







UNIL | Université de Lausanne Faculté des géosciences et de l'environnement

# GEO-AI Working Group 4 – BoK Body of Knowledge

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# Issues in defining a Body of knowledge in GEO-AI

In parallel with the Syllabus on GEO-AI (Working groups 1 to 3)

#### Supporting the GEO-AI initiative trainings

- Corresponding vocabulary
- Adapted to different levels and pathways

#### Up to date vocabulary

Online system enabling easy contributions and access

# **Main issues**

- $\Rightarrow$  Knowledge area
- $\Rightarrow$  **Coordination** with existing BoK on Geographic Information Science
- $\Rightarrow$  **Practical tools** to support users (trainers, trainees, private sector)

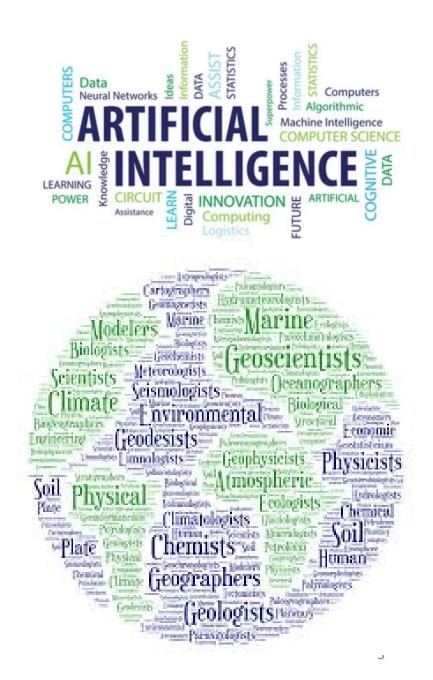
# **GEO-AI - Knowledge Area**

# At the intersection between

- Geoscience & GIS
- Al

# **Main categories**

- Geospatial Machine Learning and Deep Learning
- Generative GEO-AI Models
- Geospatial Knowledge Graphs
- Geospatial Data and ML Stewardship



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## **GEO-AI - Knowledge Area**

	<ul> <li>Spatially Explicit ML Models</li> <li>Spatial Neural Network Regression</li> <li>Geographically and Temporally Weighted Neural Networks</li> <li>Multi-Modal Spatial Contrastive Representation Learning</li> </ul>	<ul> <li>Geo-Knowledge Graphs</li> <li>KG-Based Spatial Reasoning</li> <li>Uni- Multi-partite Graphs</li> <li>Multiplex Graphs (multi-moda</li> <li></li> </ul>	al)		
Geospatial ML & DL	•		Geo-Knowledge Graphs		
Generative GEO-AI	<ul> <li>Generative Pre-trained Transformers</li> <li>Diffusion Models for Maps and</li> </ul>	<ul> <li>FAIR Geodata and codes</li> <li>Open Geodata and codes</li> </ul>	Stewardship		

- Satellite Imagery Generation
  Geo-Foundation Models
- Geo-Prompt Engineering
- ...

- Ethics for Geodata and codes
- Understanding and developing trust

• ...

#### To coordinate with existing GIS BoKs?

# **Coordination with existing BoK projects**

# 1. GIS & T Body of Knowledge : USA University Consortium for Geographic Information Science - UCGIS <a href="https://gistbok-topics.ucgis.org/UCGIS">https://gistbok-topics.ucgis.org/UCGIS</a>

UCGIS (1994-...): First edition 2006

- Professional hub for the academic GIS community in the United States
- full collection of 350+ Topics appears in its hierarchical structure

2. EO4GEO to SPACE4GEO Body of Knowledge : European consortium to empower space data users <a href="https://bok.eo4geo.eu/GIST">https://bok.eo4geo.eu/GIST</a>

#### EO4GEO (2018-2022): EU supporting Erasmus+ action for Sector Skills Alliance

- 25 partners and 50 associates from 22 countries.
- set of tools based on a shared ontology, a training and education offer
- bridge the skills gap between the supply and demand of education and training in the space geoinformation sectors

#### SPACE4GEO Alliance (2023-...) European Union Commission DG EMPL and DG DEFIS

- Leveraging on the results of EO4GE
- large-scale Skills Partnership for space data, services and applications

USA consortium contacts Diana Sinton, UCGIS

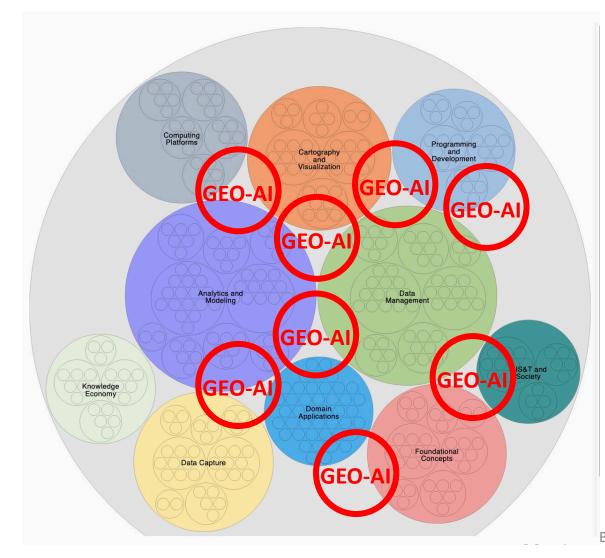
#### European consortium contacts

Sven Casteleyn (Spain, Univ. Castellon) Rob Lemmens (Netherlands, Univ. Twente)

#### **Nested structure (RDF - SKOS)**

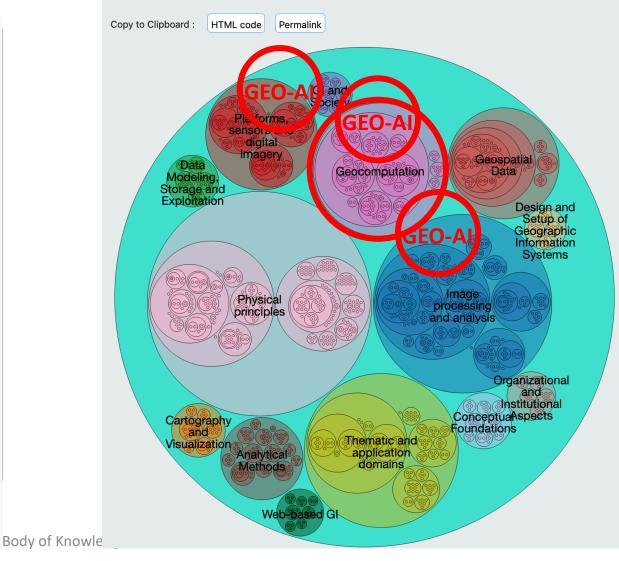
#### UC-GIS project GIS & T Body of Knowledge

https://gistbok-topics.ucgis.org/UCGIS



#### **SPACE4GEO Body of Knowledge :**

EU: https://bok.eo4geo.eu/GIST



🔳 List

#### **1.2 Tool of UC-GIS project GIS & T – Learning outcomes**

https://gistbok-ltb.ucgis.org/

#### Living Textbook Dashboard Show 🔻

# 9 - Analyze the impact of parameters on the performance of a genetic algorithm.

Analyze the impact of parameters on the performance of a genetic algorithm.

#### Topics

#### • [AM-07-078] Genetic Algorithms and Evolutionary Computing

Genetic algorithms (GAs) are a family of search methods that have been shown to be effective in finding optimal or near-optimal solutions to a wide range of optimization problems. A GA maintains a population of solutions to the problem being solved and uses crossover, mutation, and selection operations to iteratively modify them. As the population evolves across generations, better solutions are created and inferior ones are selectively discarded. GAs usually run for a fixed number of iterations (generations) or until further improvements do not obtain. This contribution discusses the fundamental principles of genetic algorithms and uses Python code to illustrate how GAs can be developed for both numerical and spatial optimization problems. Computational experiments are used to demonstrate the effectiveness of GAs and to illustrate some nuances in GA design.





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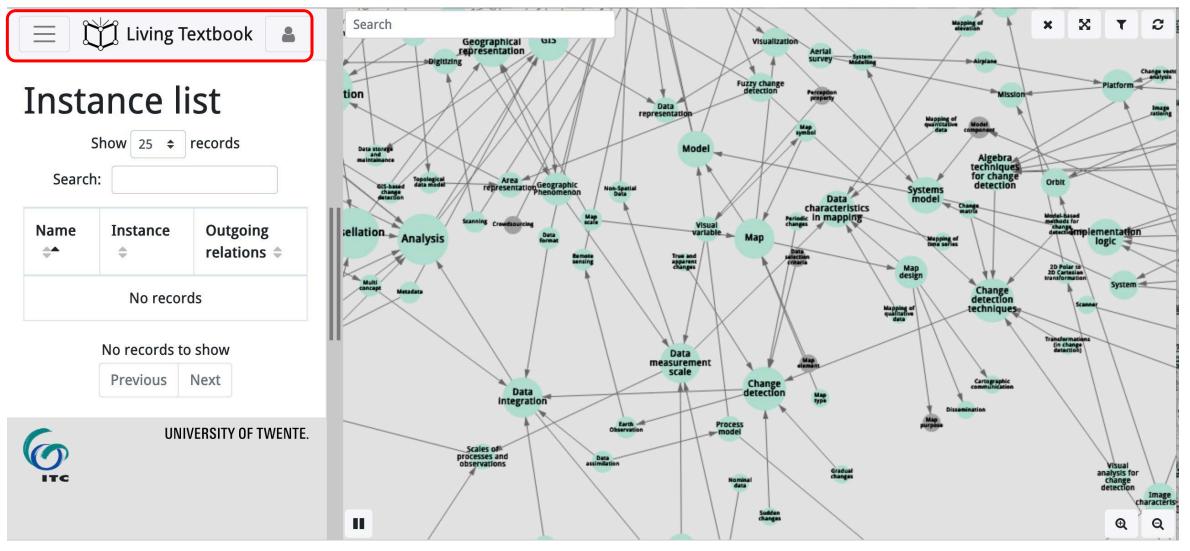
#### 1.1 Tool of UC-GIS project GIS & T – Living Textbook: Transversal links between competencies

https://gistbok-ltb.ucgis.org/

#### GIS&T USP $\mathbf{x}$ T C Search Living Textbook [GS-02-029] Standards GIS Participatory Modeling [CV-05-015] cipati (PD-03) Web Mapping [PD-04-016] Web GIS Developmen (DC-04-019) Ground iS-02-022 plication of istributed GIS&T [GS-03] Critical [CV-02-003] Programming Vector Formats and Verification Y Open map I List Perspectives and Accuracy [CV-02-020] Sources Raster Formats and Assessment [PD-02-012] [FC-02-035] Openness of GIS [PD-05-032] JavaScript [CP-04] [DA] Domain [CV-05-013] User Software for GIS Interface and [CP-04-014] User Web GIS [CV-05-036] Systems Applications Experience (UI/UX) [CV-05-016] Virtual and Geovisual Analytics Design [CP-05] Examples and Immersive Environment [CP-03-012] [GS-03-013]onsiderations, for Location-Based Applications of Computing The Domain Applications knowledge area (PD-02-037) Open Source Software [PD-04] Platform CV-05-035 Geovisualizat Services focuses on the linkages between the Epistemological [CP-01] Platforms Specific [CP] Computing Programmin critiques [DM-07] Spatial Data Computing foundational GIS&T competencies found in Infrastructures [GS-02] Governance other components of the Body of Standards & [PD] Programming and Agency nfrastructure IPD-01-010] Natural Language Processing in GIScience Applications Knowledge and their implementation across and [CV-05] a wide range of application areas, Development GS-03-0141 Interactive [CV-01-026] Cartography and Power highlighting their scope and depth and GIS and Critical Design Techniques [PD-02] CV-01-0011 Ethics providing evaluation of their impacts. This Application [CP-05-027] GIS&T and Cartography and Science Knowledge Area was not part of the first Computational [PD-05] Programming Programming Programming Canguages and (DM-07-080) Ontology for Geospatial [CV-05-019] Big Data Visualization [UCGIS] GIS& (PD-05-031) PySAL and Spatial Statistics Libraries GIS&T Body of Knowledge, published in Body of a [CP-05-023] Google Earth [CP-03-010] Social Media Analytics 2006. Knowledge Applicati Semantic Libraries [KE] Knowledge nteroperability [PD-01-014] GIS and Parallel Programming Fro [CP-04-004] Artificial [CV-03-010] Typography [CP-03] Social Media Intelligence Tools and [CV-01] [FC-02-002] Platforms for [CV] [PD-05-011] Cartography Python for GIS and [CP-03-018] GIS and the Internet of University Consortium for GIS ocation-based EOGRAPHIC INFORMATION SCIENCE Philosophi Services [GS-02-025] Spatial Decision Visualization [FC-03-032] Map [PD-01-020] Real-time GIS Semantie Information gn [CP-01-006] Graphics Processing Units (GPUs) Support Elicitation Programmer and Geocomputational Contologies Programming PD-01) ques Algorithm Design & [DM-07-057] Algorithmic [AM-09-104] [CV-06] Map Metadata. Approaches Thematic [CP-03-020] GIS&T and Wet [AM-06-080] Quality, and Uncertainty Capturing mporaty-04-018] Accuracy (FC-03-0 Ontolog Assessment (CV-06-023) Ð Q Working group 4 - Body of Knowledge

#### 2.2 Tool of SPACE4GEO – Living Textbook: Transversal links between competencies

https://gistbok-ltb.ucgis.org/

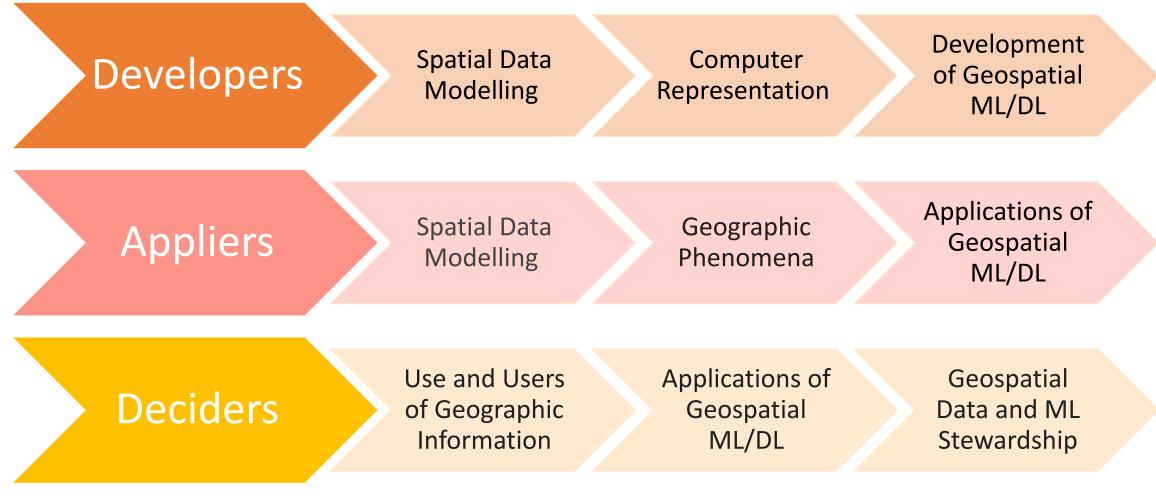


#### **2.3 Tool of SPACE4GEO – Learning path: chains of complementary competences**

#### https://ltb.itc.utwente.nl/page/498/learningpath/list

Name 📤	Follow path 🖨	Actions				
1. 01 Spatial Data Modelling - Geographic Phenomena	A Follow path	View				
1.02 Spatial Data Modelling - Computer Representation	Follow path	View				
1.02.1 Spatial Data Modelling - Topology and Time	A Follow path	View				
1.03 Exploring Geospatial Data	A Follow path	View				
1.03.1 Data Management : GIS and Database	A Follow path	View				
1.03.2 Data Management : Relational Data Model	A Follow path	View				
1.04 Spatial Referencing: Coordinate Systems and Map Projections	A Follow path	View				
1.02 Spatial Data Modelling - Computer Representation Tobler's ? Tessellation ? Regular ? Irregular ? Vector Representation? Triangulated Irregular ? Point Line Area representation? representation? representation? Representation?						

#### 2.4 GeoAl Learning paths: chains of complementary competences



# $\Rightarrow$ Coordination with Syllabus of WG1–WG3

#### 2.6 Tool linked to SPACE4GEO – Job offer tools

#### http://www.eo4geo.eu/tools/job-offer-tool/

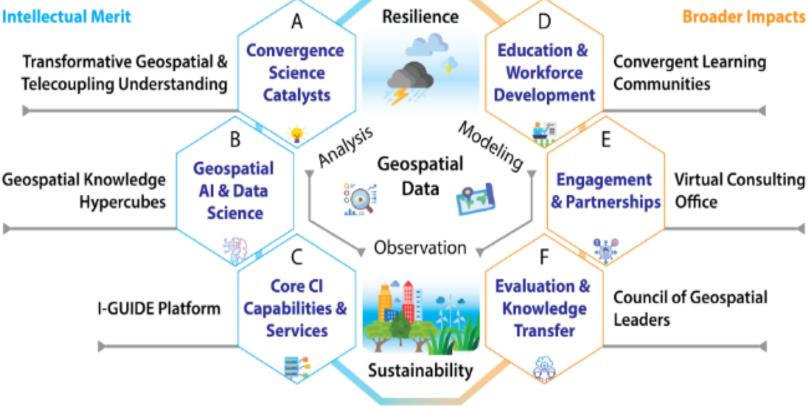
CURRICULUM DESIGN TOOL	Detail	*	ආ	ſ	Ē
OCCUPATIONAL PROFILE TOOL	<b>GIS specialist</b> E04GE0 Geographic information systems specialists use specialised computer systems, engineering measures, and geological concepts to process land, geographic, and geospatidetailed digital maps and geomodels of a reservoir. They convert technical information like soil density and properties into digital representations of it for the usage of e				ually
JOB OFFER TOOL	stakeholders interested. Knowledge 👔				
BOK VISUALIZATION AND SEARCH	[AM5-6] Cartographic modeling [AM2-3] Spatial queries [CV4-9] Spatialization [DA4] Database design AM - Analytical Methods 50% CV - Cartography and Visualization 25% DA - Design and Setup of Geographic				
BOK ANNOTATION TOOL	Skills 👔				
BOK MATCHING TOOL	[AM5-6] Develop a flowchart of a cartographic model for a site suitability problem [AM2-3] Construct a spatial query to extract all point objects that fall within a polygon				
DATA EXPLORATION AND ANALYSIS TOOLS	[CV4-9] Create a concept map that represents the contents and topology of a physical or social process Transversal skills () Attend to detail Think creatively				
	Specific Information Datasets required: Aqua Sentinel-3 A HY-2A Language(s): Spanish English				

#### **3. Other US projects: I-GUIDE**

NSF Institute for Geospatial Understanding through an Integrative Discovery Environment <a href="https://i-guide.io/platform/">https://i-guide.io/platform/</a>

# Led by the University of Illinois, Urbana-Champaign + 11 US universities: Columbia University the Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI) Florida International University

- Michigan State University
- Purdue University
- the Open Geospatial Consortium (OGC)
- University Consortium for Geographic Information Science (UCGIS)
- University Corporation for Atmospheric Research (UCAR)
- University of Minnesota, Twin Cities
- Utah State University



# **GEO-AI for good BoK**

- Geospatial Machine Learning and Deep Learning
- Generative GEO-AI Models
- Geospatial Knowledge Graphs
- Geospatial Data and ML Stewardship
- $\Rightarrow$  To be completed by the 3 working groups of Syllabus

# **Coordination with both BoK existing projects**

- USA: GIS & T Body of Knowledge
- Europe: EO4GEO to SPACE4GEO Body of Knowledge

# $\Rightarrow$ GEO-AI for good BoK in the GEO-AI Ecosystem information

WORKING GROUP: Song Gao, Céline Rozenblat, Diana Sinton, Samantha T. Arundel, Eva Malinverni et al.

Thank you for your attention





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# GEO-AI Training centers Survey

#### **Prof. Céline Rozenblat**

Chair 2023-2024 of the UN-GGIM Geospatial Societies

Vice president of the International Geographical Union (IGU)

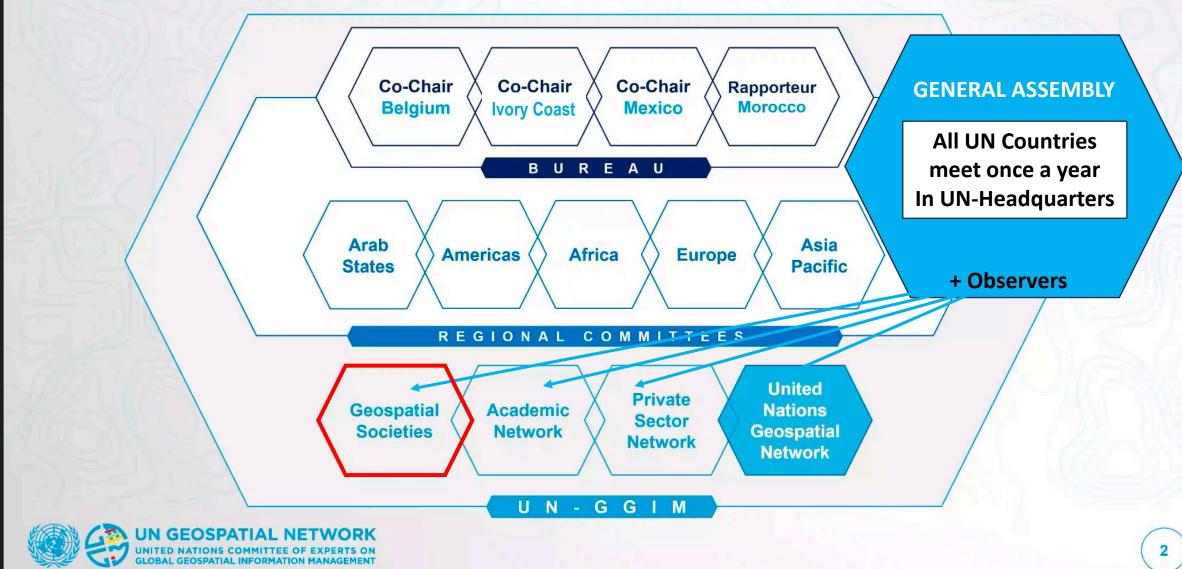
Institute of Geography and Sustainability

Faculty of Geoscience and Environment

University of Lausanne - Switzerland



# **OUR ROLE IN UN-GGIM ARCHITECTURE**



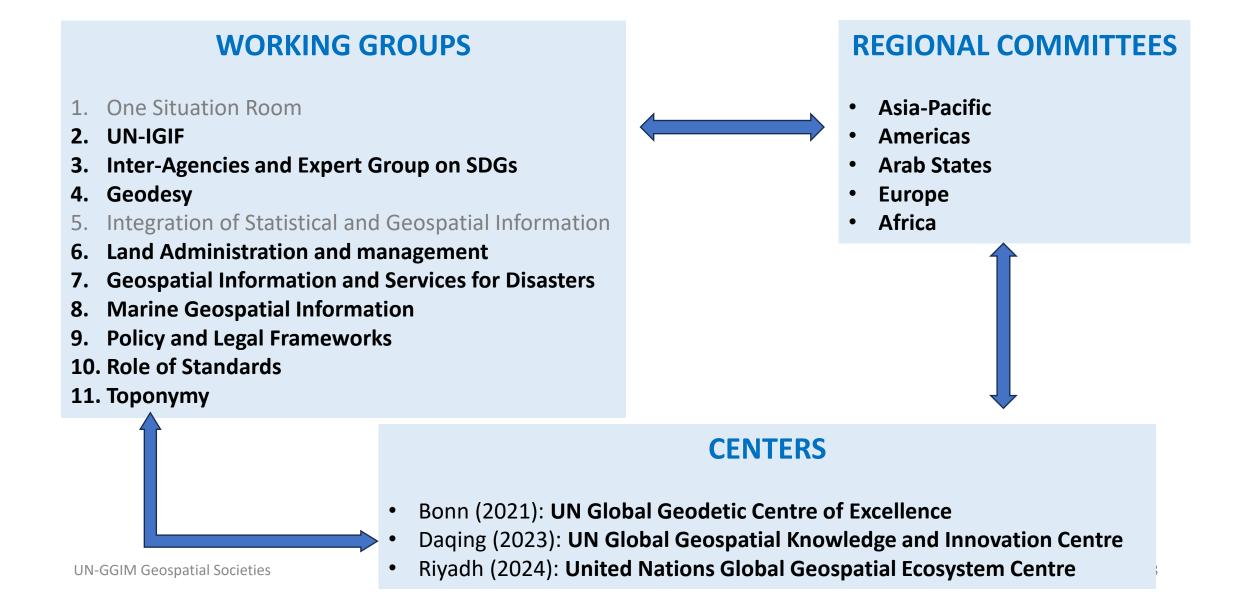


# 11 UN-GGIM Geospatial societies in 2024

IIEE	•IEEE Geoscience and Remote Sensing Society (GRSS)		CARTOGRAPHY			
IAG	<ul> <li>International Association of Geodesy (IAG)</li> </ul>			050		
ΙCΑ	<ul> <li>International Cartographic Association (ICA)</li> </ul>	<b>REMOTE</b>	SENSING	GEC	DLOGY	
FIG	<ul> <li>International Federation of Surveyors (FIG)</li> </ul>				_	
IGU	<ul> <li>International Geographical Union (IGU)</li> </ul>	GEOPHYSICS		GEODE	SY	
IMIA	<ul> <li>International Map Industry Association (IMIA)</li> </ul>					
ISDE	•International Society for Digital Earth (ISDE)			HYSICAL & HUMAN GEOGRAPHY		
ISPRS	<ul> <li>International Society for Photogrammetry and Remote Sensing (ISPRS)</li> </ul>		GLOG			
IUGG	<ul> <li>International Union of Geodesy and Geophysics (IUGG)</li> </ul>					
OS-GEO	•The Open Source Geospatial Foundation		DIG	DIGITAL GEODAT		
ISC-CODATA	International Science council (ISC) - CODATA					



# **PERMANENT WORKING GROUPS AND ACTIONS**



# **Geo Al Issues of training centers**

# Survey 2024 on training centers on GEO-AI

#### To support the Academic networks' GEO-AI initiative Syllabi & Body of Knowledge Coordinating with existing training centers of Geo-AI ⇒ What exists? What do they teach?

 $\Rightarrow$  Where? To whom? Cost and equity ?

# Making a showcase of training centers on GEO-AI

To make a showcase / webpage with links to the training centers

# An online questionnaire send via the Geospatial Societies

 $\Rightarrow$ 1<sup>st</sup> round (March 2024): 68 filled questionnaires  $\Rightarrow$ 2<sup>nd</sup> round with a map of the first answers (June 2024): 54 new filled questionnaires  $\Rightarrow$ **TOTAL: 122** 

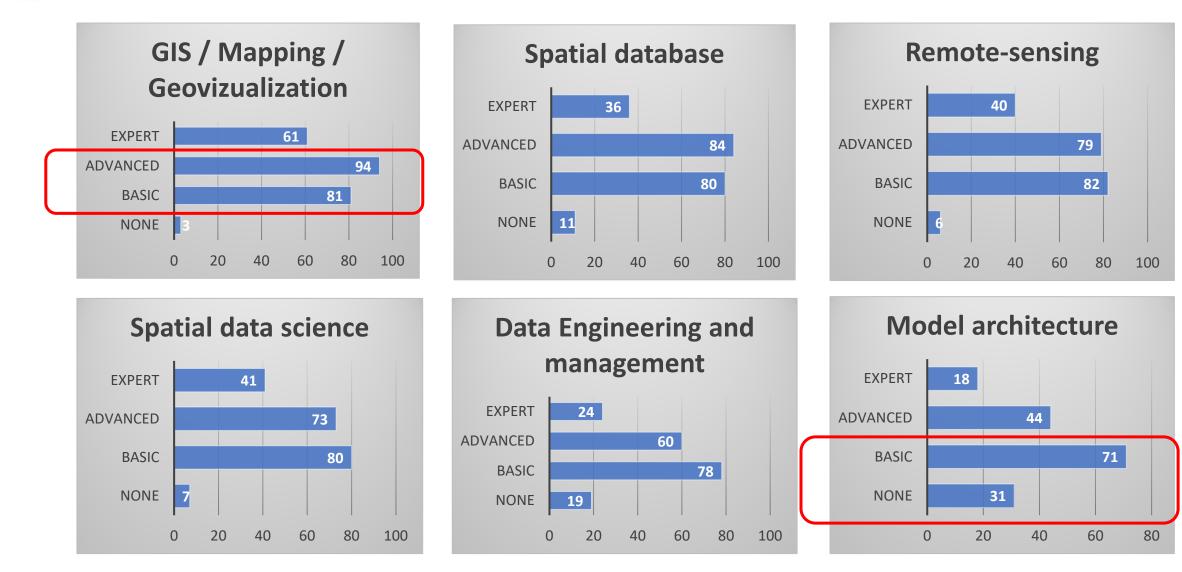


#### 122 Centers (167 trainings)



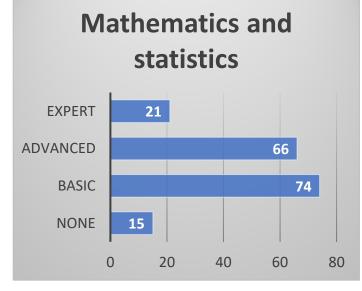


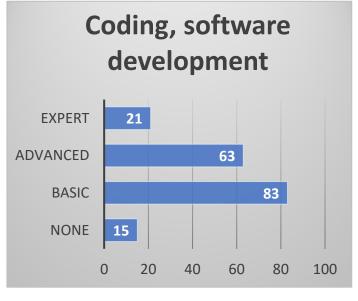
#### **TEACHED DOMAINS (1/3)**

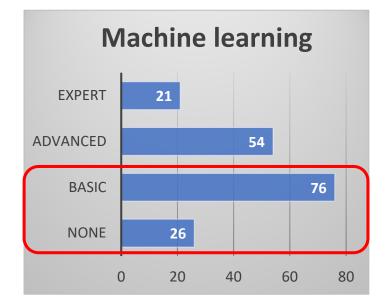




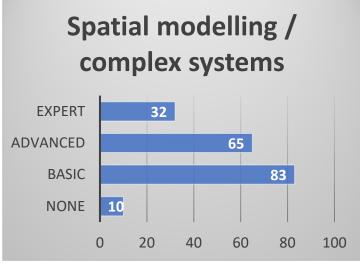
#### **TEACHED DOMAINS (2/3)**







# Deep learningEXPERT15ADVANCED39BASIC69NONE39020406080



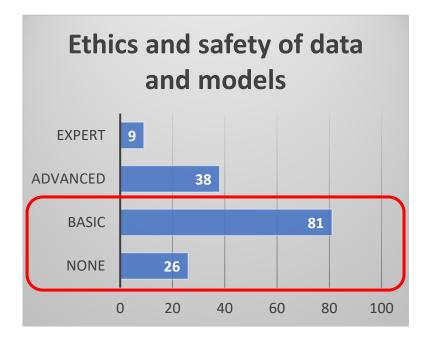
## Graph and network modelling

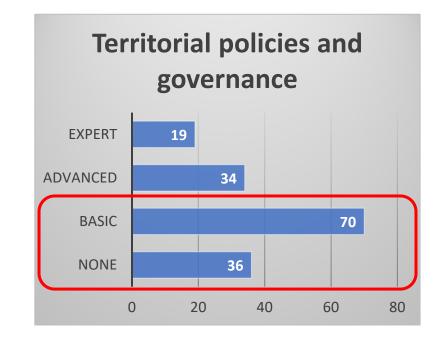


**UN-GGIM Geospatial Societies** 



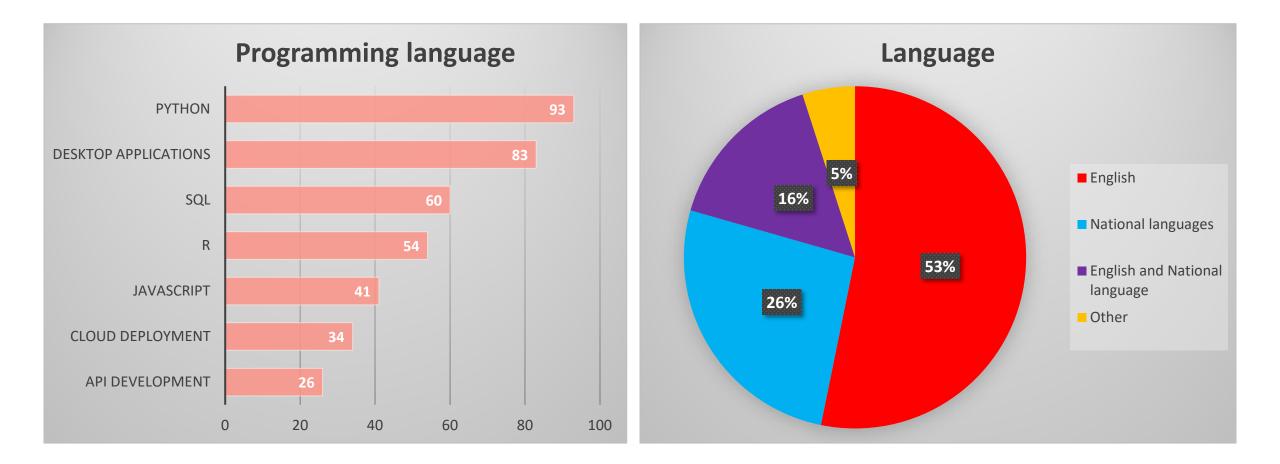
# 2024 - SURVEY ON GEOSPATIAL & AI TRAININGS TEACHED DOMAINS (3/3)







#### LANGUAGES





#### **TYPES OF TRAINING**





# INCLUSIVITY

# **Students' gender**

Women: 40%

# **Students' nationality**

Foreigners: 28% (from 1% to 100%)

# **Cost of the training for 1 semester**

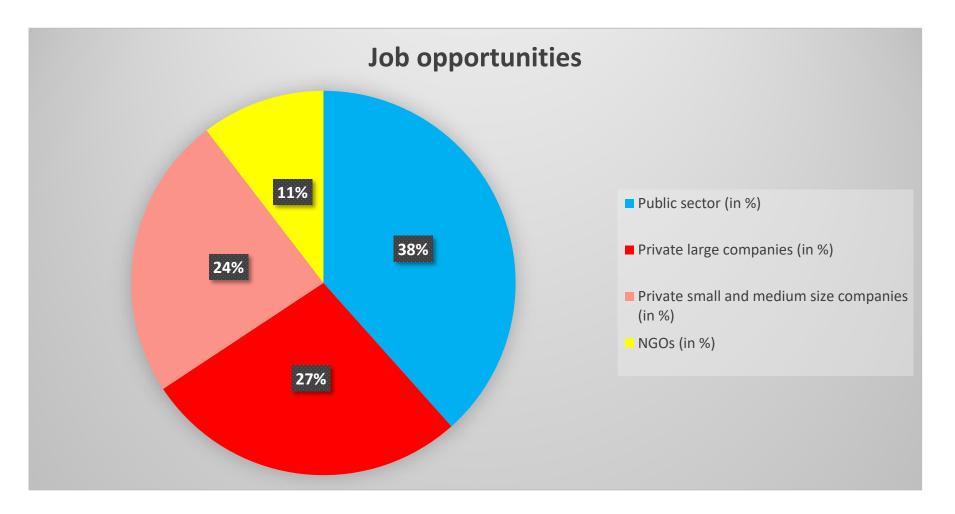
Average: 3,000 US \$

Min: Free

Max: 16,000 US \$ (School of Engineering / Aalto University – Espoo for foreigners)



# **FUTURE CAREER**





# PERSPECTIVES

# Representativeness

- Leadership?

# **Building an online platform**

- Interactive map
- Directory of training centers
- $\Rightarrow$  Issue of updating?
- ⇒ Open systems (VIVO LYRASIS) + development (resources)

# Sustain a worldwide community (around the UN-GGIM)

#### Thank you for your attention