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Geoinformation and Big Data Research Lab

Geospatial Agentic Services (GAS)
Toward Interoperable and Scalable Autonomous GIS

Zhenlong Li, PhD

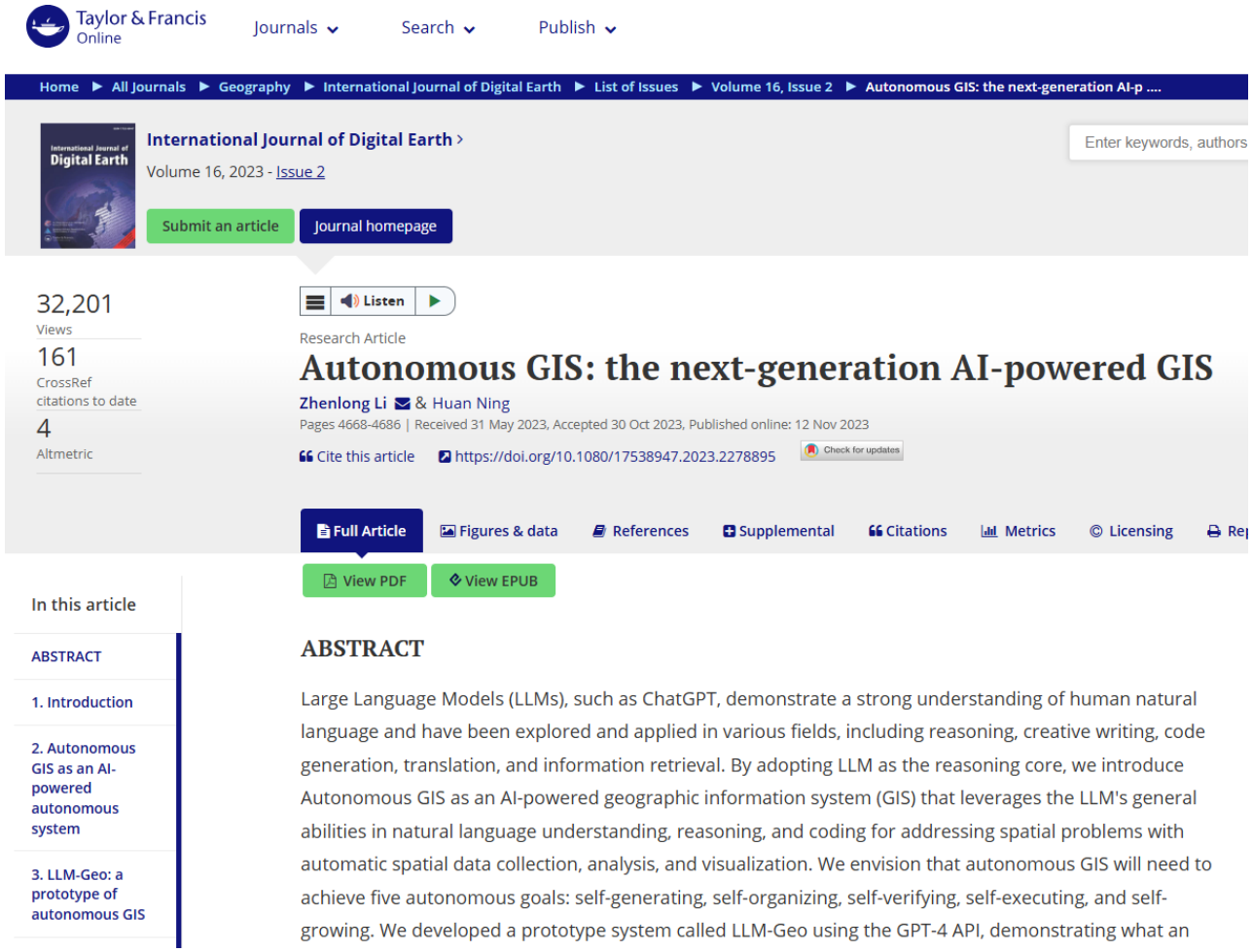
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Autonomous GIS

Autonomous GIS is *"an AI-powered GIS that leverages LLM's general abilities in natural language understanding, reasoning, and coding to address spatial problems with automatic spatial data collection, analysis, and visualization."*



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International Journal of Digital Earth

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Research Article

Autonomous GIS: the next-generation AI-powered GIS

Zhenlong Li & Huan Ning

Pages 4668-4686 | Received 31 May 2023, Accepted 30 Oct 2023, Published online: 12 Nov 2023

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In this article

ABSTRACT

1. Introduction

2. Autonomous GIS as an AI-powered autonomous system

3. LLM-Geo: a prototype of autonomous GIS

ABSTRACT

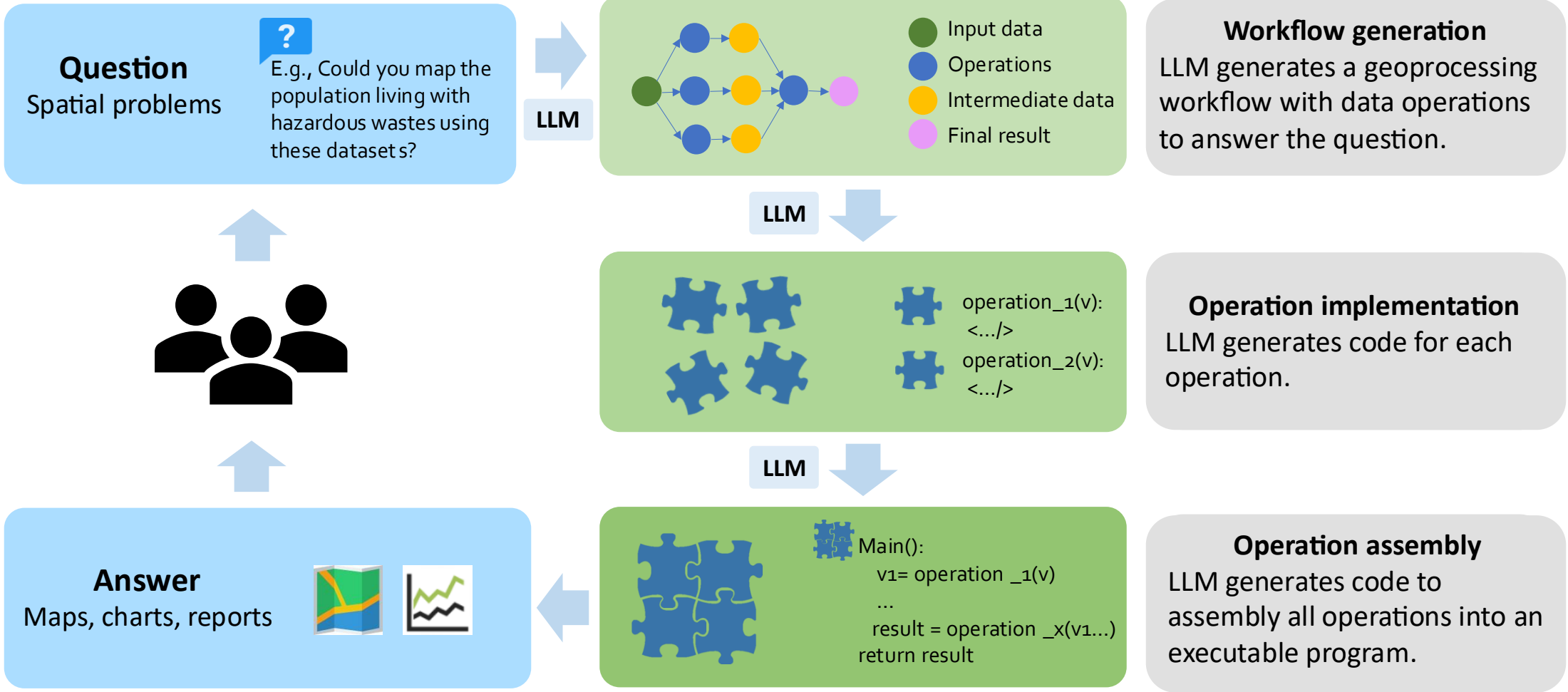
Large Language Models (LLMs), such as ChatGPT, demonstrate a strong understanding of human natural language and have been explored and applied in various fields, including reasoning, creative writing, code generation, translation, and information retrieval. By adopting LLM as the reasoning core, we introduce Autonomous GIS as an AI-powered geographic information system (GIS) that leverages the LLM's general abilities in natural language understanding, reasoning, and coding for addressing spatial problems with automatic spatial data collection, analysis, and visualization. We envision that autonomous GIS will need to achieve five autonomous goals: self-generating, self-organizing, self-verifying, self-executing, and self-growing. We developed a prototype system called LLM-Geo using the GPT-4 API, demonstrating what an

Among the earliest (05/2023) and most-cited papers that explore the integration of generative AI (LLM) with GIS/spatial analysis.

Autonomous GIS is also described with related terms such as agentic GIS, autonomous geospatial systems, GIS agents, geospatial agents, or GeoAI agents.

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LLM-Geo: among the earliest GIS Agents (March 2023)

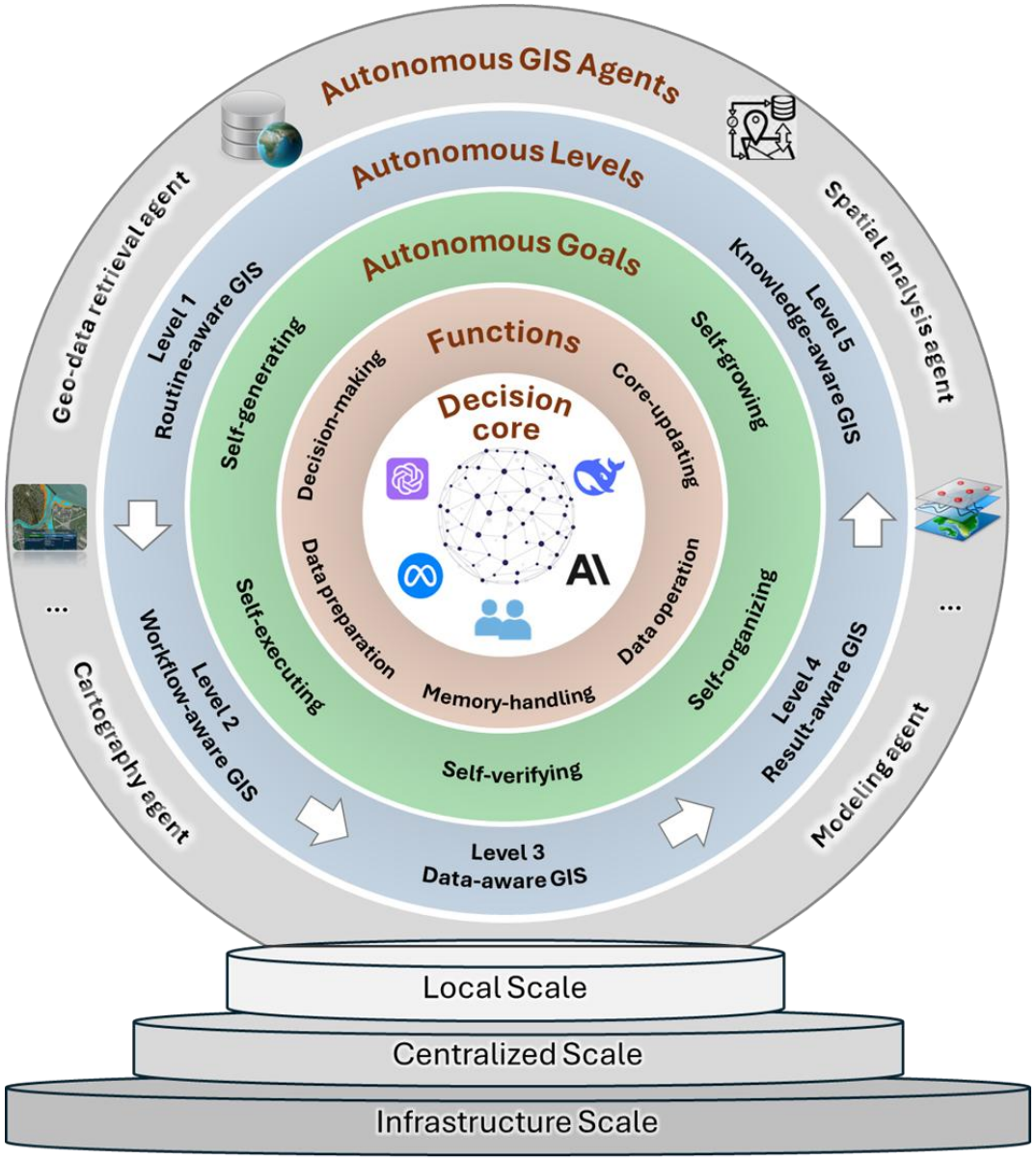


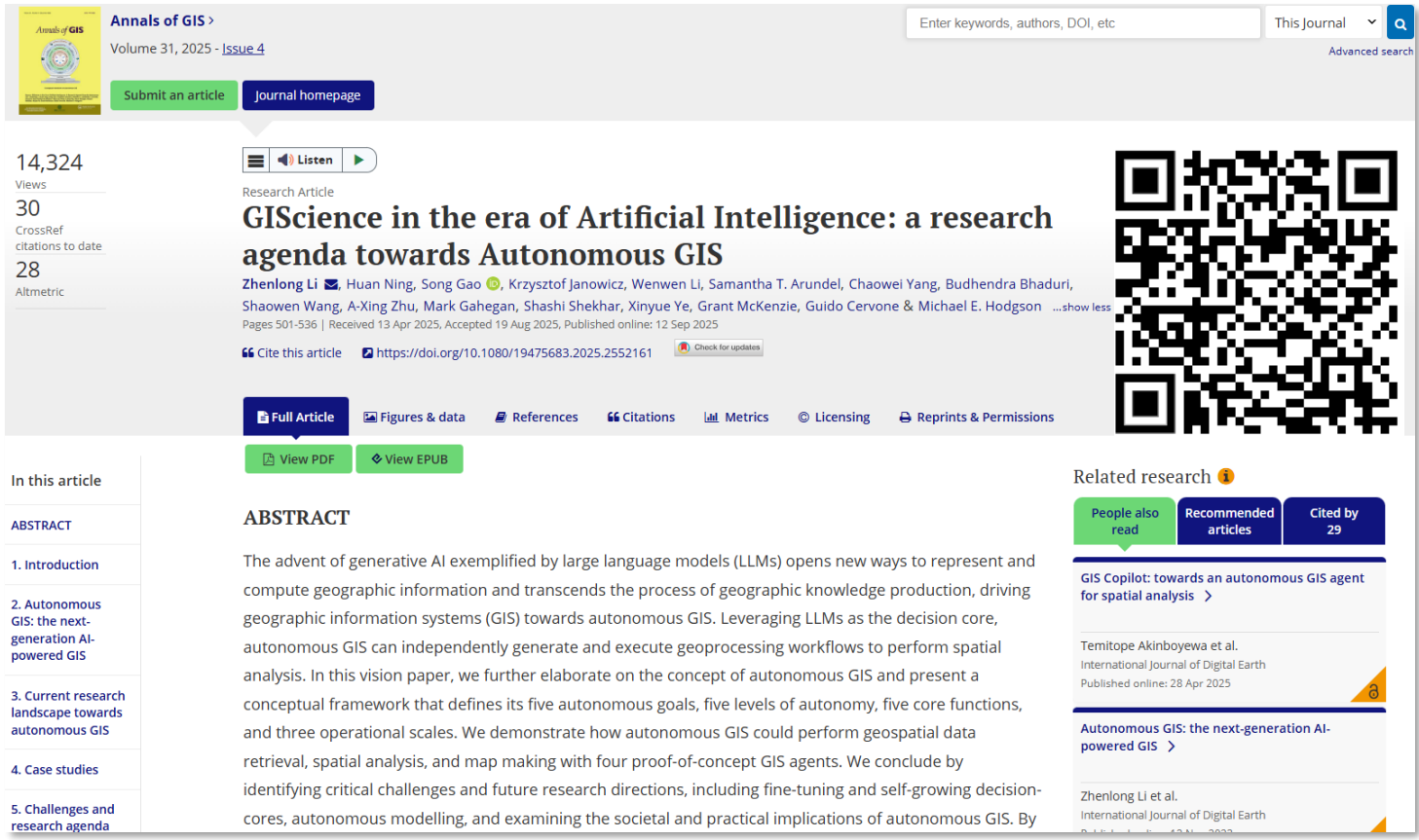
- Divide and concur (step by step)
- Plan (thinking), implement (coding), review (self-verification)
- Tool calls (GIS tools/APIs)
- Guidelines (e.g., spatial join) (skills)

Li, Z., Ning, H. (2023). Autonomous GIS: the next-generation AI-powered GIS. *International Journal of Digital Earth*, 16(2), 4668-4686.

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Research Agenda





Li, Z., Ning, H., Gao, S., Janowicz, K., Li, W., Arundel, S. T., Yang, C., Bhaduri, B., Wang, S., Zhu, A. X., Gahegan, M., Shekhar, S., Ye, X., McKenzie, G., Cervone, G., & Hodgson, M. E. (2025). GIScience in the era of artificial intelligence: A research agenda towards autonomous GIS. *Annals of GIS, 31*(4), 501–536. https://doi.org/10.1080/19475683.2025.2552161

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Some Collective Visions on Autonomous GIS

- An emerging paradigm of integrating AI with GIS, where it is not just another tool but becomes an "geospatial analyst" **knowing how to use GIS tools** and **with what data** to solve **spatial problems.** It can:
  - Use existing GIS tools (e.g., toolbox QGIS, ArcGIS)
  - Develop new tools (e.g., using APIs, libraries such as GeoPandas)
  - Use/develop spatial models: prediction, explanation, simulation; and **GeoAI models** (e.g., deep learning models, geo-foundation models such as Prithvi)
- Aims to **democratize spatial analysis and geospatial technologies** for a wider audience.
- Expected to further **promote innovations in GIScience** through **large scale automation** (e.g., autonomous GIS modeling).
- Should be designed as a **programming- and data-centric framework** that automates coding to address geospatial problems: **plan, implement, and execute geoprocessing workflows**.
- Should be implemented into diverse **autonomous "GIS/geospatial agents"** that work individually or **collaboratively**.



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The “5-5-5” Model of Autonomous GIS

A conceptual framework linking system goals, autonomy progression, and technical functions.

5 Autonomous Goals

Expected system behaviors

1. **Self generating**
   Creates hypotheses, workflows, code, and insights.
2. **Self executing**
   Runs spatial operations from inputs to outputs.
3. **Self verifying**
   Checks results and validates processes.
4. **Self organizing**
   Manages resources, memory, and time.
5. **Self growing**
   Learns from prior tasks and documents.

5 Levels of Autonomy

Progression toward autonomous GIS

1. **Level 1: Routine aware**
   Automates predefined processes.
2. **Level 2: Workflow aware**
   Builds workflows from user input.
3. **Level 3: Data aware**
   Finds, retrieves, and prepares data.
4. **Level 4: Result aware**
   Evaluates outputs and adjusts workflows.
5. **Level 5: Knowledge aware**
   Uses knowledge and experience to reason.

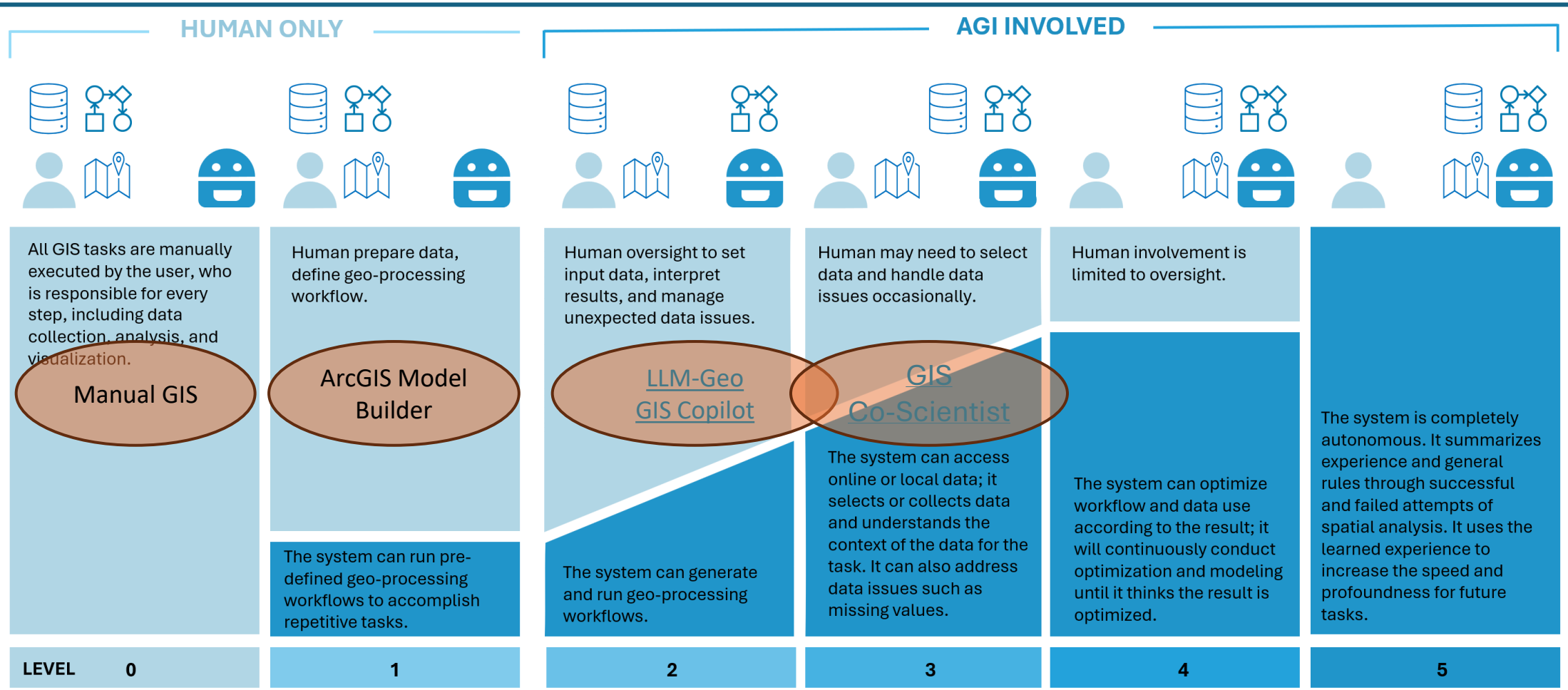
5 Core Functions

Technical mechanisms of the agent

1. **Decision making**
   Understands tasks and plans actions.
2. **Data preparation**
   Searches, downloads, and formats data.
3. **Data operation**
   Executes spatial analysis tools.
4. **Memory handling**
   Stores and recalls context and knowledge.
5. **Core updating**
   Improves logic and models over time.

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Five Levels of Autonomy



Note: the "human role" and "agent role" refer specifically to their involvement in the technical execution of GIS tasks, not in broader decision-making or responsibility.

Legend

Human | Autonomous GIS | Data Preparation | Geo-processing Workflow Generation | Result Interpretation

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Current Status: Autonomous AI agents in GIScience and broader data science (as of 06/2025)

16 GIS agents (1–16), 2 remote sensing agents (17-19), 4 data science agents (20–23), and 1 research agent (24).

No.	Studies	Task Types	Autonomous functions	Autonomous goals	Autonomous level	Scale
1	LLM-Geo (Z. Li & Ning, 2023)	Spatial analysis	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
2	GIS Copilot (Akinboyewa et al., 2024)	Spatial analysis	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
3	IntelliGeo (Mahdi Farnaghi et al., 2024)	Spatial analysis	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
4	ShapefileGPT (Lin et al., 2024)	Spatial analysis	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
5	GlobeFlowGPT (Kononykhin et al., 2024)	Spatial analysis	Decision-making, Data-preparation	Self-generating, Self-executing	Level 2	Local
6	GeoAgent (Chen et al., 2024)	Spatial analysis	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
7	GeoGPT (Zhang, Wei, et al., 2024)	Spatial analysis	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
8	LLM-Find (Ning et al., 2025)	Geospatial data retrieval	Decision-making, Data-preparation	Self-generating, Self-executing	Level 2	Local
9	ChatGeoAI (Mansourian & Oucheikh, 2024)	Geospatial data retrieval	Decision-making, Data-preparation, Data-operating	Self-generating, Self-executing	Level 2	Local
10	Geode (Gupta et al., 2024)	Geospatial data retrieval and question-answering	Decision-making, Data-preparation	Self-generating, Self-executing	Level 2	Local
11	NASA Earth Copilot (Bryson, 2024)	Geospatial data retrieval	Decision-making	Self-generating, Self-executing	Level 2	Centralized
12	Geoforge (Ageospatial, 2024)	Geospatial data retrieval, spatial analysis,	Decision-making, Data-preparation, Data-operating	Self-generating, Self-executing	Level 2	Centralized
13	MapGPT (Y. Zhang, He, et al., 2024)	Cartography	Decision making, Data-operating	Self-generating, Self-executing	Level 2	Local
14	GeoMap Agent (Huang et al., 2025)	Map understanding	Decision-making, Data-operating	Self-executing	Level 2	Local
15	GeoAgent (Huang et al., 2024)	Address Standardization	Decision-making	Self-generating, Self-executing	Level 2	Local
16	GeoLLM-Engine* (Singh et al., 2024)	Geospatial Copilot Agent parallelization	-	-	Level 2	Centralized
17	Geospatial Reasoning (Schottlander & Shekel, 2025)	GIS, Remote sensing image analysis and reasoning	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Centralized
18	Remote Sensing ChatGPT (Guo et al., 2024)	Remote sensing image analysis	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
19	Change-Agent (Liu et al., 2024)	Remote sensing image change detection	Decision-making, Data-operating	Self-generating, Self-executing	Level 2	Local
20	AutoKaggle (Li et al., 2024)	Data science agent	Decision-making, Data-operating	Self-generating, Self-executing	Level 3	Local
21	DS-Agent (Guo et al., 2024)	Data science agent based on cases	Decision-making, Data-operating	Self-generating, Self-executing	Level 3	Local
22	Data Interpreter (Hong et al., 2024)	Data science agent	Decision-making, Data-operating	Self-generating, Self-executing	Level 4	Local
23	Data Science Agent** (Google LLC, 2024)	Data science agent	Decision-making, Data-operating	Self-generating, Self-executing	Level 4	Centralized
24	Agent Laboratory (Schmidgall et al., 2025)	Assistant for AI Research	Decision-making, Data-preparation, Data-operating	Self-generating, Self-executing, Self-organizing	Level 4	Local

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Recent development in geospatial community

ESRI ArcGIS Pro Assistant

"We are building the future of GIS workflows in ArcGIS Pro—and it's conversational. "

esri Products Industries Support & Services Stories About

AI Lens

Industry & Technology Patterns / AI Lens / Geospatial AI

- Industry & Technology Pattern
  - Introduction
  - AI concepts and vocabulary
  - Geospatial AI
  - Geospatial data for AI
  - AI tools and models
  - AI assistants
  - Agentic AI
  - Integration and interoperability
  - Architecture pillars
  - Next steps and resources

Geospatial AI

Geospatial AI is the integration of GIS and AI and represents all AI capabilities Esri builds into ArcGIS.

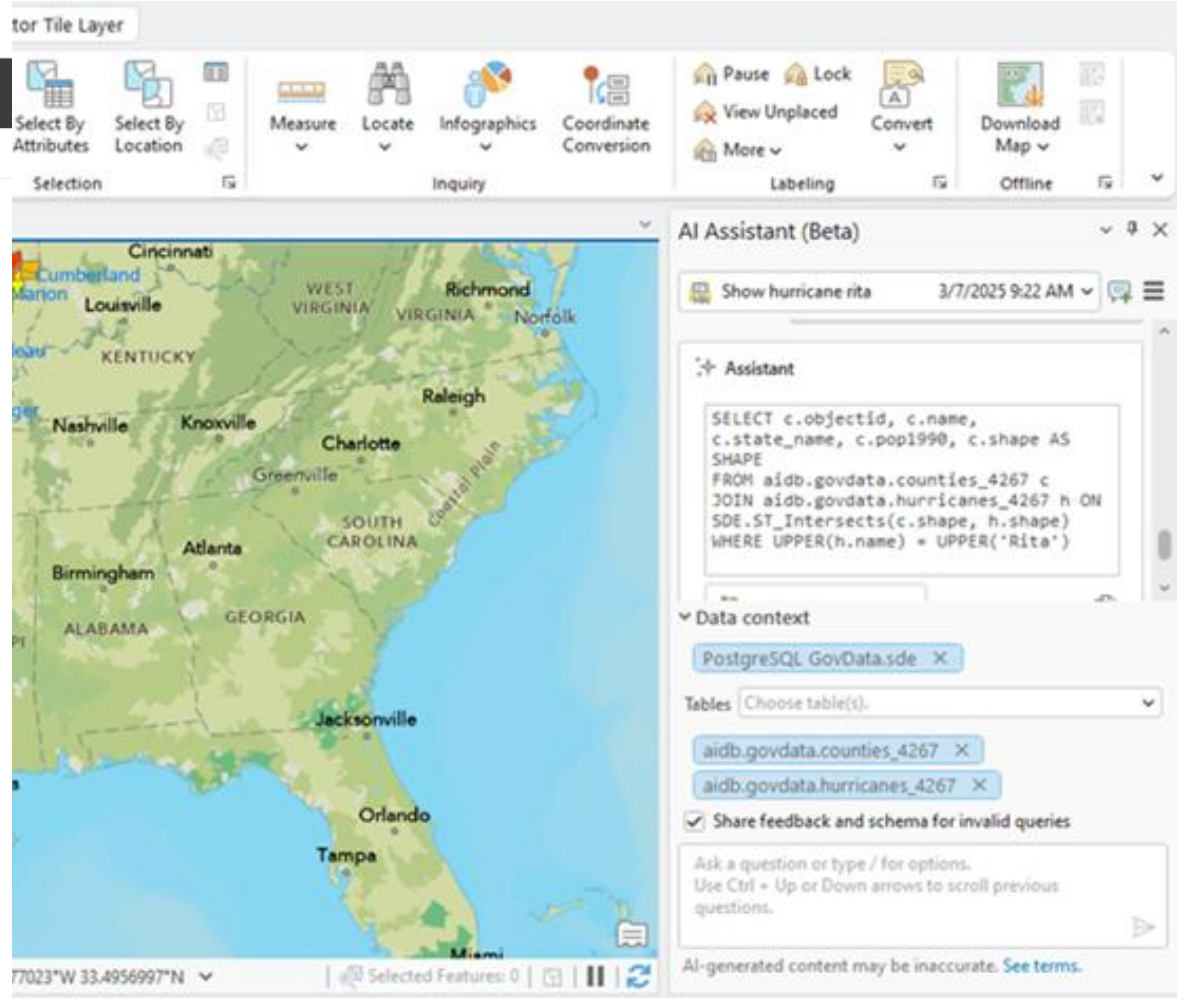
Capabilities

Geospatial AI in ArcGIS is organized around three capability areas. Each is covered in its own chapter later in the lens; this chapter describes their value proposition and alignment to the architecture of ArcGIS.

- AI tools and models automate data creation, extraction, and analysis. They are powered by machine learning, deep learning, and advanced spatial statistics, and they let users extract information from imagery, 3D data, and text, detect patterns, and make predictions from complex datasets. These are the workhorses of applied geospatial science, delivering capabilities that help GIS analysts and data scientists accelerate analytical work at greater scale. AI tools and models are the most mature of the three capabilities, with over a decade of investment behind them.

- AI assistants are in-app natural-language interfaces that make GIS more accessible and its users more productive. Task assistants guide users through workflows in apps like ArcGIS Pro, Business Analyst, and Survey123. Coding assistants help users generate and troubleshoot Python and Arcade. Together they lower the barrier for new users while helping experienced practitioners move faster. They are backed by geospatial agents and grounded on the organization's own ArcGIS content.

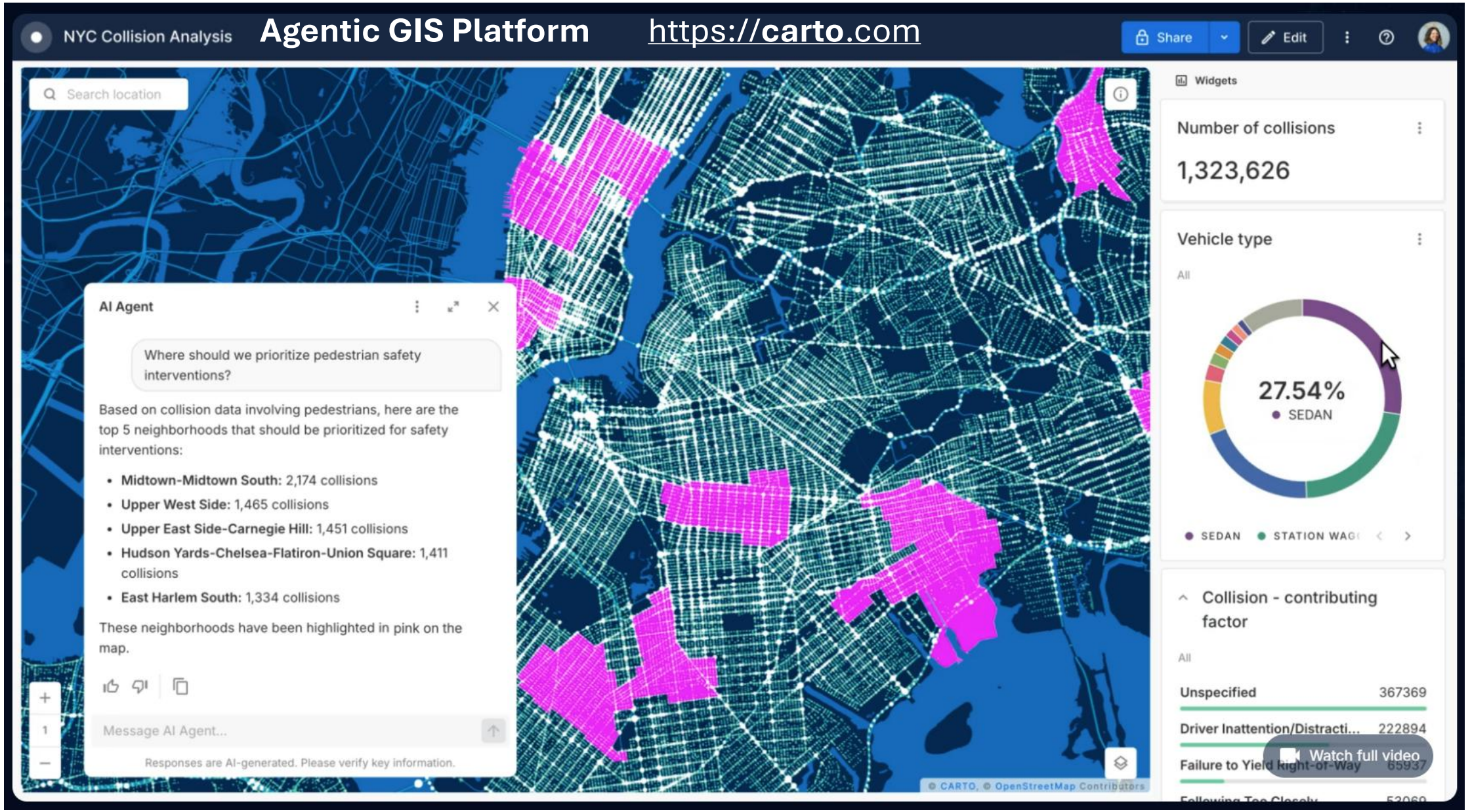
- Agentic AI introduces orchestration, automation, and integration through agents and agentic workflows. Agents can perceive context, reason about goals, and act autonomously or with a human in the loop. In ArcGIS, agentic AI shows up in three places: through integration with third-party agent



arcgis-pro-assistant-3-7-beta-and-get-more-done-in-arcgis-pro

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Recent development in geospatial community



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GeoAgent™

AI-Driven Geospatial Insights for Your Entire Organization

Geospatial data is more abundant than ever, yet its value often remains locked behind specialized tools and knowledge. Not anymore!

Introducing **GeoAgent™**, your intelligent geospatial assistant that's designed to understand your mission, interpret your intent, and automatically build and execute end-to-end workflows. GeoAgent automates data discovery, analysis, and the production of results, helping teams move faster, make better decisions, and scale geospatial insight across the enterprise.

https://www.nv5.com/geospatial/solutions/geoagent



Environmental & Agricultural

I want to understand crop trends across a region.

GeoAgent automatically retrieves data from image archives for my specified time ranges, applies machine learning to delineate fields, and tracks crop growth and rotations.



Emergency Response

Where is floodwater blocking evacuation routes?

GeoAgent quickly finds available imagery, detects flood water, intersects the results with roads, and pushes a shareable map to response teams, supporting critical decisions.

Recent development in geospatial community

From questions to discoveries: NASA's new Earth Copilot brings Microsoft AI capabilities to democratize access to complex data

Nov 14, 2024 | Tyler Bryson - Corporate Vice President, US Health & Public Sector Industries



Every day, NASA's satellites orbit Earth, capturing a wealth of information that helps us understand our planet. From monitoring wildfires to tracking climate change, this vast trove of Earth Science data has the potential to drive scientific discoveries, inform policy decisions and support industries like agriculture, urban planning and disaster response.

But navigating the over 100 petabytes of collected data can be challenging, which is why NASA has collaborated with Microsoft to explore the use of a custom copilot using Azure OpenAI Service to develop

Earth Copilot by NASA and Microsoft

*NASA worked with Microsoft to develop an AI-driven customer copilot, called **Earth Copilot**, which could simplify data access and encourage a wider range of users to interact with its **Earth Science big data** data. Together, they built the proof of concept AI model that leverages Microsoft's Azure **cloud** platform and advanced AI capabilities to transform how users can search, discover and analyze NASA's **geospatial (big) data**.*

*Earth Copilot enables users to **interact with NASA's data repository through plain language queries**. Instead, they can simply ask questions such as "**What was the impact of Hurricane Ian in Sanibel Island**?" or "**How did the COVID-19 pandemic affect air quality in the US**?" AI will then retrieve relevant datasets, making the process seamless and intuitive.*

https://github.com/microsoft/Earth-Copilot

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Challenges for Building Reliable Autonomous Geospatial Systems

As GIS shifts from passive execution to autonomous workflow generation and decision support, new challenges emerge for both **GIS users** and **GIS builders**.

GIS Co-Scientist http://dx.doi.org/10.2139/ssrn.6753098



Trust and Transparency

- Generated workflows, code, data sources, assumptions, and intermediate results may be hard to inspect.
- Reliable autonomous GIS requires outputs that are visible, traceable, and reviewable.



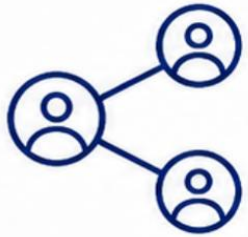
Human Oversight

- Higher autonomy does not remove the need for human expertise and responsibility.
- Human roles shift from manual operators to supervisors, reviewers, collaborators, and decision-makers.



Interoperability and Scalability

- GIS agents introduce new interoperability demands across heterogenous software, data services, spatial databases, and infrastructures.
- Complex spatial applications, such as digital twins, require autonomous GIS to scale across distributed geospatial environments.



Reuse and Sharing

- GIS agents often remain isolated within a single project, platform, or application.
- Their capabilities and outputs need to be reusable across users, systems, and organizations.

Geospatial Agentic Services (GAS) https://doi.org/10.2139/ssrn.6753201

These system-level challenges are not exhaustive, but they represent some of the core barriers to building reliable Autonomous GIS systems.

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The GAP: Isolated geospatial agents

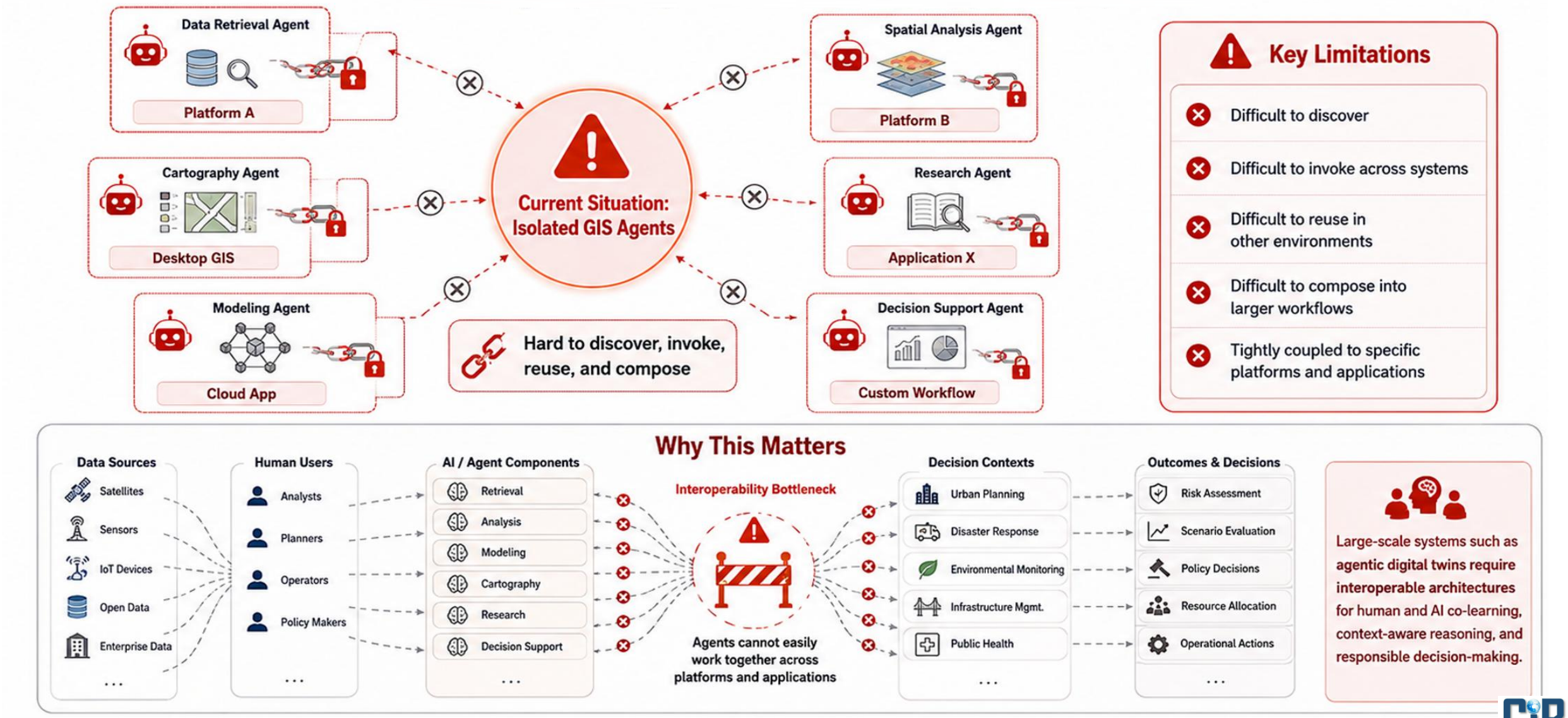
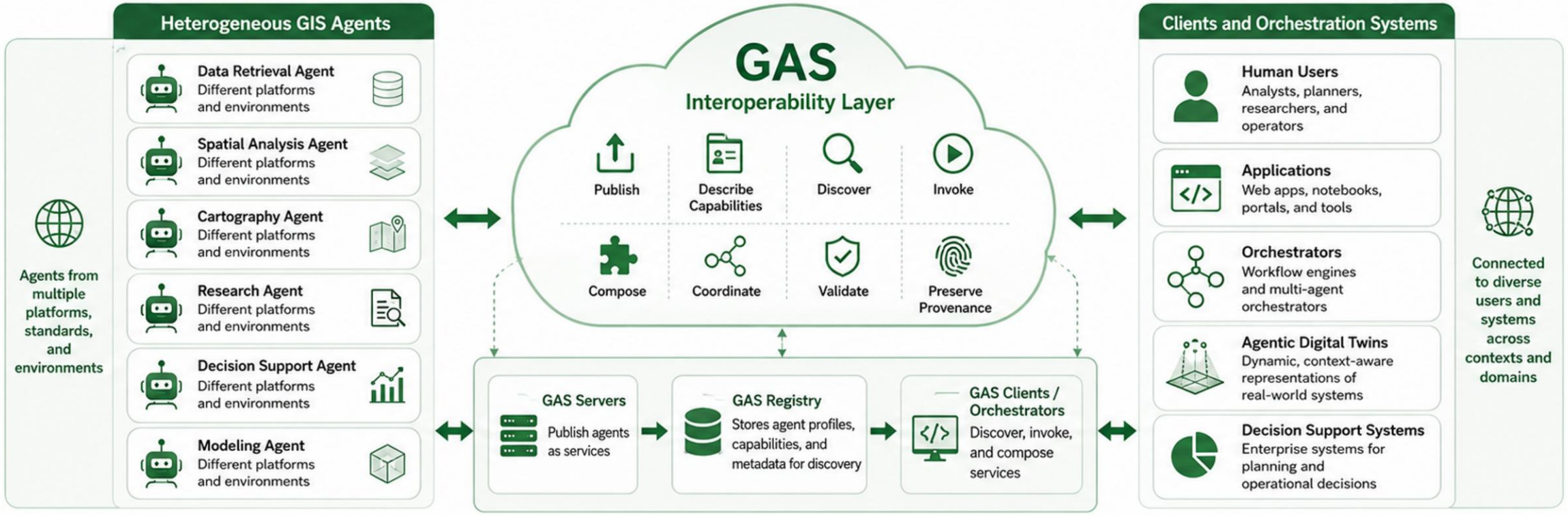


Figure generated with ChatGPT based on text from Li et al (2026)

The Solution

Geospatial Agentic Services (GAS)

A service-oriented framework for interoperable GIS agents and agentic geospatial workflows



What GAS Enables

- Discoverable GIS agents across platforms
- Reusable and invokable service components
- Composable multi-agent geospatial workflows
- Validation of intermediate results
- Provenance and reproducibility across workflows
- Interoperable architectures for human and AI co-learning
- Support for context-aware reasoning and responsible decision-making

GAS moves geospatial interoperability from data and operations to agents and agentic workflows. **Scalability**

This enables autonomous GIS to scale from isolated agents to coordinated geospatial intelligence systems.

Li, Z., Khosravi Kazazi, A., Liu, R., Akinboyewa, T., Ning, H., Huang, X., Ye, X., Arundel, S. T., Li, W., Yang, C., Wang, S., & Simonis, I. (2026). Geospatial Agentic Services: A framework for interoperable geospatial intelligence. SSRN (preprint). https://doi.org/10.2139/ssrn.6753201

Figure generated with ChatGPT based on text from Li et al (2026)

GAS as the Service Infrastructure of Autonomous GIS

An analogy to how geospatial web services enabled WebGIS

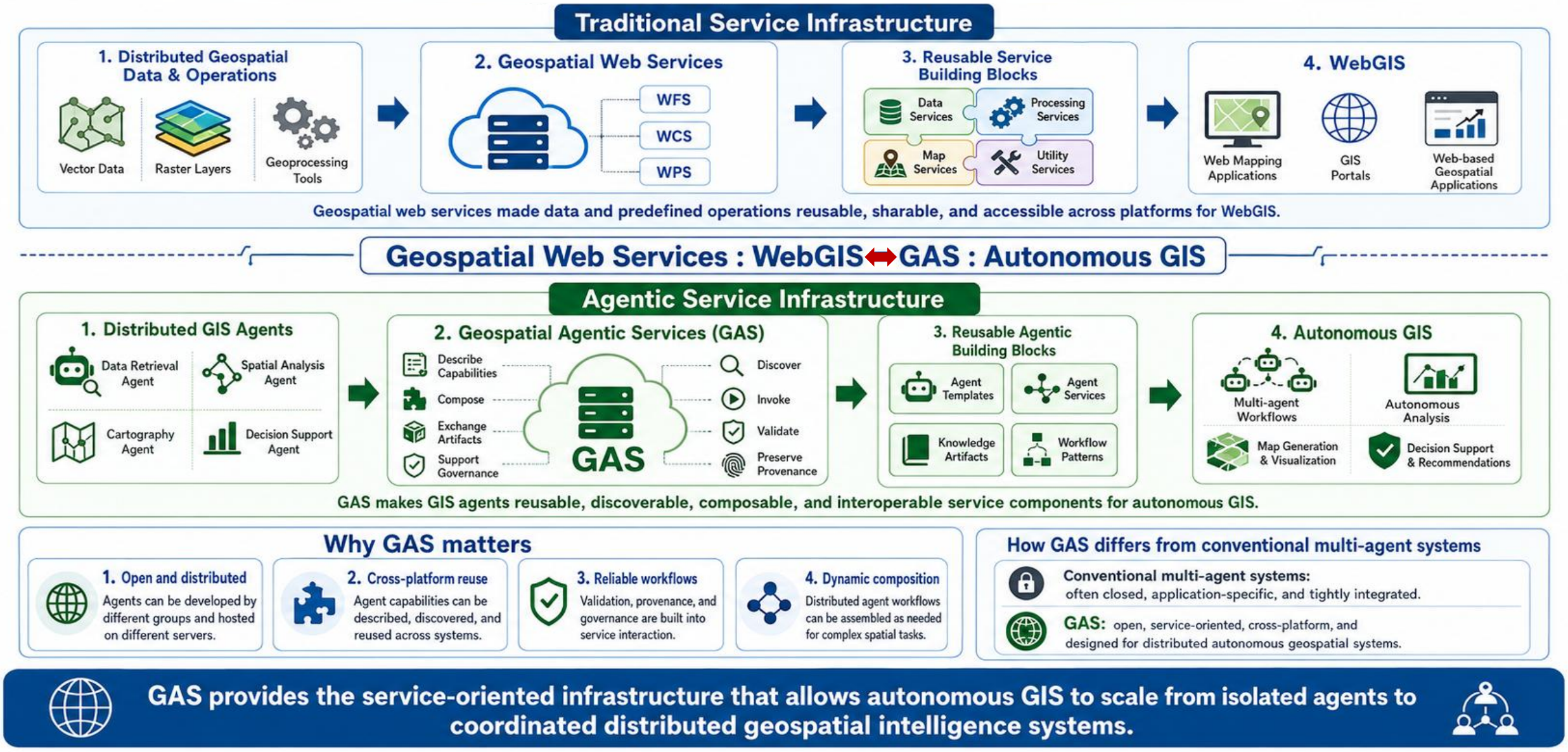
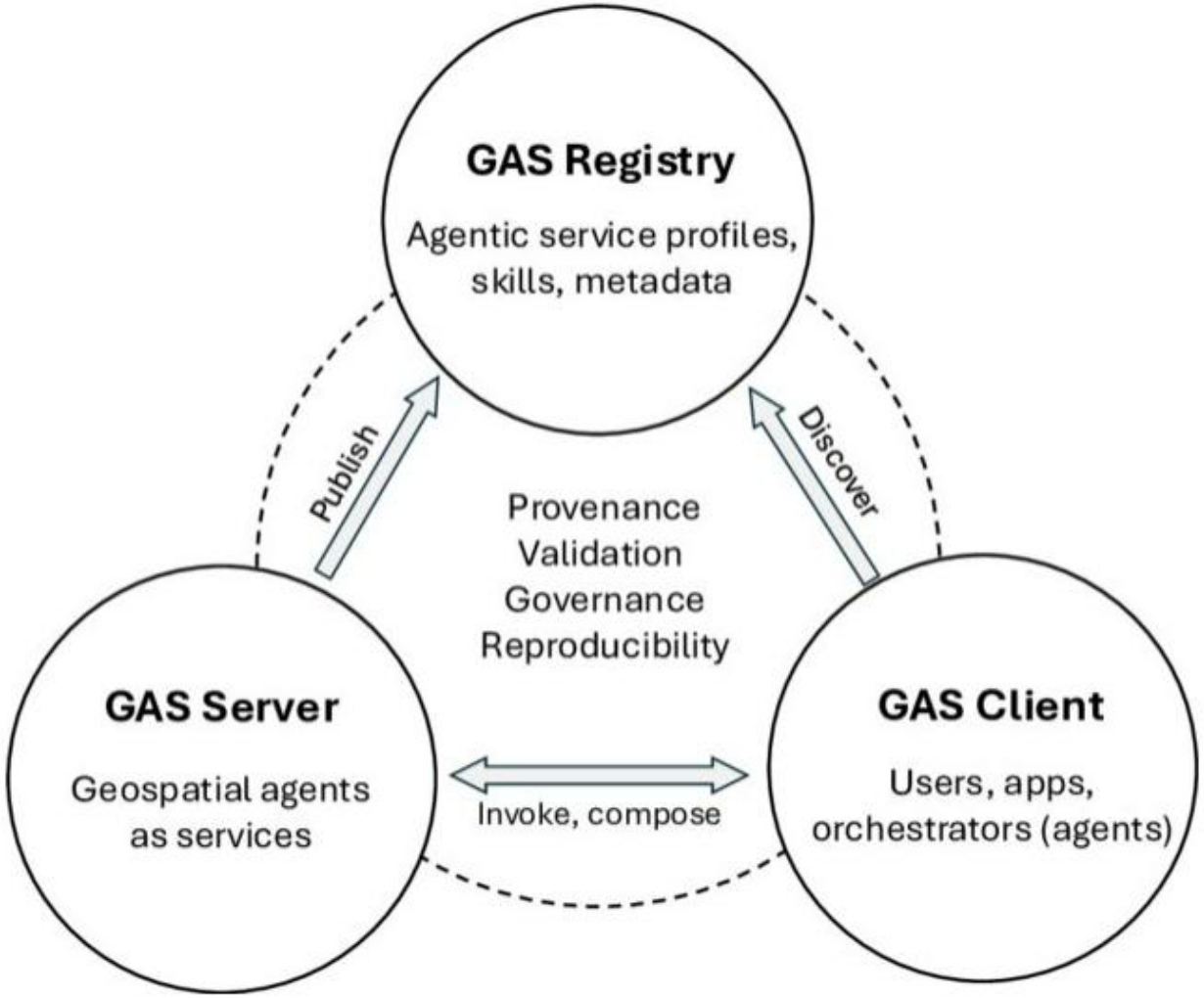


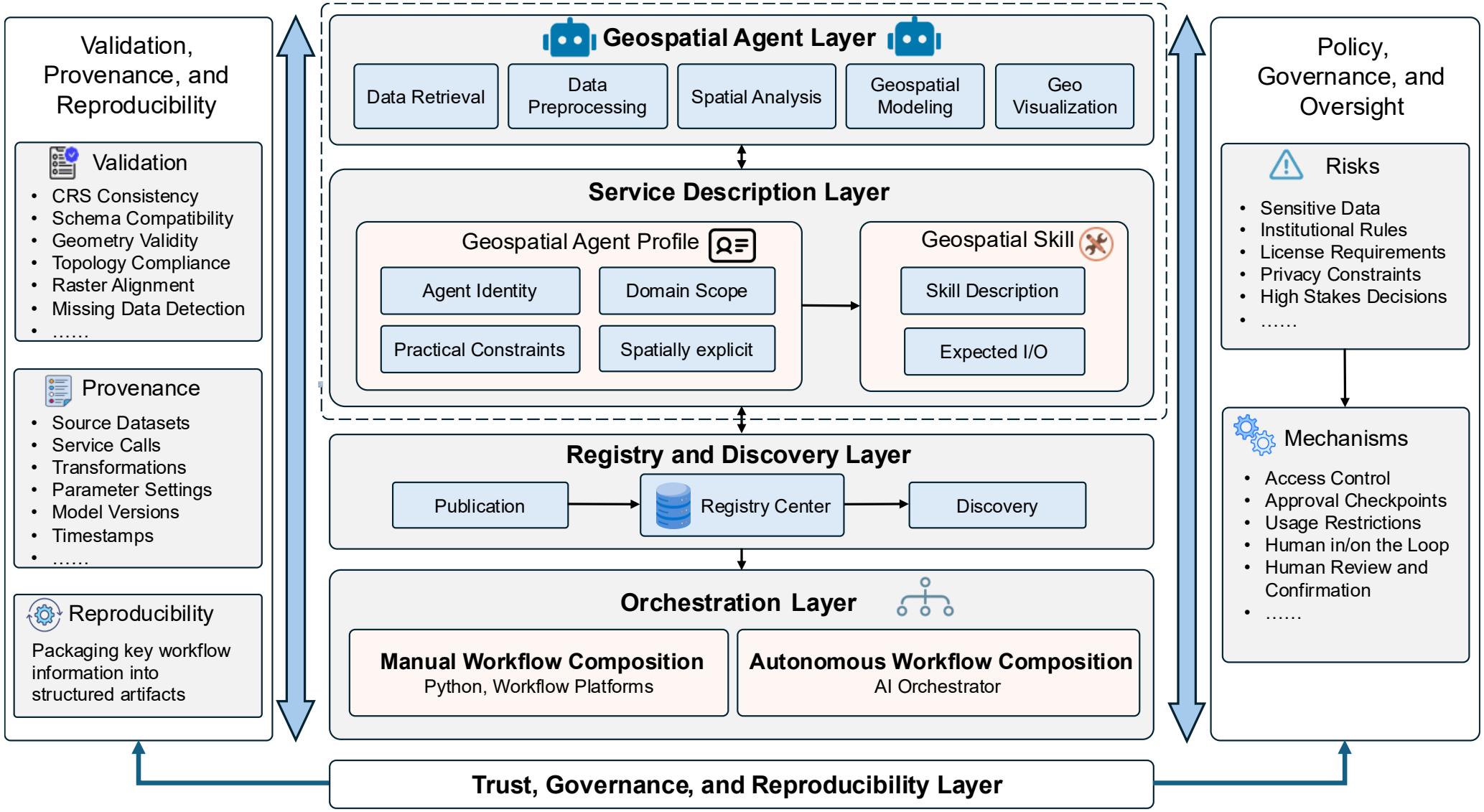
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Three core architectural roles of GAS



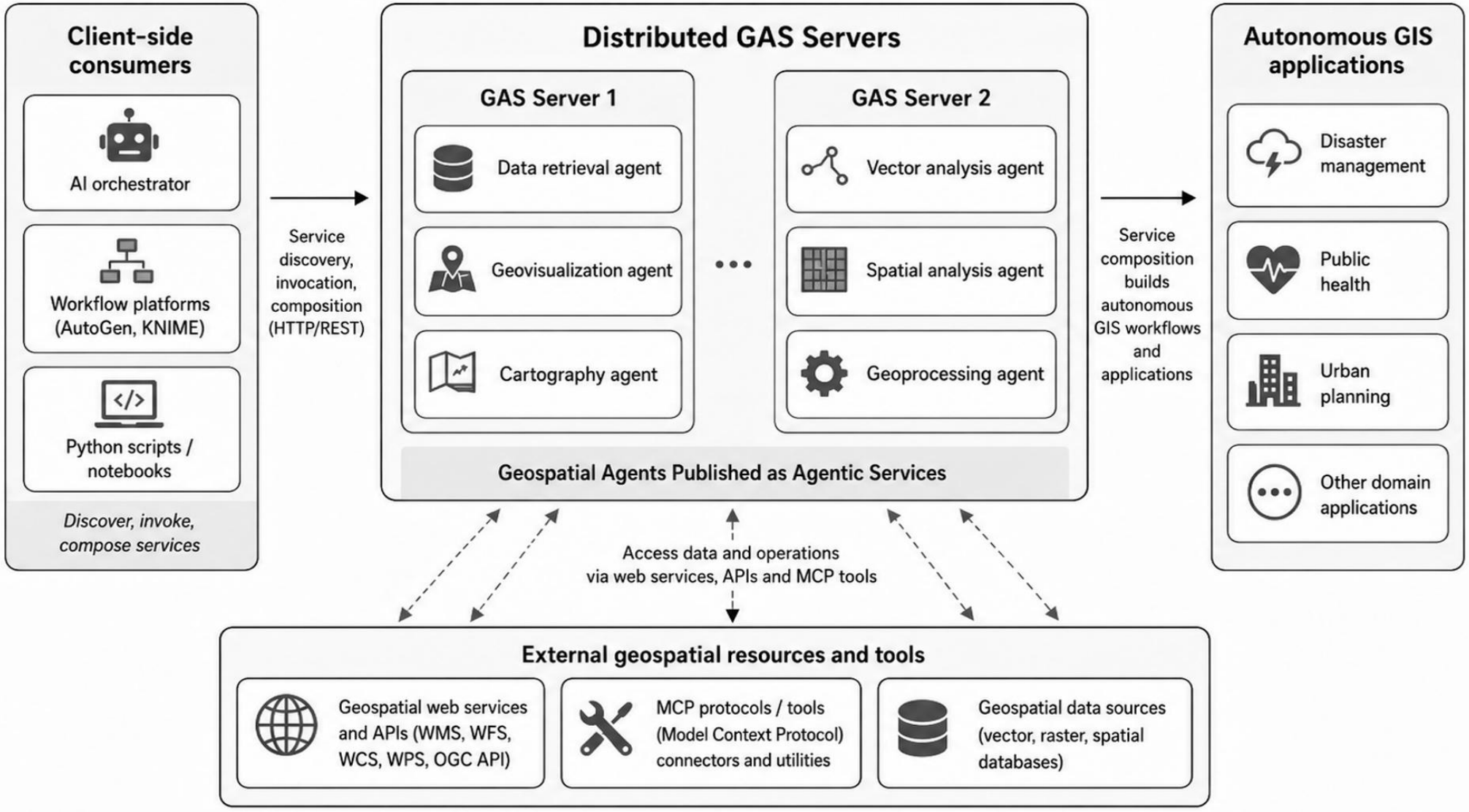
Following the Service Oriented Architecture (SOA)

Five core layers of GAS



Designed to address the system-level challenges: trust, transparency, reusability, shareability, interoperability, scalability, and human oversight.

Operational view of GAS



Distributed GAS servers publish geospatial agents as interoperable agentic services for building autonomous GIS applications across different domains.

GAS Interfaces

- capabilities.schema.json
- describe_agent.schema.json
- execute_task_request.schema.json
- task_response.schema.json

https://www.geospatial-agentic-services.online?service=GAS&version=1.0.0&request=**GetCapabilities**


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https://www.geospatial-agentic-services.online/?service=GAS&version=1.0.0&request=**DescribeAgent**&agent_id=mapping_agent

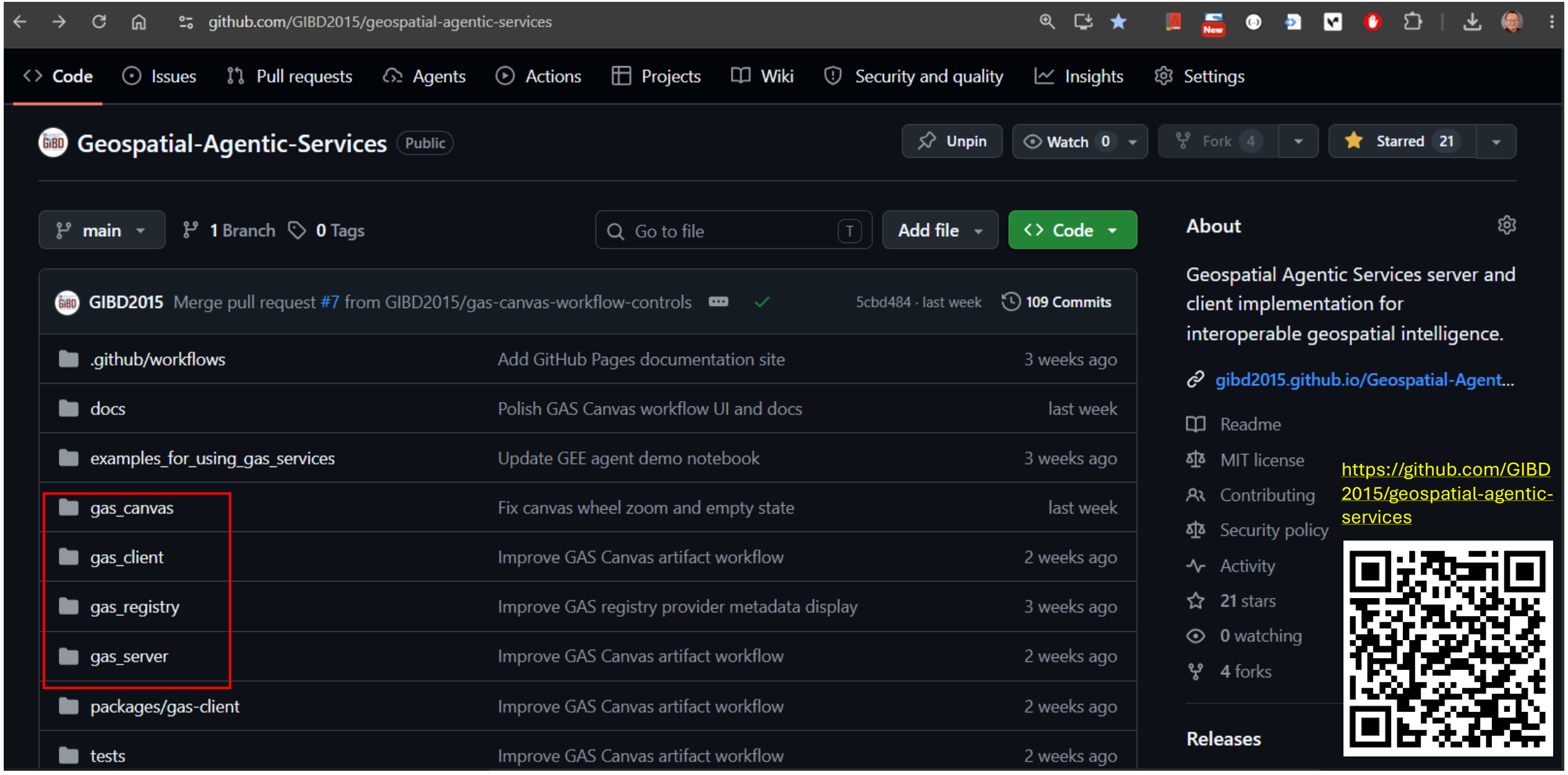

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    "raster_types": [ … ], // 2 items
    "spatial_extent_limit": null,
    "scale_or_resolution_constraints": null,
    "schema_requirements": null
  },
  "skills": [
    {
      "id": "Skill-0009",
      "name": "Raster Analysis",
      "description": "Executes raster-focused analysis such as clip, mask, slope, contour, and raster math.",
      "tags": [
```


B

The GAS JSON Schemas define the machine-readable interfaces between GAS servers and GAS clients (browsers, notebooks, and AI orchestrators).

PennState

The open-source GAS Project



https://github.com/GIBD2015/geospatial-agentic-services

19 GIS agents from 3 distributed GAS servers: Penn State, GMU, Emory University, more coming...



https://www.geospatial-agentic-services.online/registry

GAS Store

geospatial-agentic-services.online/registry

GAS Store

Published Geospatial Agentic Services in the GAS Registry

Search geospatial agentic services...

Register GAS Server | Select visible | Delete Selected | Card | List

Causal Graph Agent
Version 1.0.0
GAS server: https://emoryxiaolab.pythonanyw...
Provider: Xiao Lab

A GAS-native port of the GeoArchitect causal-analysis tool. From a research question (plus optional dataset, geographic extent, and time period) it builds a candidate causal DAG of the drivers of an outcome, then optionally scores edge importance and assesses data coverage and observation-window scope. It returns an interactive HTML graph (standalone Cytoscape.js viewer) and a GraphML file of the DAG.

Learn More

Interactive Mapping Agent
Version 1.0.0
GAS server: https://emoryxiaolab.pythonanyw...
Provider: Xiao Lab

An improved, GAS-native successor to LLM-Cat. From a prepared vector or tabular dataset and a natural-language request, it produces an interactive Leaflet/Folium HTML map (primary) and a static PNG (companion). An LLM selects the map type, value field, classification scheme, palette, and title; rendering is deterministic with no code execution, so it is robust on shared hosts. With no LLM credential it falls back to a

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Exploratory Spatial Data A...
Version 1.1.0
GAS server: https://gas-dt.stcenter.net
Provider: Spatiotemporal Innovation Center at George Mason University

Performs exploratory spatial data analysis (ESDA) on tabular and geospatial datasets. It surfaces what is in the data and how it is arranged in space — distributions, descriptive statistics, missing-data patterns, correlations, and categorical breakdowns, plus a lightweight spatial layer: geometry diagnostics, classified choropleths (Quantiles / Equal Interval / Natural

Learn More

Geospatial Data Inspection ...
Version 1.0.0
GAS server: https://gas-dt.stcenter.net
Provider: Spatiotemporal Innovation Center at George Mason University

This agent inspects vector, raster, and tabular geospatial datasets for data quality, spatial metadata completeness, validation issues, and workflow readiness. It combines deterministic dataset inspection with LLM-assisted

Geospatial Workflow Plann...
Version 1.0.0
GAS server: https://gas-dt.stcenter.net
Provider: Spatiotemporal Innovation Center at George Mason University

This agent discovers GAS server capabilities, reads DescribeAgent documents, decomposes a natural-language geospatial goal into workflow steps, matches each step to suitable GAS agent services, and returns client-side workflow

Spatiotemporal Conflict Ev...
Version 1.0.0
GAS server: https://gas-dt.stcenter.net
Provider: Spatiotemporal Innovation Center at George Mason University

A GMU/STC agent that transforms unstructured conflict reports or structured event tables into standardized, GIS-ready spatiotemporal event layers. It extracts or validates event locations, dates, categories, evidence, and coordinates, then

GiBD Geospatial Information & Big Data Research

PennState

GAS Usage Example: Manual Invocation

```python
!pip install gas-client # Install the GAS Client SDK
from gas_client import GasClient

openai_api_key = "xxxx"
gas_server1 = "https://www.geospatial-agentic-services.online/"
gas_server2 = "https://suspect-maroon-snowy.ngrok-free.dev"

gas1 = GasClient(gas_server1, openai_api_key = api_key)
gas2 = GasClient(gas_server2, openai_api_key = api_key)

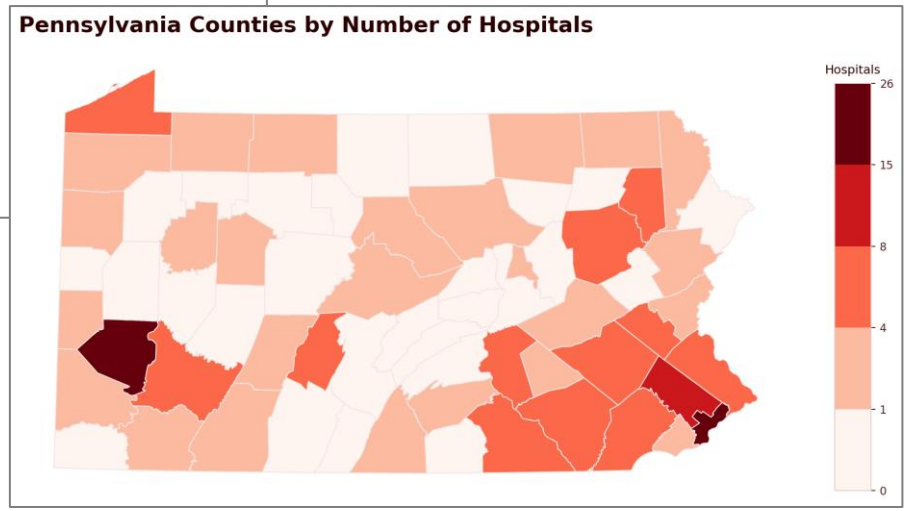
pasda_agent = gas1.agent("pasda_agent") # Agent from server 1
vector_agent = gas2.agent("vector_analysis_agent")#Agent from server 2
mapping_agent = gas1.agent("mapping_agent") #Agent from server 1

#1. PASDA Agent: Download PA County Boundaries (Synchronous Mode)
county_boundaries_task = pasda_agent.execute_task(
    instructions=("Download Pennsylvania county boundaries."
    "Include county names and county identifiers if available."),
    mode="sync", artifact_delivery="URL")

#2. PASDA Agent: Download PA Hospital Locations (Synchronous Mode)
hospital_locations_task = pasda_agent.execute_task(
    instructions=("Download Pennsylvania hospitals as a point dataset."
    "Include hospital name, address and any available identifiers."),
    mode="sync", artifact_delivery="URL")
```

```python
#3. Vector Agent: Count Hospitals in Each County (Asynchronous  Mode)
hospital_count_task = vector_agent.execute_task(
    instructions="Count the number of hospital points in each county.",
    mode="async",
    input_datasets=[county_boundaries_url, hospital_locations_url],
    artifact_delivery="URL"
)
hospital_count_task_id = gas1.get_task_id(hospital_count_task)

#4. Mapping Agent: Create a Choropleth Map (Streaming Mode)
choropleth_map_task = None
for event in mapping_agent.execute_task(
    instructions= (
            "Create a county-level choropleth map of PA showing the "
            "number of hospitals in each county. Use a reddish color"
            "scheme and apply the Lambert Conformal Conic projection."
            "Include a clear title and legend, and remove all axes."),
    mode="stream",
    input_datasets=[hospital_count_url],
    artifact_delivery="URL",
):
    gas1.print_stream_event(event)
    if event.get("event") == "task_result":
        choropleth_map_task = event.get("payload")
```

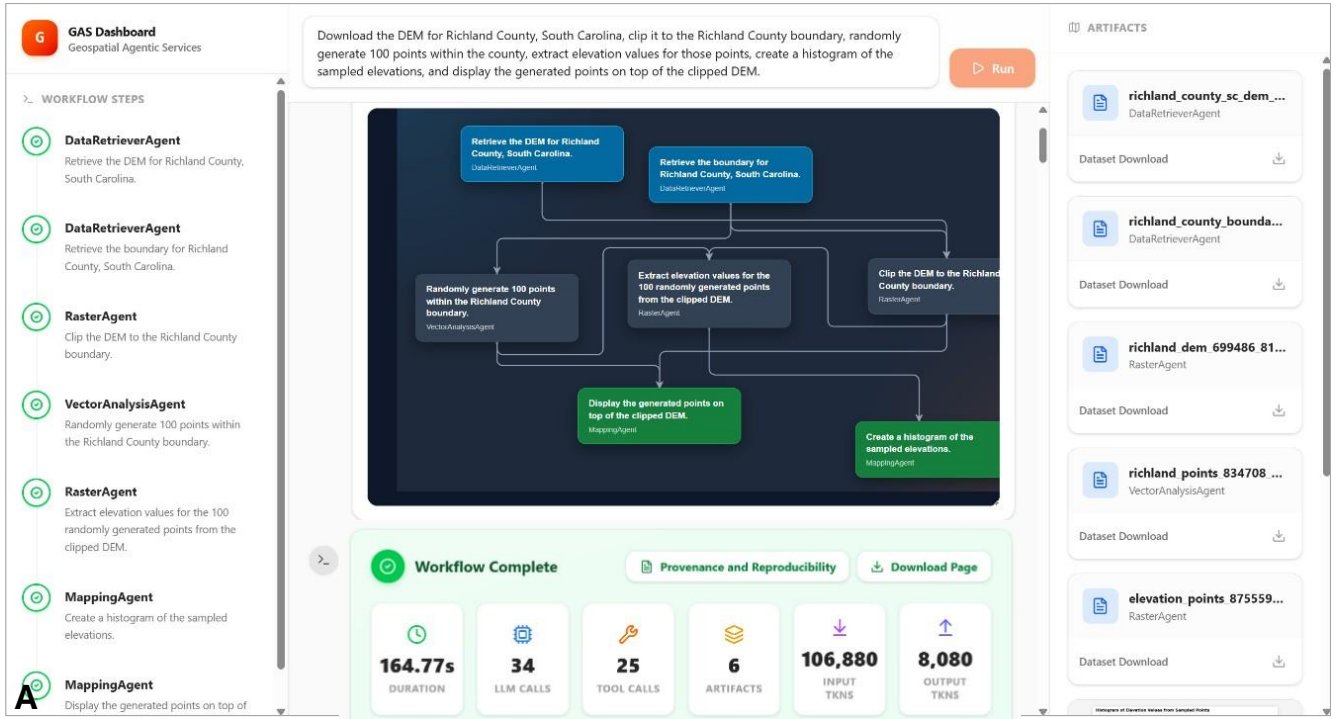


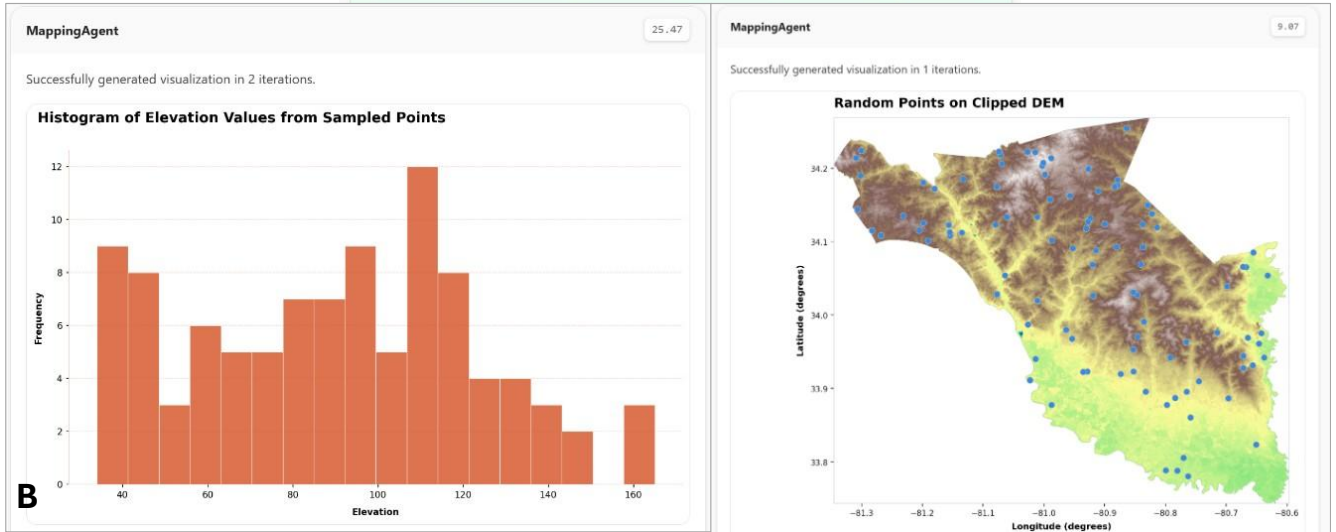
Manual invocation and composition of three GAS agent services from two distributed GAS servers using a Python script.

More GAS usage examples with Jupyter Notebooks
https://gibd2015.github.io/Geospatial-Agentic-Services/examples

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GAS Usage Example: AI Orchestrator

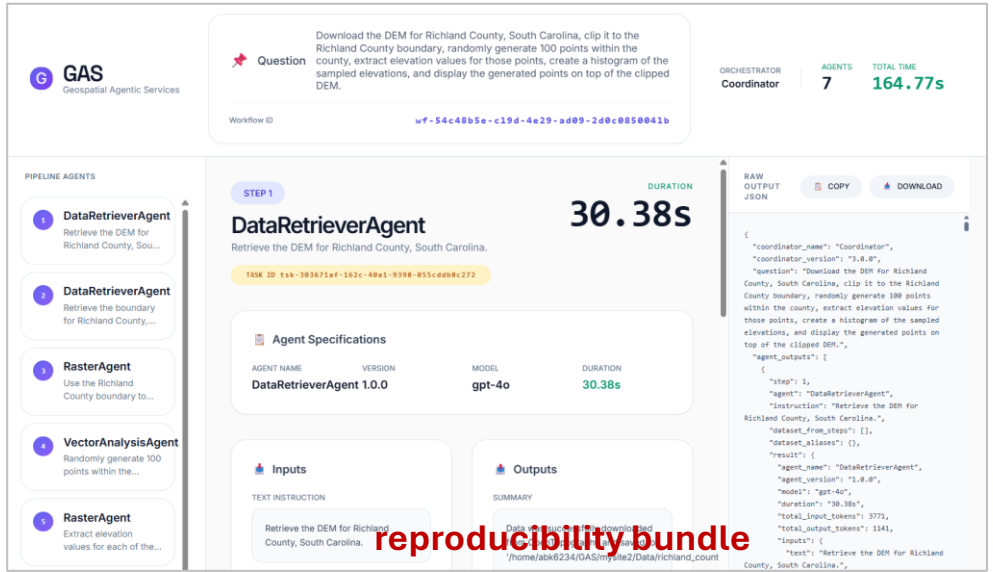




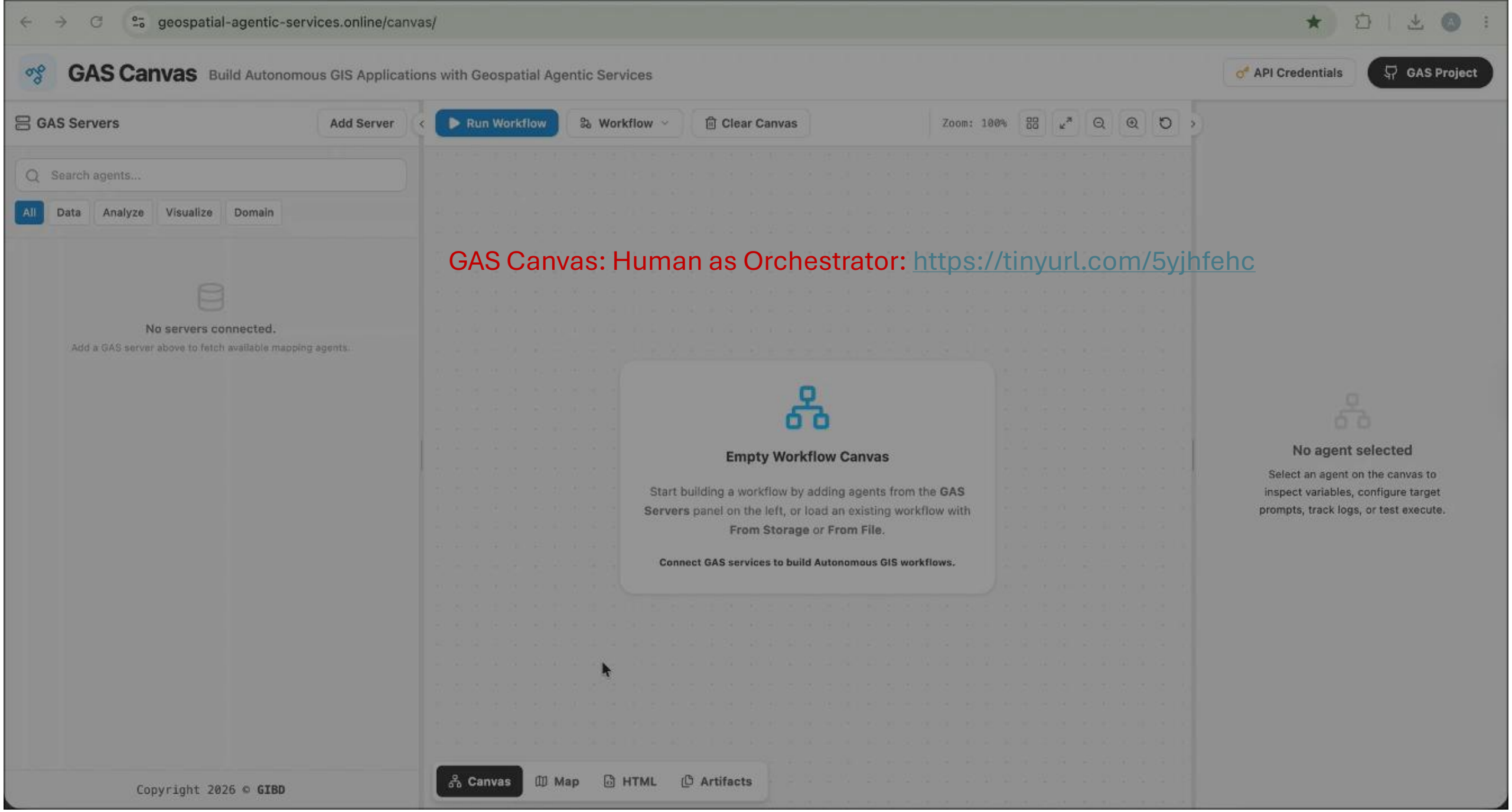
AI orchestrator-generated seven-step workflow for the terrain analysis task, a summary of workflow status, and the downloaded and generated data and products in the right panel.

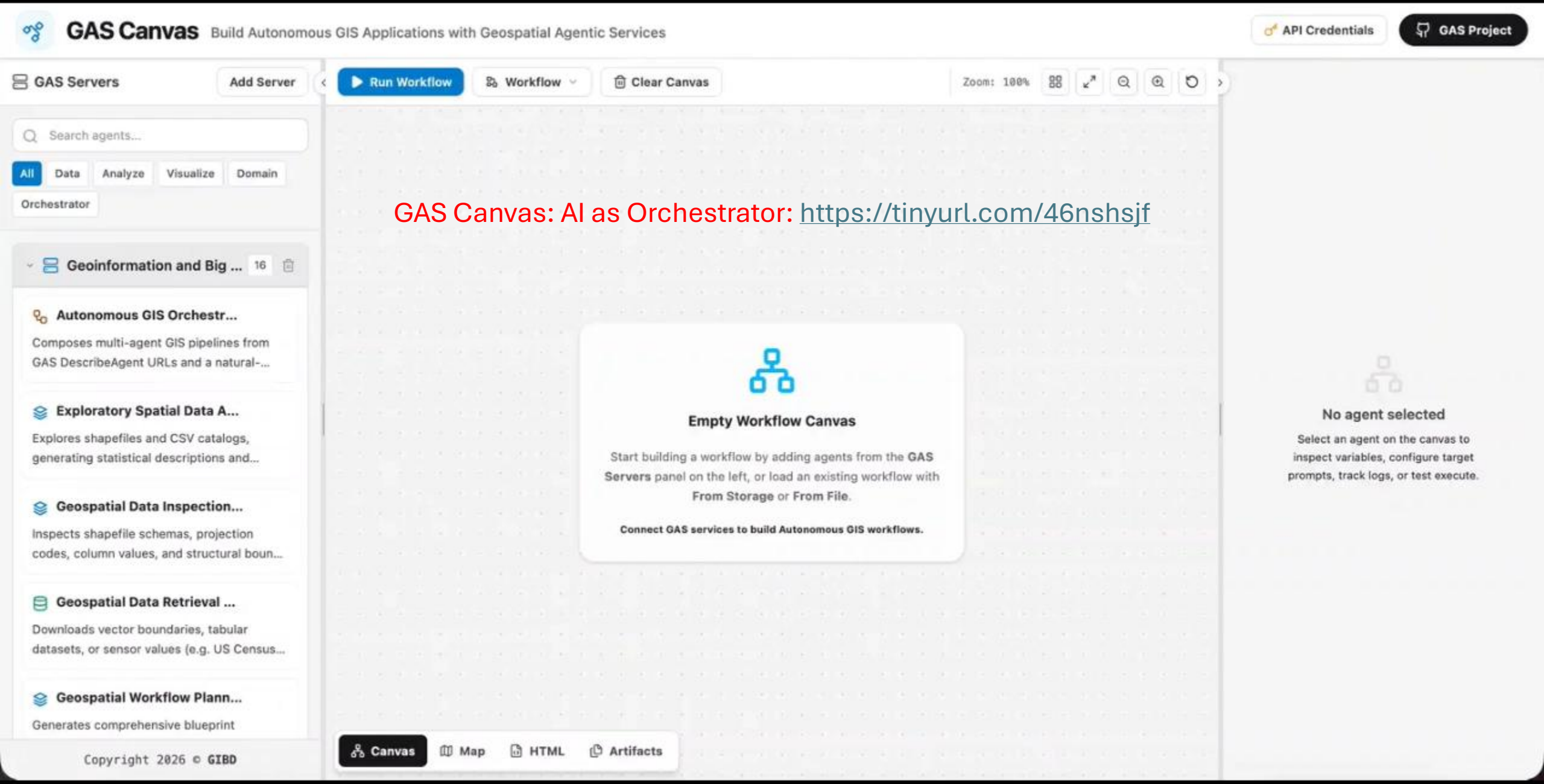
Task: Download the DEM for Richland County, South Carolina, clip it to the Richland County boundary, randomly generate 100 points within the county, extract elevation values for those points, create a histogram of the sampled elevations, and display the generated points on top of the clipped DEM.

The complete provenance record for this case, along with the reproducibility bundle, is available at https://autonomous-gis.github.io/GAS-Cases/UseCase1/index.html



reproducibility bundle


geospatial-agentic-services.online/canvas/
GAS Canvas
Build Autonomous GIS Applications with Geospatial Agentic Services
API Credentials
GAS Project
GAS Servers
Add Server
Run Workflow
Workflow
Clear Canvas
Zoom: 100%
Search agents...
All
Data
Analyze
Visualize
Domain
No servers connected.
Add a GAS server above to fetch available mapping agents.
GAS Canvas: Human as Orchestrator: https://tinyurl.com/5yjhfehc
Empty Workflow Canvas
Start building a workflow by adding agents from the GAS Servers panel on the left, or load an existing workflow with From Storage or From File.
Connect GAS services to build Autonomous GIS workflows.
No agent selected
Select an agent on the canvas to inspect variables, configure target prompts, track logs, or test execute.
Canvas
Map
HTML
Artifacts
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GAS Canvas
Build Autonomous GIS Applications with Geospatial Agentic Services
API Credentials
GAS Project
GAS Servers
Add Server
Run Workflow
Workflow
Clear Canvas
Zoom: 100%
Search agents...
All
Data
Analyze
Visualize
Domain
Orchestrator
Geoinformation and Big ...
16
Autonomous GIS Orchestr...
Composes multi-agent GIS pipelines from GAS DescribeAgent URLs and a natural-...
Exploratory Spatial Data A...
Explores shapefiles and CSV catalogs, generating statistical descriptions and...
Geospatial Data Inspection...
Inspects shapefile schemas, projection codes, column values, and structural boun...
Geospatial Data Retrieval ...
Downloads vector boundaries, tabular datasets, or sensor values (e.g. US Census...
Geospatial Workflow Plann...
Generates comprehensive blueprint
GAS Canvas: AI as Orchestrator: https://tinyurl.com/46nshsjf
Empty Workflow Canvas
Start building a workflow by adding agents from the GAS Servers panel on the left, or load an existing workflow with From Storage or From File.
Connect GAS services to build Autonomous GIS workflows.
No agent selected
Select an agent on the canvas to inspect variables, configure target prompts, track logs, or test execute.
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GAS aims to enable the Infrastructure Scale of Autonomous GIS

Li, Z., Ning, H., Gao, S., Janowicz, K., Li, W., Arundel, S. T., Yang, C., Bhaduri, B., Wang, S., Zhu, A. X., Gahegan, M., Shekhar, S., Ye, X., McKenzie, G., Cervone, G., & Hodgson, M. E. (2025). GIScience in the era of artificial intelligence: A research agenda towards Autonomous GIS. *Annals of GIS, 31*(4), 501–536.



- Run on local computers
- Use computational resources of the computer
- Limited analysis strategies
- Single user



- Run on high-end servers or computing clusters
- Centralized management
- Powerful analysis strategies
- Multiple users



- Distributed agents among institutions
- Collaborations between centralized agents and local agents
- Inter-operational standards and protocols
- Public users

enabled by

Geospatial Agentic Services (GAS)

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Date Written: May 11, 2026

Li, Z., Khosravi, A., Liu, R., Akinboyewa, T., Ning, H., Huang, X., Ye, X., Arundel, S. T., Li, W., Yang, C., Wang, S., & Simonis, I. (2026). Geospatial Agentic Services: A Framework for Interoperable Geospatial Intelligence in the Era of Autonomous GIS. *SSRN*. https://doi.org/10.2139/ssrn.6753201

We are currently working with OGC (Open Geospatial Consortium) to create an OGC GAS API Standard Working Group for geospatial agents interoperability.

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Current Founding Members of the Charter Proposal.

What has changed, is changing, and will change, as GIS becomes increasingly agentic and autonomous?



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Review Article

From tool to collaborator: rethinking GIScience as GIS becomes agentic and autonomous

Ali Khosravi Kazazi & Zhenlong Li

Article: 2687228 | Received 20 Feb 2026, Accepted 07 Jun 2026, Published online: 03 Jul 2026

Cite this article | https://doi.org/10.1080/17538947.2026.2687228 | Check for updates

Full Article | Figures & data | References | Citations | Metrics | Licensing | Reprints & Permissions

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In this article

Abstract
1. Introduction
2. From tool use to partial delegation: the migration of intent in GIS
3. The architecture of autonomy
4. From continuum to coupled roles: agentic role entanglement in autonomous GIS

Abstract

Geographic Information Systems (GIS) have traditionally been positioned along Wright, Goodchild and Proctor's continuum of GIS as tool, toolmaking, and GIScience, a framework that treats GIS as primarily executing human-authored intent. This paper argues that agentic and autonomous GIS strains that assumption by moving GIS beyond predefined command execution toward intent interpretation, workflow construction, and iterative procedural revision. Through an integrative narrative review, we trace a shift in intent from expert command execution to partial delegation of planning and procedural assembly to systems operating in iterative human-agent workflows. We propose the Agentic Role Entanglement (ARE) model to conceptualize this shift. ARE describes an epistemic action loop in which tool use, runtime method construction, and epistemic inquiry may become coupled within a single analytic episode. The model yields falsifiable implications for evaluation and peer review, motivating episode-level validation when methods are generated or revised at runtime. We then outline a validation stack centered on provenance,

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Kazazi A., Li Z. (2026), From Tool to Collaborator: Rethinking GIScience as GIS Becomes Agentic and Autonomous. *International Journal of Digital Earth*, https://doi.org/10.1080/17538947.2026.2687228

Thank You!

Questions/Comments?

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