HARNESSING ARTIFICIAL INTELLIGENCE FOR SUSTAINABLE ALPINE DEVELOPMENT

AG5 – Connectivity and Accessibility

Connecting people electronically and promoting accessibility to public services

The following Policy Recommendations have been elaborated by the members of the Actions Groups of EUSALP, reflect the expertise of the AGs members and are meant for voluntary implementation by the decision makers when it comes to the Alpine Region.

EXECUTIVE SUMMARY

This policy document outlines a strategic vision for harnessing artificial intelligence to support sustainable development in the Alpine region, which faces unique challenges due to its complex terrain, transboundary dynamics, and fragile ecosystems. Developed by Action Group 5 in collaboration with the University of Udine, the recommendations focus on building a robust technological and data infrastructure, fostering innovation, and promoting education tailored to Alpine needs.

The document calls for the creation of virtual replicas of critical infrastructure and ecosystems to enable predictive maintenance and hazard forecasting (digital twins), harmonization of data standards and deployment of sensor networks for real-time environmental monitoring, and the development of practical AI applications through targeted pilot projects in areas such as water management, tourism, and hazard monitoring. It emphasizes the importance of multilingual, cross-border education and transparent assessment systems to build trust and accountability.
The anticipated impacts include cost savings, improved resource efficiency, enhanced safety, and greater resilience for Alpine communities, as well as stronger environmental protection and social inclusion. Implementation relies on coordinated action across European, national, regional, and local levels, leveraging existing frameworks, partnerships, and dedicated resources for infrastructure, training, and ethical AI governance.
The document positions the Alpine region to become a leader in digital welfare and economic development through the responsible and innovative use of artificial intelligence.

The following is a summary list of the proposed policy recommendations:
P1: Create a High-Level Technological Framework
P2: Build a Cohesive Data and Infrastructures Ecosystem
P3: Encourage Applications and Use Cases (Digital Twins)
P4: Promote Innovation and Education.

INTRODUCTION

The Alpine regions, spanning Austria, France, Germany, Italy, Liechtenstein, Slovenia, and Switzerland within the European Union Strategy for the Alpine Region (EUSALP), face distinct challenges due to their rugged terrain, limited transportation networks, and fragile ecosystems vulnerable to climate change, natural hazards, and resource scarcity. Unlike non-Alpine rural areas, the Alps' unique topography, transboundary dynamics, and extreme environmental variability—such as "last-mile logistics" in remote valleys, cross-border water management, and tourism pressures on delicate landscapes—demand tailored AI solutions. These policies, developed as part of the study 'The Shaping of the Alpine Region Through Artificial Intelligence' commissioned by AG5 to Udine University, harness AI to enhance resource efficiency, economic diversification, safety, and environmental protection, bridging the digital divide, fostering green innovation, attracting talent, and aligning with frameworks like the EU Water Framework Directive and Alpine Convention, positioning the Alps as a global leader in digital sustainability while boosting GDP and resilience.

POLICY RECOMMENDATIONS (LIST)

P1: Create a High-Level Technological Framework: establish a robust technological foundation for AI in the Alps, creating virtual replicas of critical infrastructure (e.g. dams, bridges etc.) and ecosystems (e.g. glaciers, rivers, lakes, etc.), enabling predictive maintenance and hazard forecasting tailored to the region's complex terrain, unlike simpler rural settings. It ensures AI transparency and trust through interpretable models, vital for Alpine communities facing rapid climate shifts, and promotes secure, collaborative/federated AI development across borders, addressing the Alps' multi-nation data sovereignty needs. A shared/distributed high-performance computing network could support intensive modelling of Alpine-specific climate and hazard scenarios, leveraging transboundary collaboration unique to this region.

P2: Build a Cohesive Data and Infrastructures Ecosystem: harmonize standards for seamless data sharing across sectors like water, hazards, and climate, essential for the region's transboundary rivers and hazard-prone slopes, unlike localized rural areas. It deploys dense IoT sensor networks and satellite monitoring to capture real-time data on water flows, avalanche risks, and climate indicators, critical for the Alps' volatile environment. Robust cybersecurity protects sensitive cross-border data, a priority in the Alps' interconnected jurisdictions. A unified AI platform integrates diverse data for trend analysis and visualization, addressing the region's ecological and geopolitical complexities.

P3: Encourage Applications and Use Cases: drive practical AI applications tailored to Alpine challenges, promoting their development through targeted pilot projects. It forecasts water availability, floods, and droughts across transboundary basins, unlike the simpler water issues in non-Alpine rural areas, with pilots testing AI models in key watersheds. It supports tourism and sports through innovation hubs offering training and AI tools for sustainable practices, optimizing ski resorts and seasonal peaks unique to the Alps, with pilots in select tourism destinations. Cross-border hazard monitoring systems, piloted in high-risk border zones, tackle shared risks like landslides and avalanches, irrelevant to most rural regions. Predictive climate modelling, tested through regional pilots, addresses glacier retreat, drought and extreme weather, ensuring adaptation strategies for the Alps' unique ecosystems.

P4: Promote Innovation and Education: foster AI-driven education and accountability in the Alps, delivering tailored training platforms for rural youth and SMEs in sustainable sectors like mountain tourism and farming, addressing harsher environmental constraints than typical rural areas. Multilingual support and cross-border partnerships reflect the Alps' diverse linguistic landscape. A structured

assessment system with public dashboards ensures transparency and tracks AI impacts on Alpine-specific hazards and ecosystems, using region-specific metrics to guide policy and build trust.

Impacts

The following table summarizes the anticipated economic, environmental, and social impacts of each policy recommendation, tailored to the Alpine/ EUSALP macro-region context, to guide decision-makers in prioritizing actions that maximize value, sustainability, and community well-being.

Table 1 Impacts of harnessing AI strategies and frameworks in alpine areas

Recommendation	Economic Impacts	Environmental Impacts	Social Impacts
P1: Create a High-Level Technological Framework	Cost savings through predictive maintenance, optimized resource use, and attraction of tech investment due to advanced AI infrastructure unique to Alpine needs.	Enhanced ecosystem monitoring accuracy, reduced environmental degradation via precise simulations, and lower energy use through efficient computing, tailored to Alpine ecosystems.	Increased safety via reliable infrastructure, enhanced trust in transparent AI systems, and stronger cross-border cooperation, addressing Alpine communities' unique needs.
P2: Build a Cohesive Data and Infrastructures Ecosystem	Reduced compliance costs, optimized resource allocation, and lower disaster recovery costs due to harmonized data and monitoring systems for Alpine transboundary challenges.	Improved water quality, ecosystem protection, and climate adaptation through real-time data and secure platforms, critical for the Alps' volatile environment.	Enhanced safety, transparency, and public participation in data-driven decisions, reducing risks and conflicts in Alpine border regions.
P3: Encourage Applications and Use Cases	Increased tourism and sports revenue, reduced flood/drought damages, and efficient resource use through targeted AI pilots, addressing Alpine-specific economic drivers.	Reduced ecological footprint, better conservation of Alpine landscapes, and improved climate resilience through tailored AI applications.	Enhanced safety, improved visitor experiences, and stronger community resilience through AI-driven solutions for Alpine hazards and tourism.
P4: Promote Innovation and Education	Higher SME competitiveness, increased employability, and reduced rural unemployment (10%) through specialized AI training for Alpine economies.	Workforce skilled in sustainable practices for Alpine ecosystems, reducing environmental impact in tourism and farming.	Reduced rural brain drain, inclusive access to education, and increased public trust via transparent AI impact assessments, tailored to Alpine diversity.

Governance

The table below outlines the roles and actions for each governance level—European Union, national, regional, and local—in implementing these measures, ensuring coordinated efforts tailored to the Alps' unique cross-border and environmental context.

Table 2 Governance to implement AI strategies and frameworks in alpine areas

Recommendation	European Union Level (EC, EP, Council)	National Level (Government, Parliament)	Regional Level	Local Level
P1: Create a High-Level Technological Framework	Fund pilot projects and HPC networks via Horizon Europe/EuroHPC, develop AI ethics and interoperability standards.	Dedicate HPC nodes, align data laws for cross-border AI, support national AI ethics committees.	Lead pilot projects for digital twins, facilitate HPC access, train stakeholders in AI ethics.	Provide local data for models, engage in pilot projects, ensure ethical AI use.
P2: Build a Cohesive Data and Infrastructures Ecosystem	Fund sensor networks and platforms via Interreg, set data and cybersecurity standards.	Align data policies, invest in monitoring infrastructure, enact cybersecurity laws.	Deploy sensors, manage platforms, coordinate cross-border data sharing.	Maintain sensors, contribute data, adopt secure data protocols
P3: Encourage Applications and Use Cases	Provide funding for AI pilots under Digital Europe, develop guidelines for sustainable applications.	Support national agencies for AI adoption, fund pilot infrastructure.	Launch and evaluate pilots in tourism, sports, and hazard zones, provide training.	Adopt AI tools, participate in pilots, share local use case feedback.
P4: Promote Innovation and Education	Fund education platforms via Erasmus+, define AI impact assessment frameworks.	Align training with national AI strategies, co-fund education programs.	Establish AI training hubs, adapt dashboards to regional needs.	Facilitate training participation, report AI impacts, engage communities.

IMPLEMENTATION

General implementation guidelines

To ensure effective implementation of the AI policy recommendations for the Alpine regions, a multi-level governance approach is essential. Political dialogue between different levels of governance should be encouraged through structured dialogue opportunities within EUSALP (e.g. Roadshows). Responsible actors include EU bodies (e.g., European Commission for funding via Interreg/Horizon Europe), national governments (aligning policies and investing in infrastructure), regional authorities (coordinating pilots and data platforms), and local stakeholders (maintaining sensors and adopting AI tools). Potential enablers include existing frameworks like the Alpine Convention, partnerships with research institutions, and private-sector and digital innovation hubs. Resource requirements encompass funding for IoT sensors, HPC infrastructure, and training programs, alongside expertise in AI ethics and cybersecurity.

Key steps involve: Year 1–2: Conduct feasibility studies and establish governance structures; Year 2–4: Launch pilot projects for data networks, AI applications, and training; Year 4–6: Scale successful initiatives EUSALP-wide. Milestones include achieving data and AI interoperability, AI adoption in SMEs, and significant reduction in hazard response times by Year 6.

CONTACT PERSON(S)

Carlo Vigna, AG5 Leader
Regione Autonoma Valle d'Aosta/Région Autonome Vallée d'Aoste
eusalp.ag5@regione.vda.it

Christian Micheloni, External expert on AI
University of Udine
christian.micheloni@uniud.it