economic, environmental and food security benefits. By rebuilding soil organic matter, reducing mechanical disturbance, alleviating compaction, and maintaining continuous vegetative cover, regenerative management restores soil structure and hydrological function at scale. Our findings show that regenerating forms<sup>2</sup> of agriculture can mitigate nearly 60%<sup>3</sup> of similar flood impacts. At the landscape scale of Valencia’s perennial crop systems, this change corresponds to over 200 billion litres of additional water retained in soils rather than contributing to rapid water and mud flows and erosion.

Enduring climate resilience is imperative as cycles of drought and intense rainfall become more frequent due to the changing climate<sup>4</sup>. It is possible to embed this resilience in the Valencian landscape within a 4-6 year timeframe comparable to major

2 EARA uses the term ‘regenerating forms of agriculture’ instead of ‘Regenerative Agriculture’ on the basis that regeneration is a continuous process rather than a singular one and that regeneration is ‘unity in diversity’ facilitated by cooperation of practices and actors from different backgrounds for more details see other publications at [www.eara.farm](http://www.eara.farm).  
3 Taken as an average of the landscape under analysis.  
4 European Commission, Consequences of Climate Change (LINK)

1 Bloomberg (2025). Valencia asks for €31 Billion rescue package after deadly floods. (LINK)

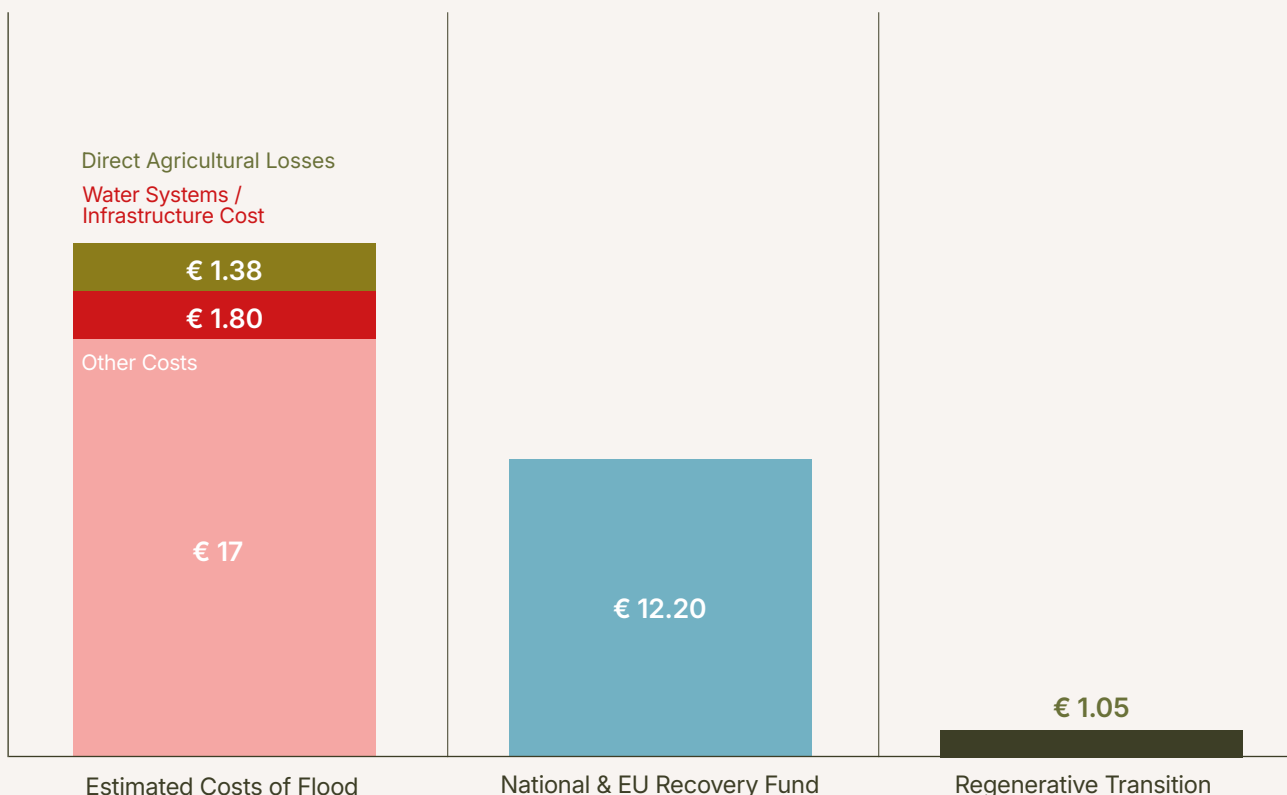
grey infrastructure projects. Focusing on high-risk zones in the upper slopes also offers a lower-cost alternative that can deliver disproportionate benefits downstream, particularly if complemented by targeted hydrological interventions across the landscape. Pairing these responses would substantially increase infiltration capacity, slow runoff, mitigate mudslides, and reduce both flood peaks and drought vulnerability. Regenerative agricultural systems are a low-cost solution. Taking the highest estimated transition cost over 5 years represents just 5% of the total economic losses, and only 8.5% of the allocated recovery fund. In return, the increased landscape resilience provided by functioning ecosystems and effective blue-green flood infrastructure could greatly reduce the economic impact of future flood events. This approach, in effect, would turn each piece of agricultural land into its own piece of water management infrastructure, while delivering a host of co-benefits that extend beyond traditional flood

mitigation infrastructure. We can invest 5% now to build living infrastructure, or pay 100% later to rebuild ruins.

Banks and lenders can reduce their exposure to stranded agricultural assets, insurers and reinsurers can mitigate their increasing loss ratios and climate insurance claims, and governments can build durable and continuously improving climate resilience through the cost-effective integration of living infrastructure. Finally, farmers can secure the long-term production of their farmland, improve their margins, reduce their input dependency<sup>5</sup>, and stabilise their production in the face of climate volatility<sup>6</sup>. This increased stability boosts local, regional, and national economies through lowered exposure to market fluctuations.

<sup>5</sup> Farmer-led Research on Europe's Full Productivity The Realities of Producing More and Better with Less - Place-based Innovation for the Good of All ([LINK](#))  
<sup>6</sup> Rehberger, E., West, P. C., Spillane, C., & McKeown, P. C. (2023). What climate and environmental benefits of regenerative agriculture practices? An evidence review. Environmental Research Communications, 5(5), 052001. ([LINK](#))

### Comparative Costs of Flood Damage to 5-year Regenerative Transition (in Billion Euros)



EARA's network of farmers and organisations holds a general indication of what pioneering regenerating farmers in Valencia and Spain can achieve in terms of soil health and water-related soil functions to date. [Asociación de Agricultura Regenerativa Ibérica](#) (ARI) released [this video](#) of a Valencian vineyard following the October floods, demonstrating the mitigating potential of integrating regenerating forms of agriculture on sloped landscapes. The video outlines the stark comparison of landscape damages to conventional against regeneratively managed systems, with a drastic reduction in erosion and mudflow<sup>7</sup>.

While the concepts outlined in the Valencian context are broadly transferable across Europe and the world, their **effective integration** requires context-specific analyses and local, farmer-led co-creation, to ensure appropriate and targeted interventions. It is equally important to note that regenerating forms of agriculture rely on systemic approaches, rather than prescriptive sets of practices. Regeneration isn't an expense; it's an insurance policy that pays its own premiums.

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<sup>7</sup> Similarly, [EARA's Research](#) highlights the improved ecological performance of regenerative farms in the Spanish, Mediterranean and European context.



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# Introduction

Natural catastrophes are increasing in both frequency and severity, leading to severe environmental, economic, and social damages<sup>8</sup>. In 2021 global natural disasters generated over €211 billion in total economic losses, of which only €88 billion were insured<sup>9</sup>. In the European context, floods alone caused approximately €46 billion in losses, of which €11 billion were insured, demonstrating the necessity for resilient, long-term climate solutions.

The European Insurance and Occupational Pensions Authority (EIOPA) estimates over €100 trillion in climate change risk exposure in Europe alone, accounting for buildings, content, and business interruption. Windstorm and river flood damage constitute the greatest exposure risk, at €42.6 trillion and €28.9 trillion, respectively<sup>10</sup>.

## Total Cost Trend of Climate Disasters from 1980-2024

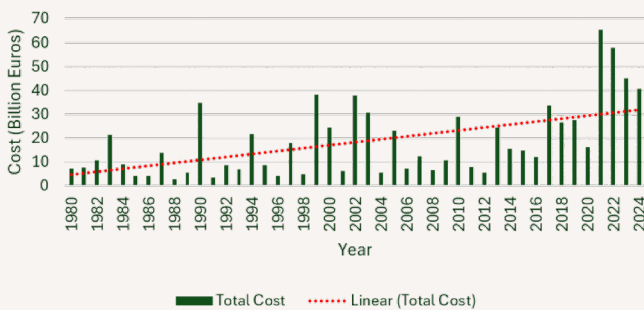


Figure 1 | Increasing economic losses caused by climate extremes in Europe, trendline in red showing the linear increase of ~€10 Billion every 12 years<sup>11</sup>.

Only 35% of total losses from climate disasters in Europe are currently insured<sup>12</sup>, reflecting enormous risk for insurers, investors, institutional asset managers, and governments. Particularly, global populations are at large risk due to changing climates and extremes where, historically, no risk was associated. Increasing frequency of these events will inevitably raise underwriting risk, liquidity risk, and capital pressure for insurers and reinsurers in the coming years.

8 European Commission, Consequences of Climate Change ([LINK](#))  
 9 European Insurance and Occupational Pensions Authority. (2022). Discussion paper on physical climate change risks: European insurers' exposure to physical climate change risk. EIOPA. ([LINK](#))  
 10 EIOPA. (2022). ([LINK](#))  
 11 Data sourced from European Environment Agency (2023). Economic Losses from weather- and climate-related Extremes in Europe - 8th EAP. ([LINK](#))  
 12 EIOPA. (2022). ([LINK](#))

This leads to inflated reinsurance costs and higher primary premiums, making insurance even less affordable or entirely unavailable for the 65% who remain uninsured. 'Permanent uninsurability' is a term growing in use in areas experiencing high climate-risk, particularly in riparian of coastal floodzones<sup>13</sup>. Risk pricing is critically important for insurers, reinsurers, and the communities they serve, yet the conversation typically revolves around adjusting premiums against rising claims and losses. If this trajectory continues, permanent uninsurability will inevitably become embedded in many landscapes, while premiums in others rise beyond the reach of local communities. Alternatively, rising claims and recovery packages risk overwhelming the institutions that bear them, potentially destabilising insurance and lending systems as they currently exist. Neither the private nor the public sector can bear the costs of risk reduction alone. It requires collaborative and coordinated intervention. Building resilience in the landscapes most exposed to these events is the most effective way to reduce claims, lower premium costs, and avoid over-extending the financial support needed to sustain it.

Regenerating forms of agriculture<sup>14</sup> offer a key pathway to restoring resilience, while boosting farm profitability and rural economies, and ultimately the long term viability of agricultural production. Generally, nature-based solutions (NbS) remain underrepresented within climate adaptation and mitigation initiatives despite their cost-efficiency and lasting effects at local and regional scales<sup>15</sup>. In Europe, nature restoration and NbS have been found to have returns ranging from €4–€38 for every €1 spent<sup>16</sup>. While the Ministry for the Ecological Transition's 'Plan Recuperación y mejora resiliencia'<sup>17</sup> for Valencia mentions NbS as a crucial target for building resilience, there is little mention of their integration to agricultural land.

Unfortunately, incorporating NbS in resilience building for risk-prone rural, peri-urban and urban zones is underexplored at the EU level as well. The focus continues to be on asset-based mitigation and adaptation measures like buildings, infrastructure, and businesses rather than implementing a systemic approach.

13 Gilmore, S. (2025). Urgent action needed to prevent an uninsurable future. [online] GlobalMarkets. ([LINK](#))  
 14 EARA uses the term 'regenerating forms of agriculture' instead of 'Regenerative Agriculture' on the basis that regeneration is a continuous process rather than a singular one and that regeneration is 'unity in diversity' facilitated by cooperation of practices and actors from different backgrounds for more details see other publications at [www.eara.org](http://www.eara.org).  
 15 Opperman, J. J., & Galloway, G. E. (2022). Nature-based solutions for managing rising flood risk and delivering multiple benefits. *One Earth*, 5(5), 461-465. ([LINK](#))  
 16 European Commission, Nature Restoration Regulation ([LINK](#))  
 17 Plan Recuperación y mejora resiliencia ([LINK](#))

Building climate resilience in agricultural landscapes is an effective approach for safeguarding lives and assets while reducing the damages incurred by natural disasters, including asset damage, waterway pollution, soil loss, and reduced agricultural production. Regenerating forms of agriculture address structural vulnerabilities inherent in conventional systems by establishing resilient and effective modes of production.

Supporting regenerating forms of agriculture through targeted investment, technical advisory, and enabling legal and fiscal frameworks can deliver multiple long-term benefits: climate adaptation, water security, rural economic resilience, and landscape regeneration. EARA's study<sup>18</sup> demonstrates regenerating farmers achieving similar yields, but with 61% less synthetic nitrogen fertiliser and 75% less pesticides, while making a 20% higher gross margin per hectare. More crucially, in the context of hydrological risk management, by rebuilding soil carbon, maintaining continuous living roots, ensuring year-round ground cover, and introducing planned grazing, regeneratively managed systems increase water infiltration and retention<sup>19</sup>, slow surface runoff, and significantly reduce the intensity of cumulative waterflow and destructive erosion.<sup>20</sup>

Over time, these production systems also contribute to the restoration of local and regional water cycles<sup>21</sup>, reducing drought and flood risk<sup>22</sup> and restoring the landscape's hydrological function<sup>23</sup>. Farm-level changes will affect the small water cycle – the capacity for a particular piece of land to effectively infiltrate, use, and cycle water. However, larger landscape-level changes can impact the large water cycle by influencing rainfall patterns and the retention of water within regional watersheds.

Scaled transitions aiming to achieve this impact require policy driven and privately supported action coordinated across regions. However, regenerative management reduces input costs and improves long-term crop yields, promoting food sovereignty, better farm profitability and increased quality of life for farmers, supporting generational renewal and rural development<sup>24</sup>.

Valencia represents less than 3% of Spanish agricultural land, but produces 65% of Spanish oranges, 18% of Spain's fruit and vegetable exports<sup>25</sup> and 12% of total agricultural exports<sup>26</sup>, making it a key pillar of Spanish agriculture. However, increasing climate vulnerability is placing the long-term productivity of Valencian agriculture at risk. Valencia's climate is characterised by both prolonged dry periods and increasingly intense rainfall. The result of these events is being exacerbated by a systematically degraded landscape with a drastically reduced capacity to regulate its ecosystem.

The vulnerability of the Valencian Community was revealed during the October 2024 floods as several hilly areas (particularly conventional winegrowing zones and citrus-producing areas) lacked any protective ground cover or functioning soil biology. With little vegetation to slow or absorb rainfall, the surge of water and the exposed topsoil created powerful mudflows and intensified the runoff, leading to devastating impact.

18 See more [here](#)  
 19 Henriette I Jager, Esther S Parish, Matthew H Langholtz, Anthony W King, Perennials in Flood-Prone Areas of Agricultural Landscapes: A Climate Adaptation Strategy, *BioScience*, Volume 70, Issue 4, April 2020, Pages 278–280. ([LINK](#))  
 20 Marley, C. L., Fychan, R., Davies, J. W., Scott, M., Crotty, F. V., Sanderson, R., & Scullion, J. (2024). Grasslands and flood mitigation—Contrasting forages improve surface water infiltration rates. *Science of the Total Environment*, 951, 175598. ([LINK](#))  
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 23 Mauser, W., & Bach, H. (2009). PROMET—Large scale distributed hydrological modelling to study the impact of climate change on the water flows of mountain watersheds. *Journal of Hydrology*, 376(3–4), ([LINK](#))

24 EARA Study, (2025)., Farmer-led Research on Europe's Full Productivity The Realities of Producing More and Better with Less - Place-based Innovation for the Good of All ([LINK](#))  
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 26 Grupo Cooperativo Cajamar (2025). NOTA DE PRENSA VALENCIA 1 DE ABRIL DE 2025. (n.d.). ([LINK](#))

# Objective of this Report

This report offers a systematic impact assessment of the potential contribution of regenerating forms of agriculture to flood mitigation over 316,000 hectares<sup>27</sup> within a high-risk watershed, an analytical exercise rarely undertaken at this scale. It seeks to support decision making by Spanish authorities as well as international governments like Italy<sup>28</sup>, Germany<sup>29</sup>, Austria<sup>30</sup>, Belgium<sup>31</sup>, Czech Republic<sup>32</sup> and beyond who have similarly suffered water-related environmental and economic erosion to rural and peri-urban areas resulting from extreme weather, exacerbated by degraded ecosystems within their farmland. Additionally, the extent and increasing cost of climate disasters in Europe is excluding high-risk zones from access to climate insurance<sup>33</sup>. A cohesive response by insurers, reinsurers, regions, and municipalities<sup>34</sup> could proactively reduce the risk of extensive damage in these zones, further mitigating the cost and damage of future events. As such, though the analyses within this report are set within the specific context of Valencia, the findings are organised to serve as a design framework for regions facing comparable challenges worldwide.

While governments typically address the immediate impacts of these events, this proposal examines the rationale and mechanisms needed to structurally re-embed resilience in the Valencian watershed through management systems for the regeneration of its farmland. For this to succeed, the recovery fund, private-sector support, and farmer advisory serve as key instruments for integration.

EARA has prepared this report, leveraging its agronomic expertise to inform policy and investment decisions which can address the root causes of this type of disaster at both national and international level. The intention is to shift from reactivity to proactivity, and to enable solutions which can prevent and mitigate the environmental, economic, and social damages caused by climate catastrophes. Reactive measures do not create long-term protection against the, increasingly probable, future climate shocks. Flood management infrastructure does not address the underlying cause of these events, nor does it insure against the likelihood of another flood disaster. Without addressing the underlying causes of the disaster, such infrastructure will prove in time wholly inadequate and may in some cases exacerbate future disasters, particularly when the amount of water may exceed infrastructure carrying capacity. It is imperative that policymakers and insurers understand the fundamental role that conventionally managed agricultural land plays in intensifying flood impacts.

Urban infrastructure, notably public drainage systems and water management networks, play an important role in managing flooding events. Paved surfaces cannot infiltrate water, only accelerate the flow of water arriving from upstream catchments. Extreme rainfall and flooding places excessive strain on this infrastructure, overwhelming its capacity to redirect or stock water. As the scope of this report relates primarily to the impact of agricultural land, in upstream and downstream zones, the development of future water infrastructure is not discussed. The focus is rather placed on these zones that receive and accumulate water before urban and peri-urban areas to reduce the flood impact further downstream, or to mitigate it once it exits the cityscape.

<sup>27</sup> Hectares derived from spatial analysis, data retrieved from [Copernicus](#)  
<sup>28</sup> Valente et al. (2025). The 2023 floods in the Emilia-Romagna Region, Italy: A retrospective qualitative investigation into response strategies and criticalities. *International Journal of Disaster Risk Reduction*, 116, 105089. ([LINK](#))  
<sup>29</sup> Frankfurter Rundschau (2023). Ahrtal catastrophe, so high are the costs for Germans. ([LINK](#))  
<sup>30</sup> Niranjan, A. (2024, September 21). "Catastrophe region": Austrian city faces up to scale of damage left by deadly flooding. *The Guardian*; *The Guardian*. ([LINK](#))  
<sup>31</sup> The Brussels Times. How Belgium's fatal floods changed its approach to future disasters. ([LINK](#))  
<sup>32</sup> Niranjan, A. (2024). "We're getting rid of everything": floods destroy homes and lives in Czech Republic. *The Guardian*; *The Guardian*. ([LINK](#))  
<sup>33</sup> As in the [Netherlands](#) and the [UK](#) where private insurers are retreating from high-risk areas.  
<sup>34</sup> Including citizens and individuals who have lost access to insurance. Investing in local farmland to cover the transition costs is a key solution to building local and regional resilience against climate extremes.

# Context

## Climate

Europe's rate of climate-related crises has increased significantly since the 1980s, with water-related events accounting for nearly half of all recorded disasters<sup>35</sup>. Mediterranean regions are experiencing more dramatic DANA (Depresión Aislada en Niveles Altos) storms, causing extreme flooding and disastrous social, environmental, and economic consequences.

Spain is particularly vulnerable, and ranks among the highest for both economic losses and mortality<sup>36</sup>. On October 29, 2024, certain Valencian regions in the Demarcación Hidrográfica del Júcar in watershed received more than 400mm/m<sup>2</sup> (4 million litres per hectare) of rain<sup>37</sup> in under 24 hours, with extreme sites recording over 700mm. Downstream impacts were intensified by the soil's limited capacity to infiltrate the water, likely diminished by sealed roads and overloaded urban drainage systems, prior droughts and fragile, extractive agricultural practices. The floods caused extensive regional damage, prompting recovery demands exceeding €30 billion<sup>38</sup> from the Valencian government, and resulting in more than 230 fatalities.

**Beyond the economic implications of this damage, the potential for health complications poses serious risks difficult to quantify. Disease and illness are largely carried by waterborne and airborne bacteria that are spread due to microbiological contamination of water sources<sup>39</sup>, bacterial diseases, and respiratory issues caused by heavy particles<sup>40</sup> in the air or in the water.**

Conventional agriculture disproportionately affects this contamination due to increased topsoil erosion, effluent deposits in waterways, and agrochemical leaching. While this is not directly addressed within

35 European Environmental Agency 2025, Economic losses from weather- and climate-related extremes in Europe. [\(LINK\)](#)

36 European Environmental Agency 2025, [\(LINK\)](#)  
37 Rombeek et al. (2025). Torrential rainfall in Valencia (Spain) recorded by personal weather stations preceding and during the 29 October 2024 floods. EGU sphere, 2025, 1-29. [\(LINK\)](#)

38 Bloomberg (2025). Valencia asks for €31 Billion rescue package after deadly floods. [\(LINK\)](#)

39 European Climate and Health Observatory, Health Impacts of Flooding [\(LINK\)](#)  
40 For example, the dust, mud, clay, or other particles that are lost due to topsoil erosion.

this report, the proposed recommendations target the causes of these adverse effects, focusing on water filtration and treatment, reduced mudflows and erosion, and a reduction of agrochemicals.

Spain's agricultural insurance loss ratio exceeds 100%, reflecting rising exposure to climate stress coupled with limited preventative action<sup>41</sup>. Spanish insured and uninsured losses are three times the EU average, with annual expected losses of €2 billion–€3 billion and estimated 1-in-50-year losses surpassing €20 billion<sup>42</sup> by 2050. Figure 2 illustrates exemplarily the cost of 1-in-50-year climate events on crop losses, with Spain bearing the highest financial burden. These events are expected to occur more frequently, reducing national adaptive capacity.

**Crop Production 1-in50 year PML for Primary Perils (€ mil.)**

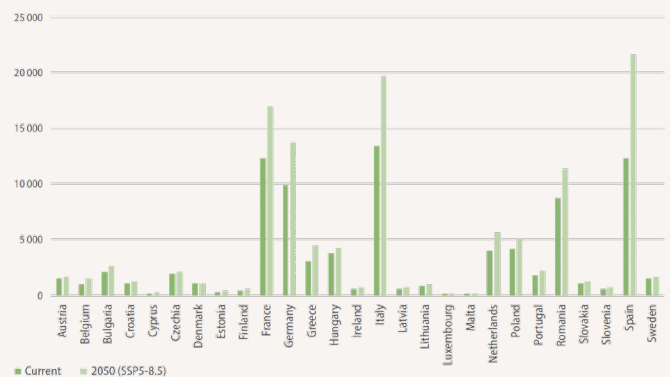


Figure 2 | Agricultural Crop 1-in-50-year Probable Maximum Loss (PML). Present day and 2050 projections<sup>43</sup>

## Valencian Agriculture

Valencian agriculture is largely characterised by conventional agriculture practices<sup>44</sup> that have led to a degradation of the landscape's protective capacity in times of climate stress (heat, flood, drought, wind, and fire). Soil health has been progressively degraded through a set of reinforcing mechanisms.

41 FI Compass 2025, Insurance and Risk Management Tools for Agriculture in the EU [\(LINK\)](#)

42 European Environmental Agency 2025 [\(LINK\)](#)

43 FI Compass 2025, Insurance and Risk Management Tools for Agriculture in the EU [\(LINK\)](#)

44 Soto et al. (2021). Restoring soil quality of woody agroecosystems in Mediterranean drylands through Regenerative Agriculture. Agriculture, Ecosystems & Environment, 306, 107191. [\(LINK\)](#)

The mechanisation of agriculture enabled the cultivation of vast new land areas, driving deforestation<sup>45</sup> and large-scale depletion of soil carbon stocks<sup>46</sup>. Repeated machinery use compacts soils, breaks down aggregates<sup>47</sup>, accelerates carbon loss<sup>48</sup> and reduces water infiltration<sup>49</sup>. Repeated compaction of the soil creates what is known as a 'plow pan', restricting oxygen and water cycling. The combined result is a landscape with reduced capacity to absorb rainfall, buffer flood events, and sustain long-term productivity.

Synthetic fertiliser dependency suppresses microbial diversity<sup>50</sup> and weakens plant-soil interactions<sup>51</sup>, reducing the soil's capacity to absorb and retain water. Extended periods of bare soil limit vegetative cover, leaving the soil exposed to surface sealing, erosion<sup>53</sup> and biological decline<sup>54</sup>. Flood irrigation, still widely practiced across the region, compounds this by mobilising excess nitrate and phosphorus into groundwater<sup>55</sup>, imposing significant costs on water treatment infrastructure<sup>56</sup>, and disrupting key biological processes within the soil by spreading synthetic inputs indiscriminately across a plot of land.

This represents a material and measurable risk to insurers, lenders and public authorities operating in the region. A more detailed contextualisation on the impact of conventional Valencian agriculture can be found in the appendix.

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45 Olmstead, A. L., & Rhode, P. W. (2001). Reshaping the landscape: The impact and diffusion of the tractor in American agriculture, 1910–1960. *Journal of Economic History*, 61(3), 663–698. ([LINK](#))

46 Haddaway et al. (2017). How does tillage intensity affect soil organic carbon? A systematic review. *Environmental Evidence*, 6(1), 30.. ([LINK](#))

47 Tavares, J.; Tessier, D. Characterization of soil structure and porosity under long-term conventional tillage and no-tillage systems. *Rev. Bras. Ciência do Solo* 2009, 33, 1837–1844. ([LINK](#))

48 Balesdent, J., Chenu, C., & Balabane, M. (2000). Relationship of soil organic matter dynamics to physical protection and tillage. *Soil and tillage research*, 53(3-4), 215-230. ([LINK](#))

49 Rathnayake, N. R. W. S., Leelamanie, D. A. L., & Maeda, M. (2025). Shallow-depth hardpan attributes influence soil surface and subsurface hydraulic properties. *Catena*, 259, 109405. ([LINK](#))

50 Geisseler, D., & Scow, K. M. (2014). Long-term effects of mineral fertilizers on soil microorganisms—A review. *Soil Biology and Biochemistry*, 75, 54–63. ([LINK](#))

51 Tripathi, S., Srivastava, P., Devi, R. S., & Bhadouria, R. (2020). Influence of synthetic fertilizers and pesticides on soil health and soil microbiology. In *Agrochemicals detection, treatment and remediation* (pp. 25–54). Butterworth-Heinemann. ([LINK](#))

52 Gupta, S. K., & Singh, A. K. *Soil and Water: A Source of Life*. ([LINK](#))

53 Gabriel, J. L., García-González, I., Quemada, M., Martín-Lammerding, D., Alonso-Ayuso, M., & Hontoria, C. (2021). Cover crops reduce soil resistance to penetration by preserving soil surface water content. *Geoderma*. ([LINK](#))

54 Barber (1979). Corn residue management and soil organic matter. *Agronomy Journal* 71: 625–627

55 Alom, K., Akbar, D., Xu, C. Y., & Dong, T. (2025). Assessing Environment Impacts of Chemical Fertilizers Consumption in Australia: State-level evidence. *Environmental and Sustainability Indicators*, 101053. ([LINK](#))

56 Visionary-project.eu. (2023). SPI of the month: Organic farming & collective water management in the Region of Valencia | VISIONARY. ([LINK](#))

# Methodology

## Key Assumptions

The analysis conducted within this report relies on certain key assumptions about the nature of the DANA rainfall event, on the state of Valencian agriculture as well as the potentials of regenerating agricultures and the transition thereto. In the absence of systematic ground-level analyses and data, these assumptions allow for the landscape analysis to guide further analyses within the Valencian community.

Firstly, for our hydrological analysis we have taken the watershed average of 200mm accumulated rainfall for the 24-hour period of the flood event. Other analyses<sup>57</sup> have put the average rainfall at 150mm over a smaller landscape (250,000 hectares). Recognising the likelihood of these events to occur more frequently and intensively with climate change proceeding, this report takes a higher average over a larger scale. Working at this scale requires approximate data, and as it is highly improbable that the entire 316,000 hectares of land under analysis will experience a uniform rainfall event of >400mm, we take 200mm to approximate optimally for extreme- and intermediary-risk flood events.

EARA has ample practical and technical experience in accompanying farmers through the regenerative transition of their land. While each journey is context-specific and highly dependent on climate, soils, financial capacity, and social barriers, our farmer-base has outlined the time period of 4-6 years as a reasonable estimate for the context of Spain, as well as Europe at large. Similarly for the cost of the transition, we take conservative estimates of a 5-year transition period as an average, and make all comparisons based on the highest estimated cost for this same timeframe. Included in these comparisons are operational costs and an agronomic consultancy fee of €1000 per farm, per year.

To demonstrate the true cost-effectiveness of regenerating forms of agriculture as a solution to compounding climate risks, our results assume a 100% adoption rate over the entire landscape.

<sup>57</sup> Rombeek, N., Hrachowitz, M., & Uijlenhoet, R. (2025). Torrential rainfall in Valencia (Spain) recorded by personal weather stations preceding and during the 29 October 2024 floods. *EGUsphere*, 2025, 1-29. [LINK](#)

We recognise this is highly unlikely without strategic concerted public-private action, though highly desirable. We make further recommendations for targeted interventions in high-risk zones that can provide disproportionate benefits to building landscape resilience.

Finally, a methodological assumption relates to the spatial resolution of the satellite data used for the NDVI analysis. Due to capacity constraints and data availability, the Copernicus land-use dataset is not resolved at the field level and does not provide delineated parcel boundaries from which farm-specific conclusions can be drawn. The analysis is therefore conducted at the pixel level. For clarity and interpretability, these pixel-level NDVI values are referred to as 'fields', although they do not correspond to actual farm parcels. This terminology is used to illustrate the potential for field- and farm-level interventions; however, higher-resolution satellite data and parcel-level delineation would be required to derive robust conclusions at farm or sub-regional scale. Further details on this approach and its limitations are discussed in the Annex.

## Landscape Identification

The methodological approach proposed in this report links systemic, extractive agricultural management and the intensification of climatic events like the floods of October 2024. The analysis shared within this case study demonstrates the potential for a nature-based response to the Valencian disaster by transitioning roughly 316,000 hectares of Valencia's agricultural land to build long-term economic and climate resilience.

Area selection for the Valencia case study was guided by a watershed-based approach, reflecting the hydrological reality that flood events are driven by cumulative water transport processes across entire catchments rather than by isolated locations. As flood risk reduction measures must be assessed holistically, watersheds were used as the initial spatial unit for analysis.

River and flow networks - each represented by a different colour in Figure 3 - were identified from the intersection of flooded areas, and to build an understanding of the landscape that contributed to high-flow flooding. Using the HydroSHEDS level



Figure 3 | Localisation of Valencia in Spain (left), and contributing flow networks across the Jucar Watershed (right)<sup>58</sup>

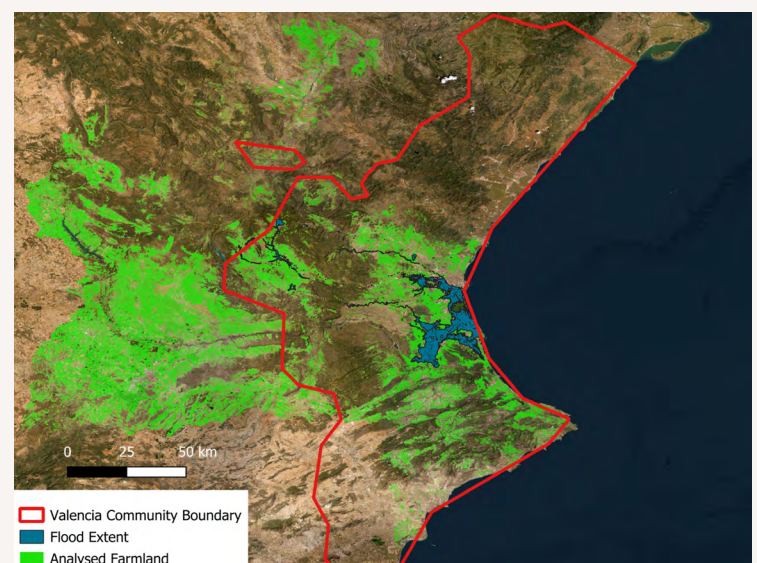
dataset<sup>59</sup>, all upstream sub-basins contributing to these flow paths were delineated. Sub-basins intersecting the affected river networks were selected and dissolved into a single geometry, defining the overall region of interest (ROI). This combined contributing area covers approximately 3.33 million hectares and represents the landscape potentially influencing flood dynamics in Valencia during the event.

Agricultural land and crop type was sourced from the Copernicus primary crop layer<sup>60</sup>, with 938,000 hectares of agricultural land identified within the watershed. Data from Copernicus outlines data on production type (permanent or annual), in addition to higher resolution data on the crop type and group.

Agricultural land within the selected watershed was then matched to weather stations (AEMET and PWS) recording the highest 24-hour rainfall totals. Figure 5 shows rainfall concentration on 29 October 2024, largely affecting the Valencian Community, particularly the upstream areas surrounding the Magro river, leading to intense flooding around the Albufera. These upstream catchments recorded over 400mm in just 24 hours, with some others exceeding the annual average rainfall for the Valencian Community of 445 mm per year<sup>61</sup>.

Many coastal and southern areas experienced much less daily accumulated rainfall, ranging from 15-100mm, however their positioning downslope of the upstream catchments like Utiel, Chiva, and Turis led to extensive flood damage from accelerated water flow.

Figure 4 | Agricultural land (green) within the Jucar Watershed, Valencia Community border in red.



58 Data retrieved from [Centro de Descargas](#)  
 59 Data retrieved from <https://www.hydrosheds.org/>  
 60 Data retrieved from [Copernicus](#)  
 61 Valencia Weather and Climate ([LINK](#))

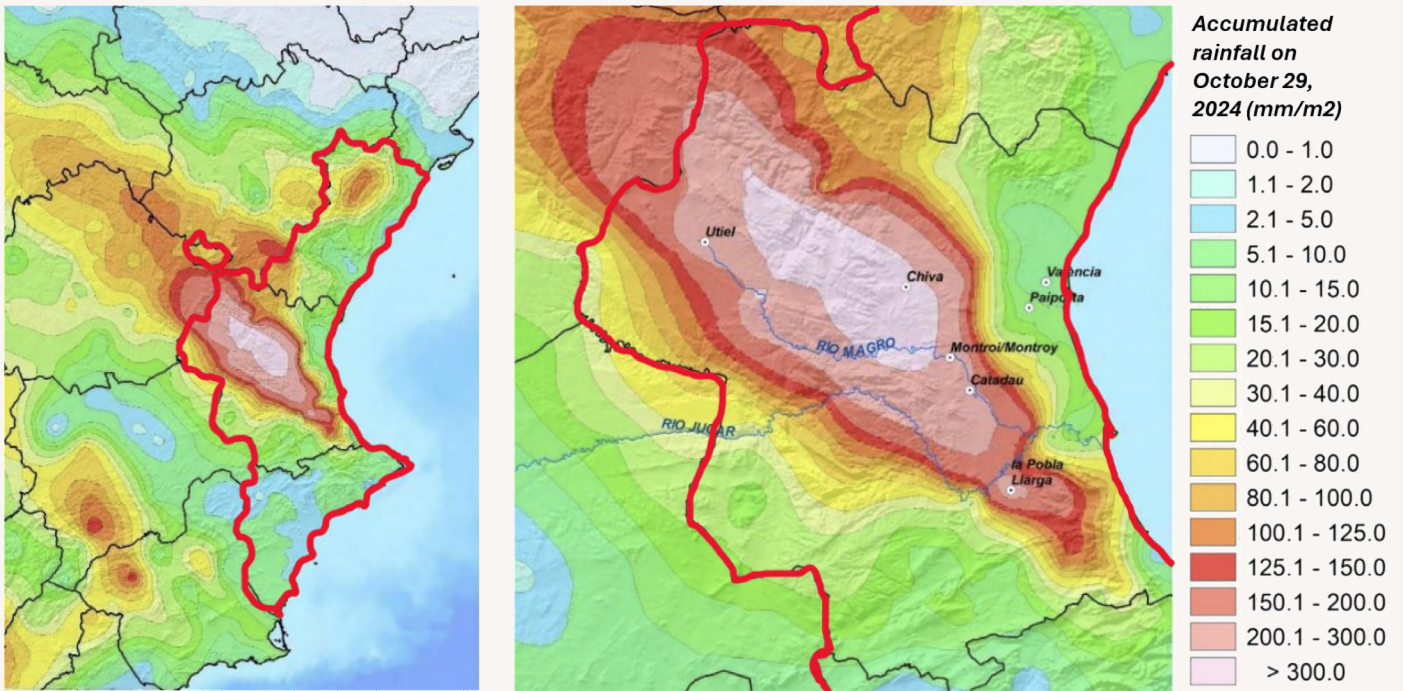


Figure 5 | Concentration of accumulated rainfall October 29 in mm/m<sup>2</sup>

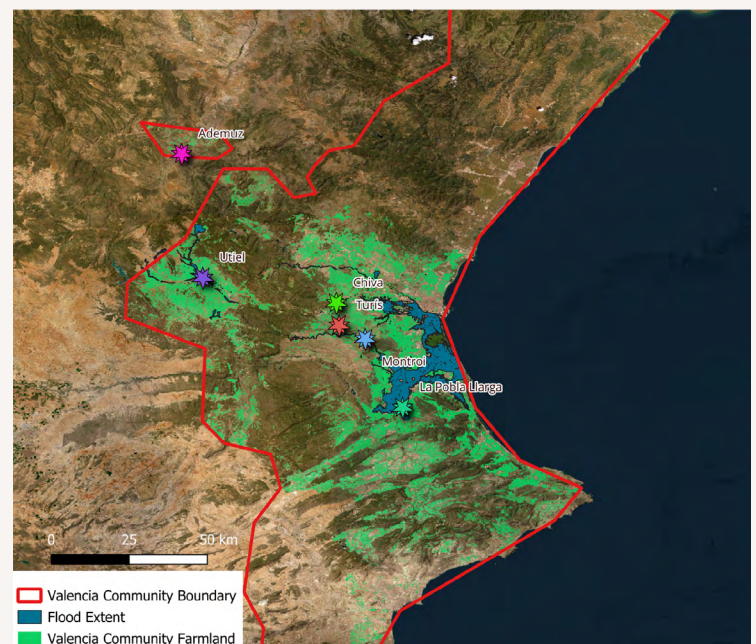
Based on the spatial overlap of agricultural land, rainfall intensity, and Eurostat NUTS 2 boundaries, the analysis was refined to 316,000 hectares of agricultural land within the Valencian Community. This area is considered the most impacted by the event and represents the zone where land management interventions would have the greatest capacity to reduce runoff, enhance water retention, and mitigate downstream flood risk in the case of future extreme precipitation events.

Figure 6 depicts the total agricultural land under analysis, together with the locations of AEMET<sup>63</sup> and PWS<sup>64</sup> stations that recorded the highest rainfall intensities during the event. Identifying these priority areas is essential, not only due to the magnitude of precipitation observed, but also because of the areas' strategic position within the catchment, particularly along the Río Magro and its confluence with the Río Júcar.

These upstream and midstream agricultural zones play a critical role in regulating hydrological flows across the wider watershed. Enhancing water infiltration, soil moisture retention, and temporary storage capacity

within these areas could substantially reduce peak runoff volumes and flow velocities, thereby lowering flood risk and associated damages in downstream urban and agricultural areas during future extreme rainfall event.

Figure 6 | Agricultural land in the Valencian Community with highest relevance to flood impacts, showing labelled weather stations with the highest recorded rainfall during the event.



62 Source: AEMET, retrieved from World Meteorological Organisation ([LINK](#))  
 63 Retrieved from World Meteorological Organisation ([LINK](#))  
 64 Rombeek, N., Hrachowitz, M., & Uijlenhoet, R. (2025). Torrential rainfall in Valencia (Spain) recorded by personal weather stations preceding and during the 29 October 2024 floods. EGU sphere, 2025, 1-29. ([LINK](#))

## Landscape Analysis

Landscape characterization of the Valencian agricultural land combined soil, vegetation, and crop data known to strongly influence infiltration capacity, runoff generation, and flood risk. Soil texture proxies were derived from SoilGrids data<sup>65</sup>, using clay, silt, and sand fractions classified according to the FAO soil texture scheme<sup>66</sup>. Regional vegetation performance was assessed using MODIS Normalised Difference Vegetation Index (NDVI) at 250 m spatial resolution and 16-day compositing intervals, from which annual NDVI area-under-the-curve (AUC) values were calculated and normalized to a 0–1 scale.

NDVI is a satellite-derived indicator that measures the presence, density, and vitality of green vegetation by comparing reflected near-infrared and red light. In this analysis, we use temporal NDVI that measures each day's NDVI rating averaged over a full annual cycle as a proxy for year-round functional soil cover and continuous root activity at landscape scale. Persistently low annual NDVI values indicate prolonged periods of bare or weakly vegetated soil, which are strongly associated with reduced infiltration capacity, higher runoff velocities, and elevated flood risk during intense rainfall events<sup>67</sup>.

Conversely, consistently higher annual NDVI reflects sustained vegetative cover, improved soil structure, and enhanced water absorption and retention. This is due to high photosynthesis levels being correlated to SOC binding to the soil, and therefore better soil structure and water infiltration<sup>68</sup>. While NDVI does not directly measure soil physical properties or non-living cover such as mulch, its temporal use provides a robust, spatially explicit indicator of hydrological performance when interpreted alongside soil type, slope, and land management data.

Taking the 99th percentile of our NDVI analysis, we identified the highest performing land within Valencian farmland to assess the potential for improvement under well-managed agricultural systems.

65 Data retrieved from (Soil Grids)  
 66 See: (LINK)  
 67 Kosmas et al. (1997). The effect of land use on runoff and soil erosion rates under Mediterranean conditions. *Catena*, 29(1), 45-59. (LINK)  
 68 Chávez-Collantes, A., Vásquez Lozano, D. J., Velarde-Apaza, L. D., Cuevas, J.-P., Solórzano, R., & Flores-Marquez, R. (2025). Influence of vegetation cover and soil properties on water infiltration. *Water*, 17(15), 2280. (LINK)

NDVI Rating	Interpretation
-1–0	Ratings below 0 typically indicate a complete lack of vegetation
0–0.1	Very little vegetation, typically barren ground
0.1–0.3	Sparse vegetation or early-growth periods
0.3–0.6	Moderate vegetation or unhealthy crops
0.6–0.9	Typical range for healthy thriving crops
0.9–1	Dense overgrown vegetation, such as rainforests

Table 1 | Interpretation of NDVI results

Landscape within this percentile demonstrates comparatively higher annual NDVI rates to the rest of the landscape, suggesting increased ecosystem functions and lower vulnerability to the impacts of flooding<sup>69</sup>. The resulting classifications are integrated into a landscape analytical framework to assess and identify high-risk areas with the greatest potential impact of a large-scale transition toward regenerating forms of agriculture. A growing body of literature<sup>70</sup> supports regenerative agriculture as a method of influencing the impact of these events.

These factors are widely considered effective proxies for flood and drought management<sup>71</sup> and strongly influence the landscape's capacity to withstand flooding events. For a more detailed discussion of photosynthesis and soil cover remote sensing literature, differentiation and future potentials, as well as correlation to productivity and ecosystem service indicators, see our first report from our Farmer-led Research on Europe's Full Productivity<sup>72</sup>.

69 Khan et al. (2025). Flood risk assessment in the Swat river catchment through GIS-based multi-criteria decision analysis. *Frontiers in Environmental Science*, 13, 1567796. (LINK)  
 70 Paustian, K., Chenu, C., Conant, R., Cotrufo, F., Lal, R., Smith, P., & Soussana, J. F. (2020). Climate mitigation potential of Regenerative Agriculture is significant. Princeton University. (LINK) Toensmeier, E. (2016). The carbon farming solution: A global toolkit of perennial crops and Regenerative Agriculture practices for climate change mitigation and food security. Chelsea Green Publishing. (LINK)  
 Ghosh, S., Saha, A., Kumar, S., & Pathania, S. (2024). Regenerative Agriculture for Climate Change Mitigation and Food Security. In *Regenerative Agriculture for Sustainable Food Systems* (pp. 83-133). Singapore: Springer Nature Singapore. (LINK)  
 71 Aparicio-Ibáñez et al. (2025). Using NDVI-derived vegetation vigour as a proxy for soil water content in Mediterranean-mountain traditional water management systems: Seasonal variability and restoration impacts. *Ecological Indicators*, 174, 113468. (LINK)  
 72 EARA Study (LINK)

## Methodological Routes

Due to our limited capacity to conduct field measurements and collect in-situ data on soil hydrological properties in Valencia, two complementary landscape-level analytical approaches were employed to assess the regenerative potential of Valencian farmland. This dual approach was adopted to strengthen the reliability of the assessment and to reduce uncertainty associated with relying on a single methodological framework.

Methodological route 'A' evaluates hydrological behaviour at the landscape scale, estimating runoff potential across Valencian soils, land uses, and agricultural practices. However, landscape modelling alone provides only a static representation of current conditions. Regenerating forms of agriculture, by contrast, represents a dynamic process in which soil structure, infiltration capacity, and ecosystem function improve progressively through management practices.

To address this limitation, methodological route 'B' draws on published literature documenting changes in soil hydrological performance under regenerative management. The two analyses therefore address different dimensions of the system: spatial hydrological behaviour under current conditions, and the documented functional improvements associated with regenerative practices.

By triangulating the results of both approaches, the analysis provides a more robust indication of the potential role of regenerating forms of agriculture in mitigating flood and drought risk.

### Methodological Route A

Landscape analyses were supported by a Curve Number (CN) analysis to determine the rate of runoff and infiltration under current agricultural systems, compared to projections of regeneratively managed landscapes. The CN method, developed by the USDA Natural Resources Conservation Service (NRCS)<sup>73</sup>, is an empirical estimation of direct surface runoff from rainfall events.

73 USDA NRCS Curve Number Loss Model (LINK)

Combining soil infiltration capacity (Hydrologic Soil Groups A–D), land use, and management practices, a single parameter ranging from 30 to 100 is given to then model runoff potential, with higher numbers indicating increased surface runoff. In agricultural areas such as Valencia, CN values reflect soil cover and texture, crop type, and tillage practices. The method is widely applied in landscape-level watershed analyses to assess runoff risk, erosion potential, and the hydrological effects of land management.

Within this report, CN were assigned according to soil group classifications and prevailing agricultural land uses outlined within the analysis. Event-based runoff was calculated using the standard NRCS equation and rainfall data to estimate surface runoff under current conditions. Expressed in figure 5 is the distribution of the accumulated rainfall for October 29 2024, with values ranging from 15mm to >300mm over 24 hours. In a landscape catchment analysis, Rombeek et al.<sup>74</sup> identified the 250,000 hectares of most impacted land and deduced an average rainfall event of 150mm. To account for future DANA-related or other flood events, this analysis assumes a rainfall event of 200mm as a comparison between analyses. This value was taken as an average for the entire area under analysis, although a more detailed analysis would be highly relevant for the planning and integration of different agricultural and infrastructural interventions in specific areas.

CN analyses are particularly useful in landscape risk assessment, however the results should be treated as a starting point to conduct further ground-level studies on runoff and flood risk.

### Methodological Route B

Through existing literature on the environmental and climatic benefits of regenerating forms of agriculture, this analysis develops indicative assessments of the potential medium-term impacts associated with the widespread integration of regenerative principles and practices. A growing body of literature documents improved ecosystem performance in regenerating agricultural systems, with particular relevance to dry and semi-arid regions such as the Mediterranean.

74 Rombeek, N., Hrachowitz, M., & Uijlenhoet, R. (2025). (LINK)

Published studies examining the effects of these practices on soil water infiltration rates and water holding capacity are compared with the rainfall magnitude observed during the October 2024 flood events. These findings are considered alongside recommendations for regenerative practices compatible with the dominant forms of agricultural production within the watershed. Based on this literature, indicative estimates are also made regarding the typical transition period required for farmland to reach a stage at which improvements in soil ecosystem functions become measurable. Each 'stage' is compared according to the time in transition, i.e., the infiltration rate and water holding capacity at 2, 5, and 10 years after the initial transition.

It is critical to have a clear distinction between water infiltration and water holding capacity:

- Water infiltration: Speed and amount at which water enters the soil instead of running off
- Water holding capacity: Amount of water the soil can store once it is infiltrated before being lost to groundwater/runoff

All results expressed within this report are predicated on simplified, indicative calculations designed to provide an initial assessment and to support further, more detailed investigation into the context-specific mitigative potential of regenerative systems. Regenerating forms of agriculture are inherently context-specific, and there is no feasible way to provide meaningful advisory solely on the basis of remote sensing, the latter must be co-created with local farmers and agronomists in each context.

## Economic Analysis

To complement the hydrological assessment, an economic analysis estimates the costs associated with scaling regenerating forms of agriculture across approximately 316,000 hectares of affected farmland in the Valencian Community. These estimated integration costs are compared with documented flood damages, recovery expenditures, and existing national and regional programmes addressing flood mitigation and water management.

This comparison provides a framework for evaluating regenerating forms of agriculture not only as an environmental intervention but also as a potential risk-reduction strategy. By placing the estimated costs of agricultural transition alongside the documented economic impacts of recent flood events, the analysis highlights the relative scale of investment required. Together, these analyses present an evidence-based case for the wider adoption of regenerative agricultural practices as a means of strengthening landscape resilience to both flood and drought risks.

# Analysis

The flood-affected agricultural land<sup>75</sup> under analysis is predominantly managed under conventional, extractive methods that favour bare soil and repeated mechanical and/or chemical treatment<sup>76</sup>. Minimising bare soil, compaction, and prioritising soil health, are critical for effective flood and drought management by restoring the landscape's natural function as a sponge. By contrast, exposed soil is known to have the lowest rates of water infiltration<sup>77</sup> and retention<sup>78</sup>.

A lack of protective cover on productive land is also detrimental to the long-term productivity of the soil. About 33% of global agricultural land is degraded through topsoil erosion or loss, shown to reduce productivity by up to 50%<sup>79</sup>. Worse still, this degradation is increasing year by year. While it is difficult to estimate the total soil loss due to the October Valencian floods, it is estimated that up to 17,000 tonnes of topsoil was lost, with zones like the Albufera National Park receiving more than 700,000 metric tonnes of sedimentation<sup>80</sup>, degrading the unique, RAMSAR protected zone and jeopardising its biodiversity. This is the equivalent of 30 years worth of debris accumulated over a single day<sup>81</sup>. Wider effects of such intense ecological degradation will likely become evident in the surrounding agricultural land for years to come.

Europe's Mediterranean soils have markedly low rates of Soil Organic Matter (SOM) and Soil Organic Carbon (SOC)<sup>82</sup>, with Spain representing the lowest average of any EU country, showing 1.4% organic matter compared to the 4.9% of the EU<sup>83</sup>.

Extractive agricultural practices have significantly diminished SOC levels since the mid 1900s, with a 20% loss of total SOC in Spanish agricultural land<sup>84</sup>. SOM and SOC play an important role in both water infiltration and water retention<sup>85</sup>.

It is extremely difficult to understand the potential impact of both SOM and SOC on water holding capacity or water infiltration without having done field tests in specific plots. Water holding capacity is highly dependent on soil particle size, clay minerals, and bulk density - however, in the absence of this data we make estimates based on public averages derived from LUCAS soil data and various studies. For every 1% increase in SOM ranges from 54,000L<sup>86</sup> per hectare to >250,000<sup>87</sup>L<sup>88</sup> per hectare at a depth of 30cm are given depending on the variables listed above. The impact of SOM on water holding capacity is most present in sandy and loam soils<sup>89</sup> with lower bulk density, as in plots of perennial crops<sup>90</sup>. In any case, on site field tests should be conducted when designing pilots or projects.

We have taken the 'average' estimate that for every 1% increase in SOC, the soil can store 144,000 litres<sup>91</sup> more water per hectare<sup>92</sup>, while infiltration is dramatically increased through aggregation and the presence of a strong microbial community within the soil. Aggregation cannot be directly inferred through SOC increase, however it plays a crucial role in the formation of soil aggregates. The rate at which SOM and SOC is incorporated into the soil is highly dependent on climate and soil type, though the positive effects on infiltration and water holding capacity are universal.

75 Eurostat Agricultural Database ([LINK](#))  
 76 Gibson et al. (2007). Plant diversity and land use under organic and conventional agriculture: a whole-farm approach. *Journal of Applied Ecology*, 44(4), 792-803. ([LINK](#))  
 77 Blanco, Mikha, Presley, Claassen (2011). Addition of cover crops enhances no-till potential for improving soil physical properties. *Soil Science Society of America Journal* 75(4): 1471-1482. ([LINK](#))  
 78 Infiltration rate is highly dependent on soil type and structure - primarily due to difference in porosity. Cleophas, F., Isidore, F., Musta, B., Ali, B. M., Mahali, M., Zahari, N. Z., & Bidin, K. (2022, August). Effect of soil physical properties on soil infiltration rates. In *Journal of physics: conference series* (Vol. 2314, No. 1, p. 012020). IOP Publishing  
 79 FAO (2025) Global Symposium on Soil Erosion ([LINK](#))  
 80 Universitat de Valencia. (2025). The DANA caused in one day the usual sedimentation volume of 30 years in the Albufera. ([LINK](#))  
 81 Fekete, A., Estrany, J., & Ramirez, M. A. A. (2025). Cascading impact chains and recovery challenges of the 2024 Valencia catastrophic floods. *Discover Sustainability*, 6(1), 1-31. ([LINK](#))  
 82 Jones et al. (2003) The map of organic carbon in topsoils in Europe, Version 1.2, September 2003: Explanation of Special Publication Ispra 2004 No. 72 (S.P.I.04.72). In *European Soil Bureau Research No.17*, EUR 21209 EN, 26pp. and 1 Map in ISO B1 Format; Office for Official Publications of the European Communities: Luxembourg, 2004.  
 83 Agricultural Land in Spain, Prepsol ([LINK](#))

84 Aguilera et al. (2018). A historical perspective on soil organic carbon in Mediterranean cropland (Spain, 1900-2008). *Science of the Total Environment*, 621, 634-648. ([LINK](#))  
 85 Hudson, Berman (1994). *Journal of Soil and Water Conservation* 49 (2) 189-194.  
 86 Libohova et al. (2018). Reevaluating the effects of soil organic matter and other properties on available water-holding capacity using the National Cooperative Soil Survey Characterization Database. *Journal of Soil and Water Conservation*, 73(4), 411-421. ([LINK](#))  
 87 United States Department of Agriculture NRCS, Soil Health Starter Kit ([LINK](#))  
 88 Mengel, D. 2012. The value of soil organic matter. In *K-State Agronomy Extension eUpdates*, No. 357, July 6, 2012. Manhattan, KS: Kansas State University Extension. ([LINK](#))  
 89 Libohova et al. (2018).  
 90 Panagos, P. et al. (2024). Soil bulk density assessment in Europe. *Agriculture, Ecosystems & Environment*, 364, 108907.  
 91 We take this knowing that the average perennial crop bulk density in loam soils in Europe is between 1.1 and 1.17 g/cm<sup>3</sup> (see Panagos et al.).  
 92 Massy, C. (2017). Call of the reed warbler: A new agriculture, a new earth. University of Queensland Press.

## Tillage

Tillage Treatment	% Groundcover	Infiltration (mm water/minute)
Molboard plow	12%	0.8
Chisel plow	27%	1.3
No-till	48%	2.7

Table 2 | How tillage affects rainfall infiltration<sup>93</sup>

Depicted in table 2 is the impact of no-till on the infiltration rate of the soil. Compared to conventionally tilled land, no-till systems are up to 3 times more effective at infiltrating water than tilled land, and likely to have a similar increase on the water holding capacity. While infiltration rates slow substantially after the first 10-30 minutes, this is still representative of 27,000L of water per minute infiltrated per hectare.

Water follows the path of least resistance, so a system with reduced or eliminated tillage<sup>94</sup> inherently promotes living roots in the soil, providing a pathway for water to infiltrate. Additionally, roots promote the formation of aggregates and a thriving microbial community through exudates, further increasing infiltration by creating porosity in the soil. Living roots and minimal mechanical and chemical interventions are key tenets of regenerative agriculture. Working with complex systems - as is the case with regenerating forms of agriculture - requires an understanding of the biological processes that enable nutrient and water cycling. Conventional agriculture has substituted these processes for mechanical and/or chemical inputs as a short-term solution to the systemic degradation of agricultural ecosystems.

## Soil Physical Properties, Land Use, and Flood Dynamics

93 Boyle et al. (1989). *Journal of Production Agriculture*, 2:4, pages 290–299 Retrieved from Strickler, D. (2018). *The drought-resilient farm: Improve your soil's ability to hold and supply moisture for plants; maintain feed and drinking water for livestock when rainfall is limited; redesign agricultural systems to fit semi-arid climates.* Storey Publishing.  
 94 Certain tools, like the Yeoman's plow, are an exception to the general damaging effect of tillage. Subsoilers designed to operate within keyline systems minimise soil inversion and surface disturbance. Rather than disrupting the soil profile, they create narrow, deep slots that improve aeration and water infiltration. By increasing oxygen availability at depth, these implements can stimulate biological activity and contribute to soil organic matter formation.  
 To maintain these benefits, it is important that no subsequent machinery traffic compact the treated area, thereby preserving soil structure and enhanced aeration.

Soil type is largely determinant of a soil's porosity, and is highly influential on the land's ability to infiltrate and store water. An analysis of Valencia's farmland shows relatively homogenous soil types, with 50% loam soil localised in the upstream, hilly areas surrounding Valencia, and 48% clay loam located predominantly in the low-lying areas in Valencia and near the Albufera. Sparsely distributed, the remaining 2% is a mixture of silty clay loam, and clay soils.

Porosity is the most influential aspect of water infiltration<sup>95</sup>. This idea is central to the conventional practice of tillage and fallow fields, as they were believed to create space in the soil to allow water to infiltrate. However, table 2 shows the opposite, this approach inhibits the soil's ability to infiltrate and store water by destabilising the soil, destroying the macropores necessary for oxygen and water cycling. Shortly after tillage, soils are prone to compaction and 'capping' - the process in which raindrops strike unprotected soil, particles are dislodged and stratified by size, with the smallest clay particles accumulating at the surface. As these particles consolidate, they form a hardened crust that restricts water and oxygen infiltration. This condition limits microbial activity, inhibits plant root function, and disrupts essential ecological processes required for a resilient landscape<sup>96</sup>.

Given the increasing frequency and intensity of extreme rainfall events, the continued use of conventional management systems in these areas enhances a structural vulnerability, reinforcing the need for adaptation. Alongside regenerative practices, clay loam soils have also been shown to respond well to certain organic amendments, increasing water infiltration and hydrological conductivity<sup>97</sup>. Loam soils generally possess favourable infiltration and water-retention properties and, when managed with continuous cover and minimal disturbance, are well suited to both drought-prone and flood-exposed environments<sup>98</sup>. Improving management practices in these upstream catchment zones can therefore play a decisive role in slowing runoff generation, reducing downstream flood peaks, and enhancing overall watershed resilience.

95 Helalia, A. M. (1993). The relation between soil infiltration and effective porosity in different soils. *Agricultural water management*, 24(1), 39-47. ([LINK](#))  
 96 Nciizah, A. D., & Wakindiki, I. I. (2015). Soil sealing and crusting effects on infiltration rate: a critical review of shortfalls in prediction models and solutions. *Archives of Agronomy and Soil Science*, 61(9), 1211-1230. ([LINK](#))  
 97 Yazdanpanah, N., Mahmoodabadi, M., & Cerdà, A. (2016). The impact of organic amendments on soil hydrology, structure and microbial respiration in semiarid lands. *Geoderma*, 266, 58–65. ([LINK](#))  
 98 Soil types in Hydrology ([LINK](#))

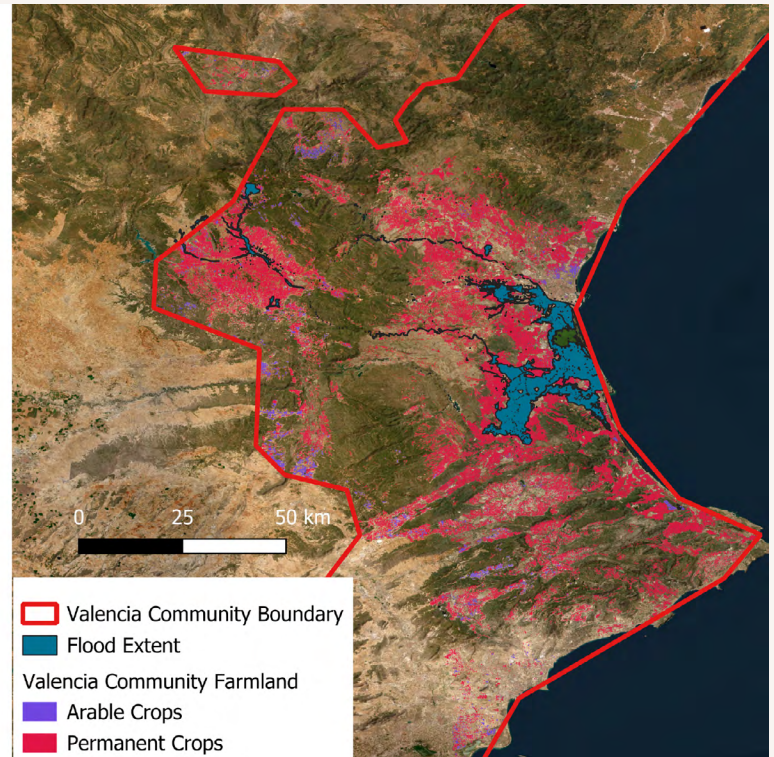
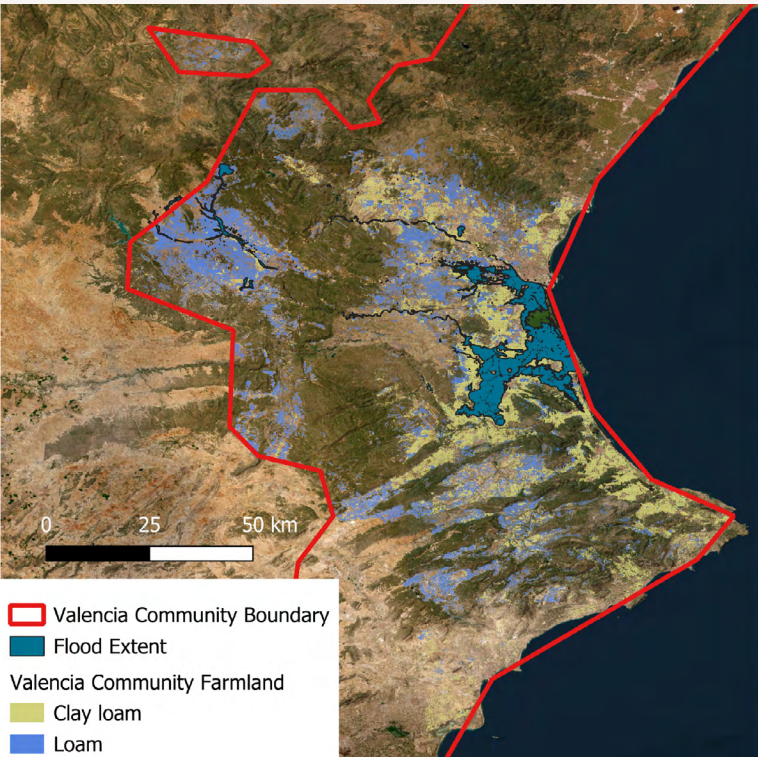


Figure 7 | Impacted Valencian agricultural land within the watershed, shown by soil type (left) and type of agricultural production (right)<sup>100</sup>.

Public land-use data demonstrates relatively similar production types within the same region of interest, with 12% of land used to produce cereals (primarily barley), and 87% of land growing permanent crops like grapes, fruits, nuts, and olives. 1% of agricultural land is coded as 'other', likely referring to small gardens, herbs, or domestic orchards. Spatial analyses and scientific literature indicates that inter-row spaces of perennial systems such as vineyards, olive groves, and orchards are frequently left bare<sup>99</sup>. This absence of cover significantly reduces infiltration capacity and exposes soils to surface sealing and erosion. Clay soils, which exhibit the weakest drainage characteristics, are particularly vulnerable during extreme rainfall events, as they have minimal capacity to absorb rapid inflows, especially when receiving accumulated runoff from upstream areas.

The mapped distribution of clay loam soils is concentrated in the low lying areas within the Valencian Community, particularly in zones surrounding the Albufera. The wetland is designated as a RAMSAR site and is closely monitored due to its vulnerable ecological and biodiversity systems. Its location at the base of the hilly terrain encompassing the city of Valencia makes it especially susceptible to flooding driven by river overflow as well as urban and rural runoff transported downstream. Additionally, limited infiltration capacity typically associated with clay loam soils exacerbates surface runoff in these areas, amplifying the risk of sediment, nutrient, and pollutant transport into the Albufera wetland system during flood events<sup>101</sup>. These areas with a higher proportion of clay would greatly benefit from living roots in the soil at all times to slow, sink, and spread the water in the soil.

99 Cerdà, A., Morera, A. G., & Bodí, M. B. (2009). Soil and water losses from new citrus orchards growing on sloped soils in the western Mediterranean basin. *Earth Surface Processes and Landforms: The Journal of the British Geomorphological Research Group*, 34(13), 1822-1830. [\(LINK\)](#)

100 Data retrieved from [Soil Grids](#) and [Copernicus](#)  
 101 Rico et al. (2025). Impacts of the 2024 flash flood on water quality, pathogenic bacteria and organic contaminant risks in the Albufera wetland (Valencia, Spain). *Environmental Research*, 123515. [\(LINK\)](#)

Flow accumulation zones are concentrated in downslope areas, typically situated between two ridges, in a geographical area known as the 'primary valley'. As the first areas to accumulate significant amounts of water, these zones have the highest potential to mitigate accelerated flows during a flood event<sup>102</sup>. In Valencia these regions have limited ground cover, leaving them exposed to flood risk and the accumulation of sediment, leading to destructive impact downstream. During the October 29 floods, various AEMET stations showed these high risk zones receiving the highest rainfall intensity at both an hourly and 24-hour rate. Regenerating forms of agriculture could act as a lever to build resilience in these zones through the reduced risk of erosion, flooding, and droughts. This is achieved by prioritising living root systems or green mulch in the soil, through practices like cover-cropping, mulching, or intercropping<sup>103</sup>.

Cover cropping stimulates the formation of soil organic matter (SOM) and soil organic carbon (SOC), crucial to the storage of water in the soil. Further, the presence of root systems in the soil dramatically improves soil stability, keeping the topsoil held in place rather than being carried in the waterflow to bring a destructive wave of water and mud further downstream. Keyline systems, swales, and berms also provide a pathway for water to spread laterally across the landscape, greatly reducing the quantity and velocity of water that accumulates as a flood.

Given the topography of the land and the rainfall intensity, regenerating forms of agriculture should be used as a component of a greater resilience-building response. Targeted hydrological interventions like keypoint dams, vegetated rock check dams, swales, and managed riparian buffers equally hold enormous potential to manage torrential rainfall and flooding. All practical integrations of nature-based solutions must be supported by ground-level analyses to determine the most appropriate and effective mitigation strategies.

102 Al-Siaede, R. (2022). Using Landscape analysis techniques to prevent silt accumulation in the reservoir of the Dwerige weir project and developing River basin, Missan, South Eastern IRAQ. Iraqi Journal of Science, 3031-3039. [\(LINK\)](#)  
 103 A wide collection of regenerative practices are effective at maintaining ecosystem vitality, the practices suggested above are a few examples of a broader 'playbook' of principles and practices.

## Landscape Analysis of Valencian Agriculture within the Júcar Watershed

Of the 316,000 hectares analysed within this report, the majority of agricultural land averaged low annual NDVI ratings, indicating a lack of healthy green cover. This drastically reduces the capacity of the soil to manage flood events and increases the risk of runoff and water accumulation. It also contributes to the pollution of public waterways, as tonnes of soil are lost from these uncovered fields that are regularly subject to mechanical and chemical treatment.

As this report was not able to conduct field experiments or data collection, this analysis was not able to identify enough regeneratively managed farms to make a direct comparison. Ideally, field tests would be conducted across critical areas like Chiva, Utiel, Turis, and low-lying areas to determine the soil structure to extrapolate results to the landscape level. Pilot tests could be achieved following the testing of 30-80 sites while mapping the impact of the 5-year regenerative transition of a given piece of agricultural land.

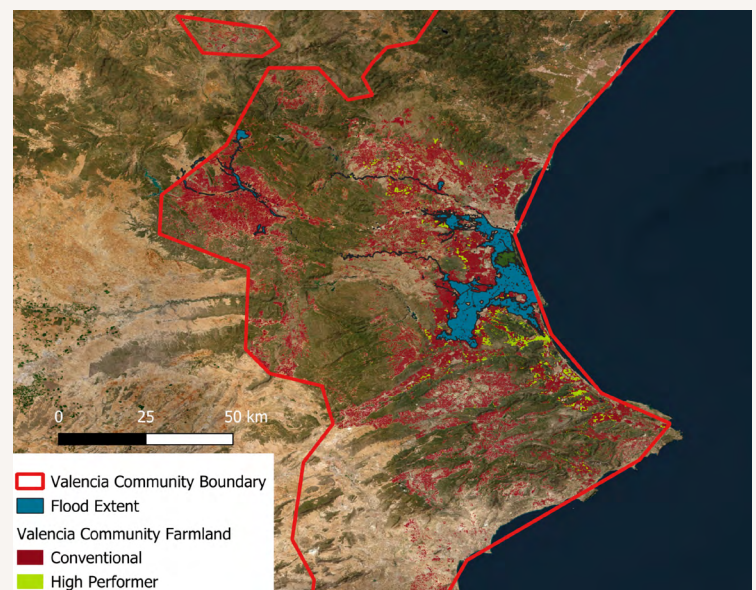


Figure 8 | 2024 Comparative average distribution of conventional and high-performing NDVI results over the Valencian watershed.

It would be interesting to also compare these results to the relatively sparse old forests within the Valencia region to determine potential infiltration capacity and SOM / SOC levels. However, through the use of satellite imagery within the assessed landscape, 2% of Valencian farmland identified through an NDVI analysis shows results that indicate some type of flood effective management.

Overall, these top-performing fields show 58% higher NDVI than the regional average, which is expressive of a more functioning water cycle, higher water infiltration, and holding capacity due to increased SOC assimilation and better-established root systems<sup>104</sup>. Higher rates of NDVI and of soil cover similarly denote increased SOM content<sup>105</sup>, inferring improved water infiltration rates and water holding capacity. Permanent crops constitute the dominant production system in the study area, representing 87% of total agricultural land. Within these systems, high-performing fields exhibit, on average, 52% higher annual NDVI values compared with other fields. Annual production similarly performs well above the regional average, with a relative increase of 65% in annual NDVI.

104 Chávez-Collantes et al. (2025). Influence of vegetation cover and soil properties on water infiltration. *Water*, 17(15), 2280. [\(LINK\)](#)  
 105 de Sousa Teixeira et al. (2017). Relative influence of NDVI in the organic matter content of semiarid soils. In Conference: III Encontro Internacional de Jovens Investigadores, at: Fortaleza-CE. [\(LINK\)](#)

### Temporal NDVI Comparison

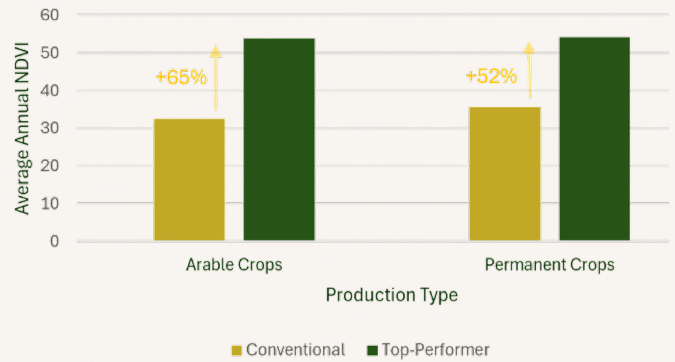


Figure 9 | 2024 annual NDVI comparison of top-performing farmland against regional average

Figure 10 | Valencian Agricultural Land, shown by yearly average NDVI in 2024 (left) and topography (right, slope analysis)<sup>106</sup>.

106 Figure derived from satellite data collected from [Centro des Descargas](#) and [Copernicus](#)

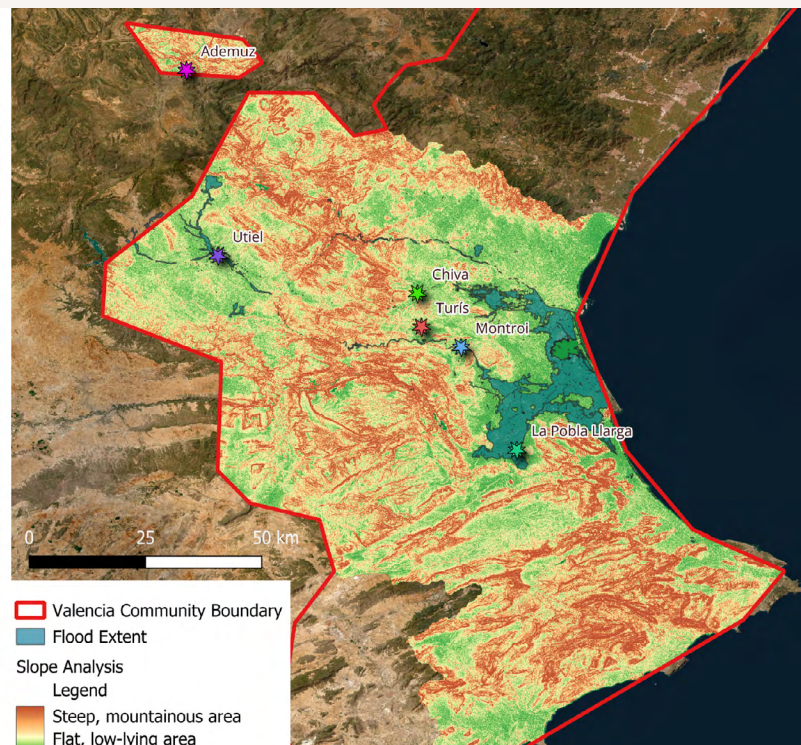
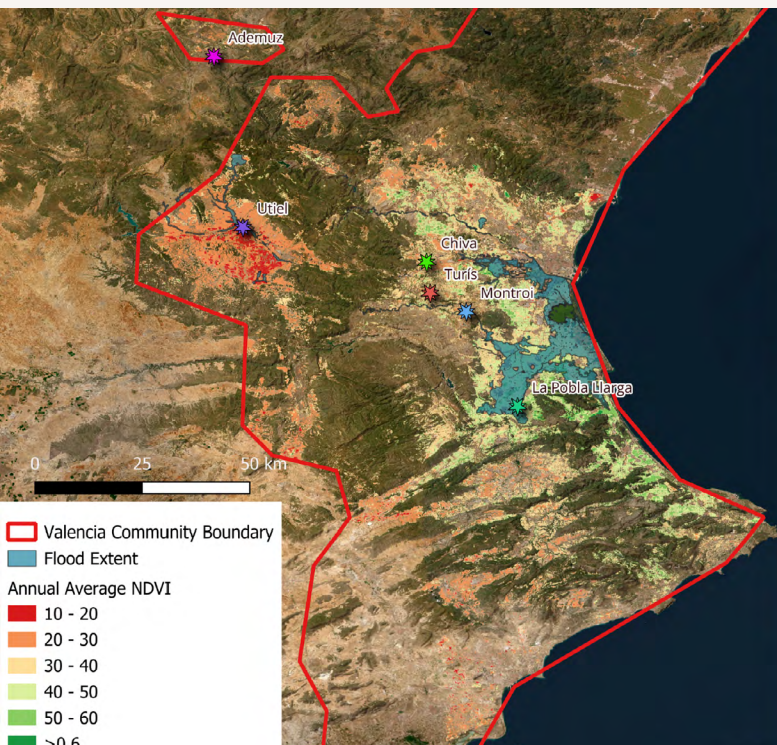


Figure 10 demonstrates that areas of highest flood risk correspond closely with the locations of weather station networks with the highest recorded accumulated rainfall during the 29 October 2024 event. These agricultural zones occupy the downslope transitional areas between the inland mountain ranges and the coastal plain, where runoff from upstream catchments, including the Magro River, converges rapidly before draining into the Valencian basin and the Albufera wetland system.

This topographic exposure is compounded by persistently low annual NDVI values across the affected areas, particularly Utiel, Chiva, and Turis, whose weather stations recorded the highest accumulated rainfall over a 24 hour period. Low NDVI values indicate sparse and weakly functioning vegetation cover throughout the year. NDVI assessment is a well established proxy for degraded landscape function<sup>107</sup>, reduced infiltration capacity and heightened susceptibility to surface runoff and erosion<sup>108</sup>.

Land use reinforces this vulnerability. The affected zones are predominantly cultivated with vineyards and permanent fruit crops, where conventional management leaves soils bare for extended periods. As discussed above, bare soil under permanent crops is a well-documented driver of surface sealing, reduced infiltration and accelerated runoff<sup>109</sup>, particularly on sloped terrain in Mediterranean contexts<sup>110</sup>. These zones therefore represent the highest-priority targets for intervention, given both the intensity of rainfall they receive and their limited capacity to absorb it.

While flow regulation across the broader catchment remains important, addressing these high-risk areas directly offers the greatest potential to reduce the speed and volume of water reaching downstream communities.

Combining nature based interventions, both the adoption of regenerative agriculture practices, particularly the introduction of cover crops and living mulches under permanent crops, and green flood management infrastructure, can substantially reduce runoff volumes and delay peak flows.

Surface runoff reduction is among the short-term benefits of cover crop adoption, showing up to 59% less runoff<sup>111</sup> compared to bare soil conditions, while also improving soil infiltration capacity<sup>112</sup> and reducing erosion rates<sup>113</sup>. These on-farm practices, combined with targeted hydrological interventions such as strategically placed small retention features and riparian buffer strips along watercourses, provide complementary flood attenuation at the landscape scale. Riparian buffers with adequate width and vegetative cover have been shown to reduce peak flow volumes by 35 to 40% during extreme rainfall events<sup>114</sup>, while simultaneously improving water quality and supporting biodiversity<sup>115</sup>.

NDVI, while a useful proxy for flood risk, does not always directly infer a functioning water cycle. Given the scope and complexity of this particular rainfall event, we have utilised NDVI as an analytical tool to identify high risk areas - notably those with persistently low annual ratings. 'High' NDVI ratings can also be attributed to evergreen crops whose canopy masks the soil, even when the soil underneath is bare. For a more detailed discussion on the limitations of NDVI and remote sensing, please see the annex.

107 Symeonakis, E., & Drake, N. (2004). Monitoring desertification and land degradation over sub-Saharan Africa. *International Journal of Remote Sensing*, 25(3), 573–592. [\(LINK\)](#)

108 Boer, M., & Puigdefábregas, J. (2005). Effects of spatially structured vegetation patterns on hillslope erosion in a semiarid Mediterranean environment. *Earth Surface Processes and Landforms*, 30(2), 149–167. [\(LINK\)](#)

109 Cerdà, A., Rodrigo-Comino, J., Giménez-Morera, A., & Keesstra, S. D. (2018). An economic, perception and biophysical approach to the use of oat straw as mulch in Mediterranean rainfed agriculture land. *Ecological Engineering*, 108, 162–171. [\(LINK\)](#)

110 Novara et al. (2011). Soil erosion assessment on tillage and alternative soil managements in a Sicilian vineyard. *Soil and Tillage Research*, 117, 140–147. [\(LINK\)](#)

111 Durán Zuazo, V. H., Francia Martínez, J. R., Rodríguez Pleguezuelo, C. R., Martínez Raya, A., & Cárceles Rodríguez, B. (2024). Cover crop effects on surface runoff and subsurface flow in rainfed hillslope farming and connections to water quality. *Land*, 13(7), 1103. [\(LINK\)](#)

112 Kincl, D., Jirků, V., Pechanec, V., & Novotný, I. (2026). Effect of cover crops on pluvial flooding: a modelling study in agricultural lowland hill in Slovakia. *Frontiers in Agronomy*, 7, 1710617. [\(LINK\)](#)

113 Sharma, A., Tiwari, K. N., & Bhadoria, P. B. S. (2023). The efficacy of conservation practices in reducing floods and improving water quality. *Frontiers in Environmental Science*, 11, 1136989. [\(LINK\)](#)

114 Sharma, R., & Kumar, A. (2025). Mitigating riparian buffer zone degradation through policy interventions and learnings from best practices. *Discover Environment*, 3, 288. [\(LINK\)](#)

115 Dugdale, S. J., et al. (2025). Developing predictive models of riparian buffer efficacy with meta-analysis. *Environmental Technology & Innovation*, 40, 103900. [\(LINK\)](#)



# Results

## The Impact Potential of Regenerating Agricultures

24 hours<sup>116</sup>, with hourly rainfall intensity at several weather stations peaking at 100L/m<sup>2</sup><sup>117</sup>. Modelled under a 400mm rain event, even a well-managed regenerative farm with verdant, established cover crops would only infiltrate roughly half of the total rainfall. However, with effective land management and established cover crops, runoff would take significantly less soil downstream compared to bare soiled fields<sup>118</sup>, and downstream cover crops or pasture could catch topsoil lost from fields in higher areas<sup>119</sup>. Reducing the loss of valuable topsoil not only secures the productive capacity of farmland, but limits the pollution of critical waterways and urban areas due to reduced mudflow.

It is important to emphasise that, while regenerating forms of agriculture are not the sole solution to future flood events, they can greatly alleviate the pressure on existing and future infrastructure, while ensuring the ecological, social, and economic resilience of rural and wider communities. Similarly, losses are generated as a function of the intensity of the water flow and the stress and damage this induces on infrastructure. Slowing down this flow through living water infrastructure in upstream accumulation zones could provide a disproportionate benefit compared to other downstream zones.

The potential to mitigate the impact of both floods and droughts can be improved through the adoption of regenerating forms of agriculture and targeted, context-specific interventions. If the soil's ability to infiltrate and retain water is increased, then the impact of water accumulation during intense rain events is largely mitigated. Additionally, the available water during periods of water stress is consequently increased.

116 Rombeek, N., Hrachowitz, M., & Uijlenhoet, R. (2025). Torrential rainfall in Valencia (Spain) recorded by personal weather stations preceding and during the 29 October 2024 floods. *EGUosphere*, 2025, 1-29. ([LINK](#))  
 117 Rombeek, N., Hrachowitz, M., & Uijlenhoet, R. (2025). ([LINK](#))  
 118 Novara et al. (2011). Soil erosion assessment on tillage and alternative soil managements in a Sicilian vineyard. *Soil and Tillage Research*, 117, 140–147. ([LINK](#))  
 119 Again demonstrated in this [video](#)

## Extended Benefits

Research documents upward trends in extreme precipitation across the Mediterranean, with heavy and widespread rainfall events becoming more common<sup>120</sup>. Expert consensus confirms that in a context of climate change, intense rainfall events that once occurred many decades apart are now recurring more frequently and with greater destructive capacity<sup>121</sup>. This reflects a landscape that has lost its capacity to regulate the water cycle. Rainfall distribution is influenced by processes such as biotic pumping, in which vegetation contributes to atmospheric moisture through transpiration while facilitating precipitation. Urban development and conventional agricultural practices have reduced this capacity by prioritising concrete infrastructure and bare soils, limiting the availability of moisture required to sustain these processes<sup>122</sup>.

In the absence of functional vegetation and soil systems, rainfall patterns become more irregular, with increased reliance on high-intensity events such as DANA storms. These events deliver large volumes of water over short periods, which the landscape is unable to absorb or store due to limited root presence and insufficient ground cover. This disruption contributes simultaneously to flood risk during extreme rainfall and to drought conditions between events, as water is neither retained in the soil nor effectively cycled through the landscape.

Increasing exposure to droughts and fires are also an important factor to consider during resilience planning. Regenerating forms of agriculture, paired with organic inputs or biostimulants can increase the plant available water during heat and drought by up to 300%<sup>123</sup>. Droughts influence floods, and a landscape that can mitigate the effect of both extremes is a key solution to building resilience. Landscape level interventions like those proposed within this report stabilise the small water cycle to reduce the frequency and intensity of extreme weather events.

120 Oria Iriarte (2021), cited in ClimateScale (2024) — for increasing frequency of Mediterranean extreme precipitation. ([LINK](#))  
 121 Science Media Centre Spain (2024) — for expert statements on increasing DANA frequency and intensity. ([LINK](#))  
 122 For a more detailed review on this process, see the works of Millan Millan in the Mediterranean. ([Research profile](#))  
 123 Gholamhadi et al. (2025). Soil conservation benefits of biochar in Mediterranean vineyards: enhancing the soil sponge function and mitigating water erosion. *Biochar*, 7(1), 106. ([LINK](#))

Regenerating key ecosystem functions in the landscape is critical for sustaining agricultural production and addressing broader risks linked to the systematic degradation of Europe's soils. Increasing heat and drought are creating structural vulnerabilities in housing, particularly in France<sup>124</sup>, where clay soils shrink and crack under low moisture conditions. This leads to ground movement that compromises building stability, causing wall fractures and potential foundation damage. Approximately 48% of all houses in France are at medium-to-high risk zones, with a large majority of these in rural communities<sup>125</sup>. Large-scale interventions in rural areas can restore soil resilience to drought. As more properties are covered by natural disaster insurance, this may contribute to reducing the scale and cost of related insurance claims. The French Prudential Supervision and Resolution Authority of Banque de France predicts a 105% increase in climate-related housing insurance claims by 2050<sup>126</sup>. Reducing the risk of housing in high-risk areas presents ample opportunities for the insurance market to gain access to more insurance contracts, while reducing the cost of insurance claims simultaneously.

Among rising costs for agricultural products like synthetic fertilisers and fuel, regenerating forms of agriculture reduce the reliance on external inputs, increasing the overall profitability of the farm due to decreased spending. In EARA's Farmer-Led study, regenerating pioneers achieved, on average, a 20% higher gross margin when compared to conventional farmers in their country. Farmers are among the first to experience the economic shocks of geopolitical tensions, resulting in diminished yields, margins, and overall financial security. Without the ability to plan for these events, farmers are subject to market fluctuations, however, systematically reducing the use of external inputs reinstores farmer autonomy and financial resilience.

Beyond climate risk reduction, regenerative systems deliver multiple co-benefits, including improved farm profitability, increased supply stability, reduced input dependence, enhanced water quality, strengthened rural economies, and greater resilience to climate variability. Future flood, drought, fire, and wind extremes can be effectively mitigated,

but their prevention requires cross-sectoral support and investment in regenerating forms of agriculture as a living infrastructure to support long-term ecological, economic, and financial resilience. Regenerative soils don't just grow food; they swallow floods.

## Results of Methodological Route A

The USDA Natural Resources Conservation Service (NRCS) Curve Number (CN) methodology was developed as a tool to model the runoff potential of different soil types under a range of land uses. Soils are classed from A (lowest runoff potential) to D (highest runoff potential) and then Curve Numbers are produced according to the land use type - i.e., bare soil, orchards with pasture, etc. These numbers are dependent on the hydrological state of the soil (good, fair, poor) determined by prior rainfall, typically within 5-7 days before the event. CN are then used in addition to the total rainfall event precipitation to calculate the runoff potential.

<sup>124</sup> Qu'est-ce qu'un sinistre sécheresse et quels liens avec l'assurance habitation ? (2024). Retrieved April 9, 2026, ([LINK](#))  
<sup>125</sup> Munich Re, Physical Climate Risks in France ([LINK](#))  
<sup>126</sup> ACPR, Main results of the climate exercise for the insurance sector ([LINK](#))

Soil group (HSG)	A	B	C	D
<b>Description</b>	Low runoff potential due to high infiltration rates even when saturated	Moderately low runoff potential due to moderate infiltration rates when saturated	Moderately high runoff potential due to slow infiltration rates; Duplex soils with a topsoil of moderately fine to fine texture	High runoff potential due to very slow infiltration rates
<b>Soil type</b>	Deep sand, deep loess, aggregated silts	Shallow loess, sandy loam, loam	Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay	Soils that swell significantly when wet, heavy plastic clays, and certain saline soils

Table 3 | Hydrological Soil Group (HSG) according to soil type and texture

As discussed within the analysis, the study area within the Valencian Community is agricultural land, with production largely focused on permanent crops like citrus and grapes. Smaller areas of arable land cultivate crops such as barley and rice, particularly in the low-lying zones surrounding the Albufera. Soil distribution broadly follows regional topography: loam soils dominate the hilly interior areas, while clay loam soils are more common in lower elevations near the coastline and along river corridors, including the Magro.

Arable land represents less than 13% of the total agricultural area analysed. Within this category, loam-soil arable production is sparsely distributed, whereas clay loam arable land is concentrated around the Albufera, notably for rice cultivation. Many of the weather stations that recorded the highest rainfall are situated within areas of permanent crop production. Accordingly, the following analysis focuses on permanent cropping systems, as they represent the dominant land cover and are likely to have the greatest influence on runoff dynamics and flood mitigation potential.

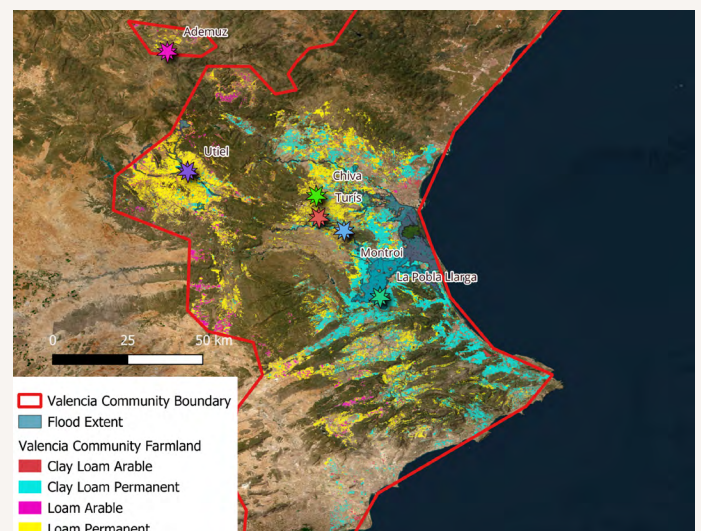
Previous analyses in the literature describe Valencian agriculture as characterised by relatively uniform management practices across agricultural systems, particularly tillage<sup>127</sup>. In permanent crops, both organic and conventional, this typically involves maintaining bare soil between rows, with mechanical or chemical interventions to control weeds.

127 Cerdà et al. (2020). Tillage versus no-tillage. Soil properties and hydrology in an organic persimmon farm in Eastern Iberian Peninsula. *Water*, 12(6), 1539. [\(LINK\)](#)

Highly conventional farms generally follow similar practices but often include the application of synthetic fertilisers and plant protection products, which can further contribute to soil compaction, the loss of soil microbiology, and reduce the soil's capacity to infiltrate and retain water.

Loam soils are typically classed as HSG B (favourable infiltration), having moderate infiltration and retention rates, however given the common use of machinery and synthetic inputs and generally low levels of SOC, two separate analyses were conducted with loam soils classed in both HSG C (less favourable infiltration) and HSG B to provide a range of potential results, while clay loam soils remain within HSG C.

Figure 11 | Valencian Community agricultural land classed by soil type and land use. AEMET stations with recorded rainfall (>100mm/h) are overlaid to illustrate risk zones



	Production Type	
	Arable	Permanent
Loam	HSG B/C	HSG B/C
Clay Loam	HSB C	HSG C
Total	37578 hectares	276199 hectars
	<b>Grand Total</b>	
	<b>313777 hectares</b>	

Table 4 | Soil grouping of predominant soil types within the Valencian Community

The October 2024 Valencia flood event was among the most extreme rainfall episodes ever recorded in Spain, with return periods estimated at over 2,000 years at point locations and exceeding 8,000 years for catchment-average rainfall<sup>128</sup>. However, the relevant question for resilience planning is not only whether such a catastrophic event recurs, but whether the landscape can manage the more frequent, moderate-to-severe events that already occur regularly and further reduce its capacity to mitigate the impact of extreme events<sup>128</sup>.

Figure 12 | Valencian farmland characterised by bare soils (up) and erosion or runoff in comparison to regeneratively managed soils (down)<sup>129</sup>

<sup>128</sup> Rombeek et al., 2025  
<sup>129</sup> Photo credits: Artèmi Cerdà, Department of Geography, University of Valencia. See research [here](#)



An average accumulated rainfall event of 200 mm is used as the upper scenario for this analysis. High-intensity rainfall events in Europe are commonly modelled above 60 mm/h because this level typically produces significant surface runoff<sup>130</sup>. On October 29 2024, the Valencian landscape exhibited multiple sites recording accumulated rainfall of 150-250mm within 24 hours, with extreme cases such as Utiel and Chiva recording >400mm. Figure 5<sup>131</sup> shows the distribution of accumulated rainfall, with these extreme sites representing a small portion of the larger watershed. As a landscape-level analysis, average rainfall is calculated on the basis of total precipitation averaged over the region of interest. For the 316,000 hectares under analysis (276,000 hectares modelled under the CN analysis), we assume a 200mm rainfall event.

Soil conditions preceding the event are highly relevant to determine the soil's ability to manage water during the rainfall event. Between 20 and 28 October less than 5 mm of rainfall was recorded, indicating that soils were not saturated. In functioning soil systems such conditions would allow landscapes to absorb and store incoming rainfall. However, high temperatures during the same period, including several days above 30°C, coupled with the widespread degradation of Mediterranean soils and a lack of protective soil cover likely reduced this ability to infiltrate and store water, due to drying and surface sealing.

Runoff potential therefore depends significantly on the hydrological condition of the soil prior to the rainfall event. Within the NRCS framework, saturated soils correspond to "poor" conditions with maximum runoff potential, while beneficial conditions with less rainfall are placed within "fair" or "good" hydrological conditions.

Conventional systems dominated by bare soil are treated as constant because the absence of vegetation and soil structure results in consistently high runoff potential regardless of previous rainfall.

Under current conditions, agricultural soils classified as HSG C with poorly or unvegetated inter-rows (often exceeding 95% of bare soil<sup>132</sup>) generate very high surface runoff. We have taken the current baseline for the analysed agricultural land as bare ground within the interrow of perennial crops for a clear analysis. Roughly 70% of the 'high performing' fields identified within the landscape analysis produce permanent crops, however this represents only 1% of the total share of analysed land, and is thus negligible within the runoff analysis.

CN analysis indicates that, under conventional management, approximately 86% of rainfall becomes surface runoff during a 200 mm event, with additional water likely accumulating as surface ponding due to limited infiltration pathways. Introducing permanent cover crops or dense grass cover between orchard rows substantially changes this response. Cover crops between permanent crops reduces the CN number from 91 to 72 for HSG C, and even further to 58 if placed in HSG B. For the same rainfall event, runoff decreases to approximately 58% of total precipitation, representing a relative reduction of roughly 34%. At the landscape scale of Valencia's perennial crop systems, this change corresponds to more than 100 billion litres of additional water retained in soils rather than contributing to rapid surface flows and erosion.

Alternatively, assuming loam soil - which accounts for 52% of agricultural land - is classed as HSG B, this further reduces the total runoff to 46%.

130 Zhang, Q., Lv, X., Ni, Y., Ma, L., & Wang, J. (2023). Slope runoff process and regulation threshold under the dual effects of rainfall and vegetation in loess hilly and gully region. *Sustainability*, 15(9), 7582. [\(LINK\)](#)  
131 Page 17

132 Hondebrink, M. A., Cammeraat, L. H., & Cerdà, A. (2017). The impact of agricultural management on selected soil properties in citrus orchards in Eastern Spain: A comparison between conventional and organic citrus orchards with drip and flood irrigation. *Science of the total environment*, 581, 153-160. [\(LINK\)](#)

	Runoff %	Runoff L/ha	Runoff L total	Potential runoff reduction total L
<b>Current</b>	86%	1,7 ML	475,062 ML	-
<b>Loam =HSG C Clay Loam = HSG C</b>	58%	1,1 ML	320,390 ML	154,671 ML
<b>Loam = HSG B Clay Loam = HSG C</b>	46%	950 KL	262,494 ML	212,567 ML

Table 5 | Runoff estimations following a 200 mm rainfall event depending on soil type

Within a reasonable timeframe of 2 years to establish perennial cover crops or pasture within the interrow spacing of permanent crops, this more than halves the total runoff in a 200mm rain event. This equates to more than 776,000L per hectare - or 212 billion litres total - of extra water absorbed and retained within the soil over the entire rainfall event.

Daily rainfall of 100mm, sufficient to trigger significant runoff on degraded bare soils, has a return period of less than five years in the Valencia region, while events exceeding 200mm occur roughly once every 75 years<sup>133</sup>. Under a 100mm rainfall CN analysis, regeneratively managed land would have roughly 25% of water runoff, against 75% for bare soil during the same event.

For sites that experienced extreme rainfall, as in the case of Utiel, Chiva and Turis with  $\geq 400\text{mm/m}^2$  of precipitation, the excess water could be redirected through living green water infrastructure to other fields, forests, or dams in lower rainfall zones. Given the intensity of such rainfall events, a certain level of runoff is inevitable, however measures such as swales, small retention basins, distributed farm dams, and keyline-aligned planting systems can intercept and redistribute excess water across the landscape. These interventions operate most effectively when combined with the broader transition toward continuous vegetation cover and soil regeneration, gradually moving the system toward a landscape that prioritises natural hydrological processes to regulate the flow of water.

The most immediate impact that can be done at the field-level is the integration of multi-species cover crops that provide both a protection for the topsoil as well as diverse root systems to allow water to infiltrate and be stored in the soil. As expressed through table 5, this change constitutes an immediate reduction in surface runoff from 86% to 58%, with the potential for this to improve over time as soil structure returns and the microbiology is reactivated.

Landscape regeneration is an ongoing process. As soil organic carbon increases and soil biology recovers, processes such as macroaggregate formation, worm activity, and root pathway development rebuild soil infiltration and water storage capacity, further reducing runoff during rainfall events. Our network of pioneering farmers cite that these changes can occur within a 4–6 year timeframe and continue improving beyond that period. Sustained regenerative management contributes to this shift through reduced compaction, increased soil organic matter and carbon assimilation, and practices that stimulate biological activity in the soil.

**Unlike grey infrastructure, nature based interventions do not become redundant or outdated, they act as living infrastructure to continuously build resilience year by year.**

133 Rombeek et al., 2025

## Results of Methodological Route B

A growing body of literature<sup>134</sup> assessing the effect of conservation agriculture on the soils hydrological function<sup>135</sup> shows significant increases in water infiltration rate and water holding capacity. Particular attention to the soil types included in the analysis reveals that in semi-arid areas closely resembling the Valencian region the increases for loam, clay loam, and clay-silt loam soils were 244%, 108%, and 300%, respectively. Similarly, soil amendments like biochar<sup>136</sup> increased water infiltration by up to 170%<sup>137</sup> and retention by 73%.

As discussed earlier, research published by EARA<sup>138</sup> shows Spanish regenerative farms with 67% higher photosynthesis and 62% higher relative soil cover compared with conventionally managed land. These same pioneering farmers across Spain reported higher SOM and SOC, in some cases up to 4% higher organic matter than neighbouring conventional fields. Leveraging the knowledge of these pioneers and integrating regenerative principles and practices can break the cycle of degradation and create a new trajectory toward regeneration.

Regenerating forms of agriculture prioritise the health of the soil, creating an abundance of soil life and soil food. Organic matter is a critical component of healthy soil, and is composed of decomposed plant matter, micro- and macroorganisms (microbes, worms, etc.). Under regenerative management, organic matter is stocked rather than depleted, and is achieved through a range of practices like manure application and

residue management paired with minimum or zero tillage, cover crops, diverse swards with abrasive texture, swales, and biostimulants. When used in conjunction, these practices have been shown to mobilize nutrients, improve water quality, retention, and infiltration<sup>139</sup>, with benefits visible within one year in the mediterranean<sup>140</sup>.

Living root systems promote soil aggregates and macroporosity, fundamental aspects for increasing infiltration and water holding capacity, subsequently increasing the resilience of the land in flood events. Living roots and field residue from cover crops, pruning, or annually harvested cash crops also increase and regulate soil nutrients and the levels of SOM and SOC in the soil<sup>141</sup>. Through the decomposition of root matter and exudates, these systems provide substrates for soil microorganisms, driving organic matter transformation and carbon stabilisation<sup>142</sup>. It is essential to integrate permanent living root systems to Valencian farmland to facilitate water infiltration and avoid erosion and pollution caused by soil deposition in downstream areas.

Among the stacked benefits of regenerative management, the impact on the SOM content of the soil is crucial to flood and drought mitigation. Regenerating forms of agriculture have been shown to improve the SOM of degraded soils by up to 0.5% per year<sup>143</sup>, a stark contrast to conventional systems that extract SOM and SOC, leaving it exposed to mineralisation<sup>144</sup>. We estimate that, accompanied by regenerative advisory operating at local and regional levels, regenerative principles and practices can be embedded in Valencian agriculture within 4-6 years. Within the scope of this analysis, we estimate a conservative annual increase of 0.25-0.3% SOM, resulting in a total increase of 1.5% for this timeframe, and approximately 3% in 8-10 years. **This timeline is similar to that of major grey infrastructure projects, but at a fraction of the cost.**

134 Some examples include:

Parihar et al. (2019). Soil water dynamics, water productivity and radiation use efficiency of maize under multi-year conservation agriculture during contrasting rainfall events. *Field Crops Research*, 241, 107570. [\(LINK\)](#)

Mitra, S., Saha, R., & Alam, N. M. (2022). Impacts of conservation agriculture practices on soil water dynamics. In *Conservation Agriculture and Climate Change* (pp. 351-359). CRC Press. [\(LINK\)](#)

García-Tejero et al. (2019). Conservation agriculture practices to improve the soil water management and soil carbon storage in Mediterranean rainfed agro-ecosystems. In *Soil health restoration and management* (pp. 203-230). Singapore: Springer Singapore. [\(LINK\)](#)

135 Abdallah et al. (2021). Conservation agriculture effects on soil water holding capacity and water-saving varied with management practices and agroecological conditions: A Review. *Agronomy*, 11(9), 1681. [\(LINK\)](#)

136 Woodchips heated in low-oxygen environments creating 'char' with extreme porosity, highly effective at infiltrating and storing water.

137 Abrol et al. (2016). Biochar effects on soil water infiltration and erosion under seal formation conditions: rainfall simulation experiment. *Journal of Soils and Sediments*, 16(12), 2709-2719. [\(LINK\)](#)

138 Farmer-led Research on Europe's Full Productivity The Realities of Producing More and Better with Less - Place-based Innovation for the Good of All [\(LINK\)](#)

139 Soto et al. (2021). [\(LINK\)](#)

140 De Leijster et al. (2019). Agroecological management improves ecosystem services in almond orchards within one year. *Ecosystem Services*, 38, 100948. [\(LINK\)](#)

141 de Torres et al. (2021). Soil organic matter and nutrient improvement through cover crops in a Mediterranean olive orchard. *Soil and Tillage Research*, 210, 104977. [\(LINK\)](#)

142 Carrascosa et al. (2025). "Improved management increases soil mineral-protected organic carbon storage via plant-microbial-nutrient mediation in semi-arid grasslands." *SOIL*, 11, 911-937. [\(LINK\)](#)

143 Macray, J. E., & Montgomery, D. R. (2023). Trends in soil organic matter and topsoil thickness under regenerative practices at the University of Washington student farm. PeerJ, 11, e16336. [\(LINK\)](#)

144 Blanco-Moure, N., Gracia, R., Bielsa, A. C., & López, M. V. (2016). Soil organic matter fractions as affected by tillage and soil texture under semiarid Mediterranean conditions. *Soil and Tillage Research*, 155, 381-389. [\(LINK\)](#)

Cover cropping is one of the fastest ways to build SOC and SOM<sup>145</sup> in both perennial and annual systems, due to root exudates and residue nutrient management<sup>146</sup>. Integrating perennial grasses and forbs as cover crops not only builds soil fertility and SOM, but allows for aggregate formation, giving water a pathway through which it can infiltrate easily.

Of the main soil and cropping types we identified, we assume that a 1.5% increase in SOM is possible within the reference period of 5 years, effectively increasing the average water holding capacity to 569,000 L/ha. Additionally, multiple studies cite that well-functioning perennial systems with permanent grass and forb cover can increase the hourly water infiltration to >70mm/m<sup>2</sup><sup>147</sup>, compared to 20mm or lower in conventional systems<sup>148</sup>.

Systems that aim for permanent soil cover dramatically influence soil aggregation and porosity, key drivers of infiltration and holding capacity<sup>149</sup>. Mulch alone can increase infiltration by a further 16.2mm. Complementing regenerative management with organic soil amendments like biochar similarly boosts water infiltration and holding capacity<sup>150</sup>. In simple terms, the soil acts more like a sponge and less like concrete.

Straw Mulch	
Straw rate (Tonnes per hectare)	Infiltration Rate (L per hectare)
0	228,600
1.25	228,600
2.5	431,800
3.75	609,600
6	635,000
8.4	635,000

Table 6 | Mulching and the impact on infiltration rate<sup>151,152</sup>

145 Abad et al. (2023). Under-vine cover crops: Impact on physical and biological soil properties in an irrigated Mediterranean vineyard. *Scientia Horticulturae*, 311, 111797. [\(LINK\)](#)  
 146 de Torres et al. (2021). Soil organic matter and nutrient improvement through cover crops in a Mediterranean olive orchard. *Soil and Tillage Research*, 210, 104977. [\(LINK\)](#)  
 147 Sastre, B., et al. (2024). Groundcovers improve soil properties in woody crops. *Agriculture*, 14(12), 2288. [\(LINK\)](#)  
 148 González-Rosado, M., Parras-Alcántara, L., Aguilera-Huertas, J., & Lozano-García, B. (2021). Soil productivity degradation in a long-term eroded olive orchard under semiarid Mediterranean conditions. [\(LINK\)](#)  
 149 Helalia, A. M. (1993). The relation between soil infiltration and effective porosity in different soils. *Agricultural water management*, 24(1), 39-47. [\(LINK\)](#)  
 150 Gholamahmadi et al. (2025). The impact of biochar application on sponge function, water erosion, and vegetation cover in a Mediterranean vineyard soil. *Journal of Environmental Management*, 388, 125916. [\(LINK\)](#)  
 151 Mannering & Meyer (1963). The effects of various rates of surface mulch on infiltration and erosion. *Soil Science Society of America Proceedings* 27:84-86.  
 152 Strickler, D. (2018). The drought-resilient farm: Improve your soil's ability to hold and supply moisture for plants; maintain feed and drinking water for livestock when rainfall is limited; redesign agricultural systems to fit semi-arid climates. Storey Publishing.

	Improved Regenerative Performance	
	Infiltration Rate	Water Holding Capacity
Current System	~200,000 L/h	~400,000 L/h
2-year Cover Crop	420,000 L/h	450,000 L/h
5-year Regen Transition	630,000 L/h	550,000 L/h
10-year Regen Transition	>800,000 L/h	>700,000 L/h

Table 7 | Estimated impact of regenerating forms of agriculture on water infiltration per hour and holding capacity in L per hectare

With the increasing frequency of climate-related disasters such as DANA storm events, regenerating forms of agriculture offer a robust means of building long-term resilience. Unlike conventional infrastructure, which degrades over time and may become inadequate as events intensify, regenerative systems improve and adapt continuously, thereby reducing the risk of increasingly severe flooding and drought in the future.

Due to the intensity of the rainfall over such a small period of time, it is impossible that even after the water infiltration and retention capacity have been improved the entirety of the flood damage would be mitigated. **However, well-managed regenerative systems would have likely absorbed up to 60% of the peak hourly rainfall on average, greatly reducing surface runoff while eliminating mud slides and consequent economic, environmental, and social impact on the Valencian Community.**

Remaining runoff can be treated with nature-positive hydrological interventions such as keyline swales or terracing, keypoint leaky dams in critical areas, or flow managing riprap (stones or gravel used to slow down water flow). In all cases, these interventions should be implemented with the end goal of having natural ecosystem functions rather than grey infrastructure.

Protecting the soil drastically reduces - if not eliminates - the amount of topsoil loss during extreme flooding. This, in turn, reduces the costs associated with the pollution of waterways and water infrastructure. While these interventions do not eliminate the impact of future floods, they become slower, shallower, and far less destructive.

Seen at a wider landscape level, regenerating forms of agriculture functions as a decentralised, living water infrastructure. Instead of relying only on concrete infrastructure like large dams, channels, water is slowed, absorbed, stored, and released by countless hectares of healthier soil. This approach is complementary to other flood protection measures like targeted infrastructure investments, but it can dramatically reduce the scale, speed, and damage of future flood events, while delivering ongoing benefits to productivity, soil health, and farm resilience. Specific regenerative practices exist as operational levers for improving soil hydraulic function and flood resilience. These practices include minimum, strip, or no-tillage, cover cropping, organic amendments and the use of biostimulants, keyline design, and the integration of swales in conjunction with earthworks. Together, these interventions are prioritised for their ability to increase continuous soil cover, enhance soil structure, and redistribute water more effectively across the landscape.

Regeneratively managed systems utilise more effective irrigation systems while reducing the need for water inputs by prioritising soil cover year-round, in the form of living roots or green mulch. A soil populated by living roots stimulates microbial li

fe, leading to the formation of stable aggregates and increased SOM, improving the soil's ability to retain plant-available water. Green growth in the soil not only promotes higher infiltration rates but can also 'catch' lost topsoil from neighbouring fields as demonstrated in this video taken weeks after the flooding event in one of the most affected zones. In addition, perennial root systems and soil aggregates function as natural filters, so that any water lost to the watershed is cleaned.

## Two Routes, One Result: A Cost-Effective Response to Build Climate Resilience

To achieve the results discussed above at scale, we calculate the cost for incentives to enable farmers to engage on their regenerating journey from 150€ to 500€ per hectare and year.

Table 8 | Economic comparison of a full-scale regenerative transition<sup>153</sup> across the 316,000 hectares of impacted agricultural land in the Valencian Community against sector-specific losses, total incurred costs, and confirmed recovery funding.

	Regenerative Transition		Direct water systems / Infrastructure cost	Direct Agricultural Losses	Estimated Costs of Flood (Zurich Insurance)	National & EU recovery fund	Total amount demanded for recovery
	1-year	5-year					
Cost per Hectare	€150 - €500	€750 - €2500	€5,696	€4,367	€63,291	€38,608	€98,101
Cost per Farm	€1,000	€5,000	€33,894	€25,986	€376,605	€229,729	€583,804
Total Amount	€100.5M - €211.1M	€502.5M - €1055.5M	€1.8B	€1.38B	~€20B	~€12.2B	~€31B
Relative Cost	-	Reference	70% higher	31% higher	1896% higher	1056% higher	2839% higher
Basis of Calculation	Full-scale regenerative transition of Valencian farmland		Cost of damages to infrastructure	Loss of crops, soil, damages to land	Estimated costs of economic losses	Funds allocated to affected land	Funds allocated to affected land

<sup>153</sup> A full-scale transition to regenerating forms of agriculture is widely cited as taking 4-6 years. For simplicity in our economic analysis, we have taken 5-years as an 'average'. We have similarly taken the highest cost of the transition to demonstrate the cost-effectiveness of this approach as a means to build landscape resilience.

For total costs we calculate with remunerating farmers for 5 years as a sufficient timespan to thoroughly root a regenerating land use system. Actual costs per hectare can vary widely as they are context-specific. We propose in the next chapter a remuneration model of performance-based incentives endorsed by the European Economic and Social Committee and supported by transition insurance that is structured to eliminate transition risk.

Annual estimates of the total cost listed in table 8 include an agronomic consultancy allowance of €1,000 per farm per year. As there is no published figure for the number of farms within the analysed landscape, the 316,000 hectares under analysis are assumed to represent 53 percent of the total 589,000 hectares of farmland in the Valencian Community. The number of farms is therefore estimated as the same proportion of the total 100,200 farms, resulting in ~53,100 farms under analysis.

From the €30 billion requested by the Valencian government, only two thirds have been accounted for, and less than half have been allocated<sup>154</sup>. Zurich Insurance evaluates the cost of the floods at approximately €20.3 billion<sup>155</sup>, due to extensive material damage and direct impacts on regional physical assets. This amount encompasses damage to public infrastructure as well as insured and uninsured losses to private property, and represents an approximate measure of the event's total economic cost. The estimate is based on internal assessments from the Generalitat Valenciana, the Insurance Compensation Consortium (CCS), and the EMPLEA UPV Chair<sup>156</sup>. While a large portion of this budget will be directed at compensation and the reconstruction of critical flood mitigation infrastructure, table 8 shows that with much less investment Valencian agriculture could be entirely transitioned to flood and drought mitigating systems, providing long-term economic, environmental, and social security.

The Valencian Association of Farmers places the total estimated agricultural losses suffered by Valencian farmers at €1.379 billion, 31% higher than a full 5-year transition of the region. Moreover, the loss of over 17,000 tonnes of fertile agricultural topsoil will likely translate to extended losses as the land stabilise and tries to deliver the nutrients required for plant

growth<sup>157</sup>. As the frequency of similar events increases, it is both crucial and cost-effective to embed resilience in these systems through regenerating forms of agriculture.

The relative cost difference in row 4 of table 8 is taken from the highest estimated cost for a five-year transition period to demonstrate the impact potential of a full scale transition. Realistically however, true adoption rates will vary, particularly depending on the support that is offered to farmers during the transition period, and the capacity of local experts that can provide agronomic support. Initial best responses might include focusing on target zones, such as those highlighted in the landscape analysis section. Regenerative agriculture and other living water infrastructure in Chiva, Turis, and Utiel could potentially have a disproportionate impact on mitigating flood damage due to their topographic location, highly degraded landscape, and upstream contributing flow.

Accounting for less than 30% of the total agricultural land under analysis, this would translate to a total 5-year cost of €316 million. Currently, the Valencian recuperation plan<sup>158</sup> proposes €768 million toward the development of grey water and flood mitigation measures. For less than half of this amount, key Valencian farmland could be transformed into effective flood, drought, and fire mitigation zones.

Structural damage caused by flooding is largely driven by water velocity as it flows through the natural and artificial channels within a given area<sup>159</sup>. On October 29, hourly, 6-hour, and 12-hour rainfall intensity records were broken across parts of Valencia<sup>160</sup>. Rather than slowing this flow, agricultural fields intensified it as thousands of tonnes of displaced topsoil obstructed flood mitigation infrastructure, reducing its capacity to regulate accelerated water flow. A more detailed hydrological analysis would be required to quantify the precise economic reduction associated with the regenerative land transition proposed in this report. Nevertheless, had the surrounding landscape's ecosystem been functioning, our analysis indicates that combined with targeted hydrological interventions, the same landscape under regenerative management could have massively reduced total economic losses.

154 Council of Ministers. (2024). The Government of Spain activates a plan for the recovery of the areas affected by the DANA. [\(LINK\)](#)  
 155 Zurich Insurance Spain. (2025) PERC Report on Valencia Floods [\(LINK\)](#)  
 156 Zurich Insurance Spain. (2025) [\(LINK\)](#)

157 Zurich Insurance Spain. (2025) [\(LINK\)](#)  
 158 Plan Recuperación y mejora resiliencia [\(LINK\)](#)  
 159 Kreibich et al. (2009). Is flow velocity a significant parameter in flood damage modelling?. *Natural Hazards and Earth System Sciences*, 9(5), 1679-1692. [\(LINK\)](#)  
 160 Zurich Insurance Spain. (2025) [\(LINK\)](#)

# Discussion

## Leveraging Existing Funds to Aid the Transition

Farmers require a set of enabling conditions to successfully transition to regenerative systems. These include access to multi-year agronomic advisory support, investment capacity for appropriate machinery and infrastructure, fair and stable pricing for their outputs, and a reduced administrative burden to allow focus on operational change. Delivering this support requires private sector support, as well as a strong policy framework that enables farmers to be rewarded for the services they provide to wider society.

## Private Sector Support

Operational risk associated with changing practices and management at the farm gate level constitute the largest barrier to successful and systemic regeneration. For this reason, scaling regenerative forms of agriculture requires institutional support, to ensure today’s farmers do not bear the financial brunt of generations of systemic degradation.

The restoration of farmland’s vital ecosystem functions results in reduced risk for rural, peri-urban, and urban communities at large. Therefore, societal benefits at this scale should have cross-sectoral support, with the private sector playing a key role in securing the economic resilience of farmers during the transition period. Local, regional, or national consortia can act as a key lever for this financial support, bringing together stakeholders holding a vested interest in regenerating systemic risk through agricultural systems. Banks, insurance companies, supply-chain offtakers, water management companies, and public institutions have existing synergies that could be leveraged to provide farmers with comprehensive financial and technical support. Collaborating to support European farmers would deliver extensive benefits to rural and urban communities, but also across the institutions that are currently exposed to the embedded risk in conventional agricultural systems.

Practical tools exist for monitoring the progress of each farmer’s performance over time. As regenerative MRV<sup>161</sup> systems continue to be developed, outcome-based indicators are considered an accurate and useful proxy for regeneration. EARA’s study on the regenerating productivity of pioneering regenerative farmers has operationalised these indicators, pulling together farmer-reported and satellite data to communicate the improved resilience of regeneratively managed systems.

161 Monitoring, Reporting, Verification

Benefits of the regenerative transition			
Banks	Insurers	Supply Chain	Water management
Improved farm profitability and resilience, reduced default risk, increased stability of agricultural lending portfolios	Reduced claims frequency and severity, improved loss ratios, shift toward prevention-based risk management	Increased yield stability, reduced supply risk, improved long-term procurement security	Improved water quality, increased water availability, reduced water treatment costs

Table 9 | Benefits of the regenerative transition for different private-sector actors

For a more detailed review on the methodology used to assess the ecological and economic performance of regenerating farms, please see our study<sup>162</sup>. Similarly, EARA's Regen Compass<sup>163</sup> provides a comprehensive overview of the 29 most prominent regenerative agriculture certifiers and MRV providers.

By collectively ensuring farmer's margins or yields during the transition, these stakeholders share both risk and long-term benefits. As systems stabilise and margins improve, farmer contributions can progressively shift from full support toward performance-based insurance premiums.

This collaborative approach has significant potential to secure the long-term viability of Valencian agricultural land while improving regional and peri-urban livelihoods. This transition will allow farmers to address financial considerations while also realising non-monetised benefits associated with biodiversity, social wellbeing, and the health of human, animal, and plant life.

## Public Sector Support

In September 2025, Spanish president Pedro Sánchez proposed a State Pact to tackle the Climate Emergency between all administrations in the country<sup>164</sup>. 10 specific commitments were stipulated within this pact, of which 4 are particularly pertinent to this report. Citing both the 'climate emergency' and intensifying DANA storms, the president proposed the creation of permanent recovery funds for areas impacted by climate events. The pact also calls for updated water plans and land-use regulations that further restrict development in flood-prone areas, and a National Water Resilience response to increase the capacity of towns and cities to manage floods and droughts. Crucially for the agricultural dimension of this report, the pact explicitly promotes regenerative agriculture, agroforestry, managed grazing, and efficient irrigation as core tools for climate adaptation, while also committing to reforestation with mixed, fire-resilient forests and preventive silvicultural management.

Together, these commitments signal a meaningful shift in Spanish policy toward nature-based and land-management approaches as structural responses to climate risk.

It is increasingly evident that nature based solutions offer a cost-effective and significant alternative to grey infrastructure, and there are already existing funds that could support their integration in the Valencian context.

Despite accounting for only 2.5% of Spanish cultivated land<sup>165</sup>, Valencian agriculture contributes nearly 8% to the Spanish agricultural sector, specialising in fruit and citrus production<sup>166</sup>. Under the 2023-2027 Spanish Strategic plan for the CAP, a total of €3.9 Billion was allocated to environmental interventions like the promotion of organic farming, aid to areas with natural or other specific constraints, and aid to areas with specific handicaps<sup>167</sup>. With the proposed changes to the CAP inciting more member state participation, this brings forward the possibility for targeted action in building resilience in risk prone areas. If just 8% of this funding went toward strengthening Valencian agriculture, that would provide €310 million to support the full-scale transition.

The disparity between effective investment in resilient systems and existing funding mechanisms can be addressed through targeted support to rural communities and land stewards. As outlined above, agriculture has transversal effects across the economy, environment, and rural livelihoods, enabling co-benefits that are not captured through grey infrastructure investments alone. For a fraction of the costs incurred as a result of the October floods, regenerating forms of agriculture could mitigate a significant share of damages while reducing future climate-related losses. Such an approach allows existing and complementary funding initiatives to be leveraged more efficiently, strengthening landscape resilience while delivering long-term economic, environmental, and social returns.

<sup>162</sup> [\(LINK\)](#)  
<sup>163</sup> EARA, Regen Compass, A Farmer-Led Guide to Frameworks, Certification & Claims in Regenerative Agriculture [\(LINK\)](#)  
<sup>164</sup> La Moncloa (2025). Pedro Sánchez proposes a State Pact to tackle the Climate Emergency between all administrations and with the cross-cutting support of civil society. [\(LINK\)](#)

<sup>165</sup> Eurostat Agricultural Database [\(LINK\)](#)  
<sup>166</sup> Valencian Agricultural Sector Report (2022). [\(LINK\)](#)  
<sup>167</sup> Fondo Europeo Agrícola de Desarrollo Rural (2026). [\(LINK\)](#)

There is also potential to support the recovery of Valencia's landscape through existing programmes focused on funding effective water and energy management, fostering collaboration, and delivering extended benefits at lower cost. One example is the Secretary of State for Agriculture and Food's declaration of a €2.5 billion investment in new irrigation systems under programmes aimed at reducing pollution in the Albufera<sup>168</sup>. This plan was proposed in light of the widely practiced flood-irrigation, a highly inefficient method of irrigation that disrupts the soil's ability to infiltrate and store water. A portion of the budget allocated to modernising the irrigation system could be directed toward the development of regenerating agricultural systems that address water<sup>169</sup> and energy<sup>170</sup> efficiency while restoring the key ecosystem functions required for a stable environment.

There is significant opportunity for a portion of these funds to support and scale regenerating forms of agriculture as highly effective, natural water treatment infrastructure.

Of the €768 million proposed for the development of water treatment and flood mitigation measures, €500 million of this is defined for grants/actions for water supply, sanitation and wastewater treatment<sup>171</sup>. As discussed in the results, regenerating forms of agriculture are a highly efficient, cost-effective, and transversally beneficial method of cleaning, storing, and retaining water during times of stress and/or excess. Multiple pilots exist in Europe that explore the potential of regeneratively managed land as a method of water treatment<sup>172</sup>.

Table 10 | Public sector action to support the transition and build climate resilience

Redirect existing funds	Establish performance-based incentives	Integrate landscape hydrology in plans
Rather than focusing adaptative and preventative funding from recovery budgets to grey infrastructure, a share should enable the regenerative transition of agricultural land. This is not a reallocation away from flood protection; it is a more cost-effective and durable form of it.	Outcome-based payments that reward measurable improvements in SOC, soil cover, and input reduction create an incentive for farmers to transition without requiring indefinite subsidy. Performance-based frameworks reduce fiscal exposure over time as improving landscape function reduces the frequency and severity of events that trigger public recovery expenditure.	Updated land-use regulations and water plans should incorporate soil health and hydrological function as material factors in planning and flood risk assessment. For example, addressing conventional management practices that increase runoff risk (bare soils, repeated tillage) within updated regulatory frameworks for agricultural land in upstream catchments.

168 MADRID Agrodriario. (2025, October 7). Agrodriario. [\(LINK\)](#)  
 169 Al-Fatlawy, R. R., Alkhafaj, M. A., & Karuna, G. (2025). Optimized Water Management Strategies in Regenerative Agriculture for Resilience and Efficiency. In SHS Web of Conferences (Vol. 216, p. 01010). EDP Sciences. [\(LINK\)](#)  
 170 Rhodes, C. J. (2017). The imperative for regenerative agriculture. Science progress, 100(1), 80-129. [\(LINK\)](#)  
 171 Pp.142 of the Plan Recuperación  
 172 Pour une hydrologie régénérative [\(LINK\)](#) & Eau de Paris [\(LINK\)](#)

# Concluding Remarks & Recommendations

Valencia's October 2024 floods exposed structural vulnerabilities of a landscape systematically stripped of its ability to manage water. The objective of this report was to demonstrate that regenerating forms of agriculture can play a key role within a larger response to mitigate up to 60% of total surface runoff, functioning as living, decentralised flood infrastructure. Unlike grey infrastructure, this capacity does not degrade over time but improves continuously to deliver cascading benefits to soil health, water quality, farm profitability, and landscape resilience. Based on the experience of pioneering farmers across Spain and Europe, a meaningful transition can be embedded within 4 to 6 years.

A full-scale transition across the 316,000 hectares under analysis would cost less than the agricultural losses incurred in a single flood event, placing it among the most cost-effective climate resilience investments available to policymakers today. It is equally possible to reduce costs further through target interventions in high-risk zones like Chiva, Turis, and Utiel, however these interventions must be a part of a wider climate strategy. Regenerative land management should also be accompanied by targeted hydrological interventions like keyline systems, swales, retention basins, and riparian buffers that are proven to slow, spread, and sink water across the landscape.

**Delivering multiple co-benefits, regenerating forms of agriculture can boost both local, regional, and national economies, and build cross-sectoral social, economic, and ecological resilience. Banks and lenders can reduce their exposure to stranded agricultural assets. Insurers and reinsurers would see declining loss ratios and reduced catastrophe claims. Water management companies gain natural filtration and retention infrastructure. Regional and national governments build durable, cost-effective climate resilience without sole grey infrastructure. Finally, the farmers who steward this transition secure the long-term production of their farmland, improve their margins, reduce their input dependency, and augment their stability in the face of increasing climate volatility.**

To guide the planning and integration of these solutions, we make the following key recommendations for regenerating against systemic risk in the Valencian watershed and broader contexts:

1. **Co-Create Programmes with Practitioners, leading Agronomists and Anchor Them in a Compelling Narrative for the Next Generation.** Policy and financial mechanisms must be designed in direct partnership with pioneering farmers to ensure they are practical, context-specific, and trusted. Furthermore, regenerating forms of agriculture must be positioned not merely as a technical shift, but as a forward-looking narrative of hope, resilience, and generational renewal. By framing soil health as a public good and regeneration as a pathway to secure livelihoods, this movement can attract and empower the next generation of land stewards, securing the long-term viability of Valencian agriculture.
2. **Mobilise Cross-Sectoral Finance to De-Risk the Farmer Transition.** The primary obstacles to systemic regeneration are capacity limitations, operational expenses, and the perceived risks of transforming farm management. To overcome these, we propose performance-based, per-hectare incentives that empower farmer decision-making, coupled with agronomic support selected by pioneering farmers. For additional security, public-private Transition Insurance Consortia uniting banks, insurers, supply chains, and public bodies can collectively underwrite farmer margins during the critical 4–6 year transition. This model distributes risk and secures long-term benefits, giving farmers the financial stability, incentives and agronomic support to innovate. As systems mature, farmer compensation can seamlessly transition to performance-based payments from CAP, national, regional, and private programmes, all verified through a unified MRV system.
3. **Adopt a Unified, Context-Specific, Outcome-Based Monitoring Framework.** To monitor progress, accelerate impact, and reduce administrative burden, recovery programmes must implement a pre-competitive, harmonised Measurement, Reporting, and Verification (MRV) system. Building on the consensus established in the recent EESC Opinion on Regenerative Agriculture, this framework should

track core, measurable outcomes such as Soil Organic Carbon, Bulk Density, and Soil Cover. Doing so requires the use of integrated data from soil tests, satellite mapping, and farm records. A shared MRV backbone minimises duplication, lowers costs, and unlocks future access to carbon, or premium markets.

Successful, lasting transition must be co-created on the ground, in direct partnership with local farmers and experienced regenerative agronomists who understand the specific soils, crops, and conditions of the Valencian landscape. EARA and its practitioner network in Spain and internationally can support with technical expertise, farmer trust, and regional knowledge required to turn this analysis into action.

Nature has always presented constraints and opportunities. Effective responses require working in alignment with natural systems through agricultural practices, enabling systemic regeneration and addressing risks generated by current land-use patterns. The evidence is clear, the economics are compelling, and the knowledge and expertise can be leveraged. What is now required is the institutional commitment to act proactively, with the understanding that every year of delay compounds both the risk and the cost.

# Annex

## Calculations

[→ Link Table](#)

## Valencian Agriculture Continued

### Excessive Machinery Use and Tillage

Frequent use of heavy machinery leads to soil compaction and the formation of hardpans, typically 10–30 cm below the surface. Even thin compacted layers can severely restrict water movement<sup>173</sup>, oxygen availability and root growth<sup>174</sup>, and microbial activity, all contributing to increased dry and wet stresses in the soil<sup>175</sup>. Restricting vegetation or living roots leaves soils compacted, crusted, and prone to runoff, particularly on slopes. Deep tillage is often used to break compacted layers but can perpetuate a cycle of degradation by relying on the same machinery that caused compaction.

Tillage negatively affects soil organic carbon, soil structure, and water infiltration. Root systems and stable aggregates create pore networks that allow water to infiltrate and be stored<sup>176</sup>. Reduced tillage systems slow the decomposition of organic matter by protecting the soil surface<sup>177</sup>, while intensive tillage accelerates carbon loss by exposing organic matter to oxidation and disrupting soil aggregates<sup>178</sup>. Repeated disturbance weakens soil structure, increases erosion risk, and reduces the soil's ability to absorb rainfall.

173 Rathnayake, N. R. R. W. S., Leelamanie, D. A. L., & Maeda, M. (2025). Shallow-depth hardpan attributes influence soil surface and subsurface hydraulic properties. *Catena*, 259, 109405. ([LINK](#))

174 Armstrong, W., & Drew, M. C. (2002). Root growth and metabolism under oxygen deficiency. In *Plant roots* (pp. 1139–1187). CRC Press. ([LINK](#))

175 Hamada, K., Inoue, H., Mochizuki, H., Miyamoto, T., Asakura, M., & Shimizu, Y. (2021). Effect of hardpan on the vertical distribution of water stress in a converted paddy field. *Soil and Tillage Research*, 214, 105161. ([LINK](#))

176 Tavares, J.; Tessier, D. Characterization of soil structure and porosity under long-term conventional tillage and no-tillage systems. *Rev. Bras. Ciência do Solo* 2009, 33, 1837–1844. ([LINK](#))

177 Kassam, A., Friedrich, T., Derpsch, R., Lahmar, R., Mrabet, a R., Basch, G., ... & Serraj, R. (2012). Conservation agriculture in the dry Mediterranean climate. *Field Crops Research*, 132, 7–17. ([LINK](#))

178 Abdallah, A. M., Jat, H. S., Choudhary, M., Abdelaty, E. F., Sharma, P. C., & Jat, M. L. (2021). Conservation agriculture effects on soil water holding capacity and water-saving varied with management practices and agroecological conditions: A Review. *Agronomy*, 11(9), 1681. ([LINK](#))

Field experiments by the USDA Natural Resources Conservation Service show that water infiltration is substantially lower in tilled soils than in soils protected by vegetative cover<sup>179</sup>. Conversely, regenerative practices such as reduced or no-till, cover cropping, and intercropping improve infiltration without reducing yields<sup>180, 181</sup>.

### Excessive Chemical Intervention

High reliance on synthetic inputs disrupts critical soil biological processes<sup>182</sup> essential for aggregation<sup>183</sup> and infiltration<sup>184</sup>. Fertiliser-dependent systems suppress microbial diversity<sup>185</sup> and weaken plant–soil interactions<sup>186</sup>. Reduced fungal biomass and aggregate stability lower infiltration capacity and increase runoff during heavy rainfall events<sup>187</sup>, while declining ground cover and shallow root systems further increase vulnerability.

### Fallow fields and fert-irrigation

Bare fallow accelerates soil degradation through multiple, well-documented mechanisms. When soil is left without vegetative cover or roots for extended periods, surface residues and organic matter are absent<sup>188</sup>. Surface organic matter protects the soil from raindrop impact, which otherwise promotes sealing and crust formation that reduces infiltration and increases runoff and erosion<sup>189</sup>. In bare soils without continuous root activity, soil pore networks collapse and microbial populations decline. Roots and associated exudates create and stabilise macropores; microbial activity contributes to aggregate stability and porosity<sup>190</sup>.

179 Blanco-Canqui, et al. (2006). Corn stover impacts on near-surface soil properties of no-till corn in Ohio. *Soil Science Society of America Journal* 70: 266–278

180 Raseduzzaman, M. D., & Jensen, E. S. (2017). Does intercropping enhance yield stability in arable crop production? A meta-analysis. *European Journal of Agronomy*, 91, 25–33. ([LINK](#))

181 Pittelkow, C.M., et al. (2015). "When does no-till yield more? A global meta-analysis." *Field Crops Research*, 183, 2015 ([LINK](#))

182 Tripathi, S., Srivastava, P., Devi, R. S., & Bhadouria, R. (2020). Influence of synthetic fertilizers and pesticides on soil health and soil microbiology. In *Agrochemicals detection, treatment and remediation* (pp. 25–54). Butterworth-Heinemann. ([LINK](#))

183 Amézketa, E. (1999). Soil aggregate stability: a review. *Journal of sustainable agriculture*, 14(2–3), 83–151. ([LINK](#))

184 Savci, S. (2012). An agricultural pollutant: chemical fertilizer. *International Journal of Environmental Science and Development*, 3(1), 73.

185 Geisseler, D., & Scow, K. M. (2014). Long-term effects of mineral fertilizers on soil microorganisms—A review. *Soil Biology and Biochemistry*, 75, 54–63. ([LINK](#))

186 Gupta, S. K., & Singh, A. K. *Soil and Water: A Source of Life*. ([LINK](#))

187 Zaller et al., 2014 ([LINK](#))

188 Barber (1979). Corn residue management and soil organic matter. *Agronomy Journal* 71: 625–627

189 Gabriel, J. L., García-González, I., Quemada, M., Martín-Lammerding, D., Alonso-Ayuso, M., & Hontoria, C. (2021). Cover crops reduce soil resistance to penetration by preserving soil surface water content. *Geoderma*. ([LINK](#))

190 Lebeau, S. (2023). Cover crop effects on infiltration, aggregate stability, and water dynamics. *Agronomy Journal* (article summary) ([LINK](#))

Removal of plants during fallow reduces organic inputs and biological activity, resulting in poorer soil structure and lower infiltration rates relative to vegetated soils.

Irrigated systems are broadly found in the Valencian region, flood irrigation is still widely practiced and is increasingly combined with soluble fertilisers, contributing to nutrient leaching and water pollution<sup>191</sup>. Excess nitrate and phosphorus mobilised by irrigation increase risks to groundwater quality and require costly water treatment, particularly where soil cover and biological uptake are low<sup>192</sup>.

The advent of highly mechanised agriculture and excessive chemical inputs enabled the cultivation of great spaces for crops, leading to extensive deforestation<sup>193</sup> and the pronounced loss of carbon and organic matter stocks in the soil<sup>194</sup>. Soil degradation occurs as modern cropping systems seek to suppress weed biomass<sup>195</sup>, while root systems typically represent a smaller share of total plant biomass relative to above-ground growth<sup>196</sup>.

## NDVI Discussion and Limitations

In a similar analysis conducted within EARA's Farmer-led Research<sup>197</sup>, the data shows that pioneering Spanish farmers from Andalusia, Extremadura, and Castilla y Leon achieved, on average, a 67% relative increase in photosynthetic activity over a 6-year period when compared to conventional systems<sup>198</sup>.

Throughout this same period they exhibited, on average, a relative increase of 62% in annual soil cover in comparison to conventionally managed systems. These farms consistently prioritise the ongoing regeneration of their land, and predominantly consist of livestock farms, cropland, and permanent crops like olives.

191 Visionary-project.eu. (2023). SPI of the month: Organic farming & collective water management in the Region of Valencia | VISIONARY. [online] Available at: [\(LINK\)](#) [Accessed 12 Jan. 2026].

192 Alom, K., Akbar, D., Xu, C. Y., & Dong, T. (2025). Assessing Environment Impacts of Chemical Fertilizers Consumption in Australia: State-level evidence. *Environmental and Sustainability Indicators*, 101053. [\(LINK\)](#)

193 Olmstead, A. L., & Rhode, P. W. (2001). Reshaping the landscape: The impact and diffusion of the tractor in American agriculture, 1910–1960. *Journal of Economic History*, 61(3), 663–698. [\(LINK\)](#)

194 Poeplau, C., & Don, A. (2017). How does tillage intensity affect soil organic carbon?

A systematic review. *Environmental Evidence*, 6(1), 30. [\(LINK\)](#)

195 Guzmán et al. (2014). Working paper No. 2: Methodology and converters to calculate the net primary productivity (NPP) of the agro-ecosystems. *Sociedad Española de Historia Agraria – Documentos de trabajo, DT-SEHA*, 1407 [\(LINK\)](#)

196 Chirinda, N., Olesen, J.E., Porter, J.R. (2012). Root carbon input in organic and inorganic fertilizer-based systems. *Plant and Soil*, 359, 321–333 [\(LINK\)](#)

197 See the study [here](#)

198 See the study [here](#)

It is important to note that NDVI, while a useful proxy for assessing vegetation greenness and for approximating flood risk and water efficiency, is not directly comparable to the indicators employed to analyse soil cover and photosynthesis.

### Average relative increase of Regenerating Farms in Spain

Year	Photosynthesis	Soil Cover
2019	80%	82%
2020	55%	47%
2021	75%	70%
2022	79%	74%
2023	77%	69%
2024	39%	32%
<b>Average</b>	<b>67%</b>	<b>62%</b>

Average relative increased performance of Regenerating Farms in Spain.<sup>199</sup>

Unlike NDVI, which compares infrared and red light images, photosynthesis is assessed through the fraction of absorbed photosynthetically active radiation (FPAR), which measures the proportion of incoming radiation in the 400–700 nm range absorbed by vegetation and is directly linked to carbon assimilation. FPAR differentiates itself as it avoids saturation under high canopy density and provides a more stable representation of productive capacity. Comparative studies show that FPAR-based estimates of gross primary productivity correlate strongly with flux-tower measurements and outperform simpler spectral indices. Within EARA's research, photosynthesis is evaluated through regional peer comparison, assessing field performance relative to comparable agricultural land under similar regional conditions, increasing robustness and reducing uncertainty. NDVI results within this analysis, however, were taken as a landscape aggregation, with comparative results deriving from the position against all other farmland under analysis.

199 See the study [here](#)

Similarly, soil cover is evaluated as a separate indicator reflecting surface protection and hydrological regulation rather than plant productivity. Reduced tillage, residue retention, and cover-cropping practices enhance soil moisture retention, reduce erosion, and influence surface albedo. In DORA, soil cover is derived from NDVI- and RVI-based assessments at the pixel level for individual satellite scenes, which are binarised to determine whether soil is covered or exposed. These classifications are aggregated temporally to calculate the number of days per year that soil remains covered by vegetation, and deviations from regional benchmarks are used to infer tillage intensity and cover retention. This provides a meaningful indication of two core regenerative practices: minimising soil disturbance and maintaining continuous cover.

In addition, NDVI values are highly dependent on production type and biophysical context. Pasture, annual crops, and permanent crops exhibit fundamentally different canopy structures, phenological cycles, and baseline greenness, resulting in systematically different NDVI ranges. NDVI is also strongly influenced by underlying environmental conditions, including climate, soil quality, and historical land degradation. Consequently, regenerative management practices tend to produce the largest relative NDVI improvements in arid or degraded landscapes, where vegetation productivity is water- and soil-limited, while absolute NDVI differences may be less pronounced in humid or naturally high-biomass systems such as temperate or rainforest environments. Despite the relevance of these indicators, it was not possible to apply this analytical framework within the region of interest in Valencia. This was due to financial constraints associated with operating the programme at the scale of the analysed zone, as well as insufficient resolution of delineated agricultural parcels. In this case, land units were aggregated according to Copernicus land-use categories, such as agricultural and permanent or arable land, which does not allow for the field-level precision required to robustly apply these indicators.

For a more detailed discussion on these indicators and their operationalisation in agricultural landscape analysis, please see our Farmer-led Research on Europe's Full Productivity<sup>200</sup>.

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200 See the study [here](#)