# Artificial Intelligence Technology and Ecological Transition -Analysis and Criticism-

*Yassine* Barakat[1,*], *Samira* Khoulji[1], *Salmane* Bourekkadi[2], *Mohamed* Larbi Kerkeb[2]

[1]The Information Systems Engineering Research Team (ERISI), National School of Applied Sciences - Abdelmalek Essaadi University, Tetouan-Morocco
[2]Ibn Tofail University, Morocco

**Abstract.** Artificial intelligence (AI) refers to an application capable of processing tasks which are currently performed satisfactorily by human beings insofar as they involve high-level mental processes such as perceptual learning or the organization of memory (Marvin Lee Minsky, 1956). Until now, research in this field has shown a difficulty in validating and certifying artificial intelligence systems at the service of decarbonization, ecological and energy transition objectives. In this context, this article focuses on an effective analysis of 05 of today's most popular AI technologies in the field of environment, Artificial Neural Networks, fuzzy logic, Case-based reasoning, the multi-agent system and the process of natural language. The results show that our analysis can be beneficial for developers to select the appropriate technology for a reliable and successful implementation of artificial intelligence.

**Keywords:** Artificial Intelligence, Ecological Transition, Technologies, Reliability.

* Corresponding author : yassine.barakat@gmail.com

# 1 Introduction

Artificial intelligence is present in all sectors. Cities or airports are equipped with facial recognition tools. Voice recognition-based assistants are being installed in our phones and homes. Our planet's systems are analyzed for the improvement of environmental sustainability. But AI-based systems are not reliable enough. Artificial intelligence tools are not yet as reliable as traditional software, and there is no standard or certification. This poses a problem for the choice of applications (Benoît Georges, 2019).

The approach proposed in this article is based on the selection of artificial intelligence technology as an important element in defining the reliability of AI. Our paper is organized like this:

- Data collection and analysis
- Interpretation of results and critical vision
- Conclusion and future research

# 2 Data collection and analysis

## 2.1 Artificial Neural Networks:

In the field of neuroscience, many researchers have conducted serious studies on the human brain. At that time, studies on the brain showed that neural signals are in fact electrical signals, not much different from the current flowing in an electrical circuit. An artificial neural network is the simplest definition of modeling the human brain (Jake Frankenfield, 2020). A complex RNA contains only thousands of neurons with hundreds of connections. Although simpler than biological neural networks, the goal of RNA is to build computer systems with learning, general processing, and adaptive capacities, similar to those seen in real brains. Artificial neural networks can learn to recognize certain inputs and produce specific outputs for a given input (Toru Miwa, 2021).

Attempting to mathematically model the human brain is a set of Core Processors (EP) (artificial neurons) tightly connected and running in parallel. The EPare interconnected via a one-way signal channel. Each PE calculates a single output based on the information received and the information processing structure distributed in parallel.

RNAs are made up of several interconnected neurons. Different types of neurons can be represented in RNA. Neurons are arranged in a layer and the different layers of neurons are connected to other neurons and layers. The way neurons are interconnected determines the architecture of RNA. As shown in the figure (Fig. 1), a neural network consists of three layers: an input layer, an intermediate layer and an output layer. The blue boxes shown here represent neurons and arrows represent connection points. The data set prepared for training at the input layer is shown to the network. The network assigns the weights of the events it learns to connection points in the middle layer. Each point must be a value and some points can be zero.

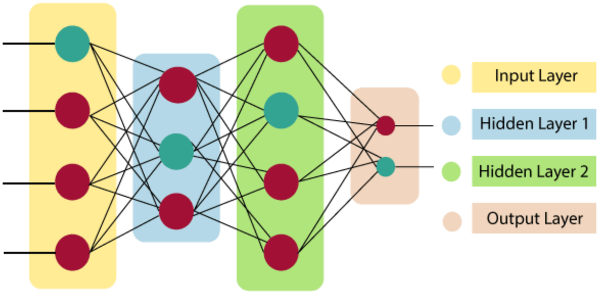


**Fig. 1.** Architecture of a neural network.

Artificial neural networks are used to try to solve complex problems that are easier to solve by the brain than by a computer

- Recognition of a familiar face
- Driving in the rain
- Shape recognition

Artificial neural networks can be applied to many areas of ecological transition, such as:
**Energy**: Neural networks can be used to predict energy production from renewable sources (Y. Bengio, 2016), such as solar or wind power, or to optimize energy consumption

.

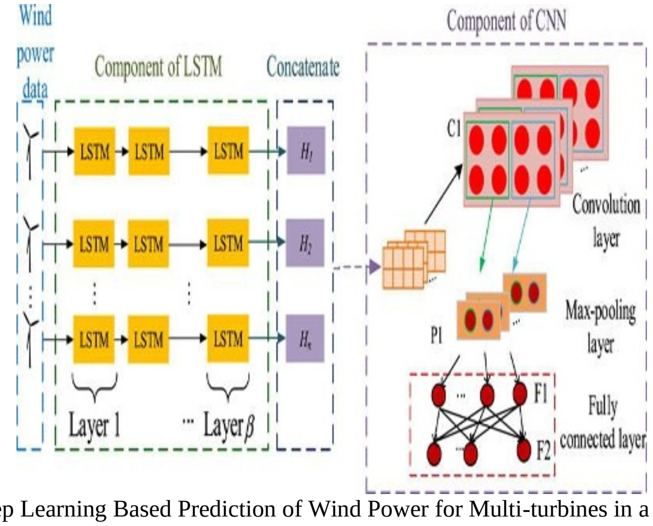


**Fig. 2.** Deep Learning Based Prediction of Wind Power for Multi-turbines in a Wind Farm.

**Transportation**: Neural networks can be used to optimize transportation routes by improving distances traveled, enhancing vehicle logistics, or anticipating machinebreakdowns (M. Nielsen, 2015).

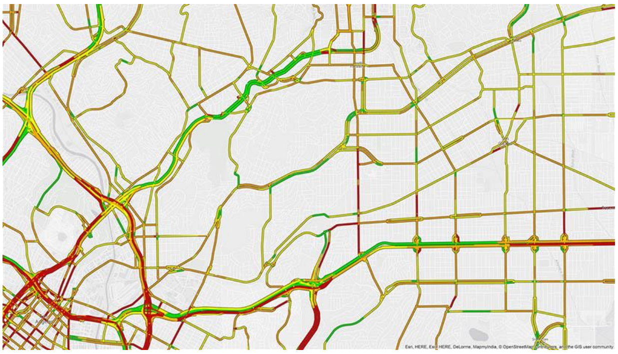

**Fig. 3.** Route Optimization Improves Healthcare Delivery for Home Visits on a deep Recurrent Neural Networks (RNN)..

**Agriculture**: Neural networks can be used to optimize agricultural production (A. Géron, 2019), for example by predicting weather conditions or analyzing data on soils and crops.

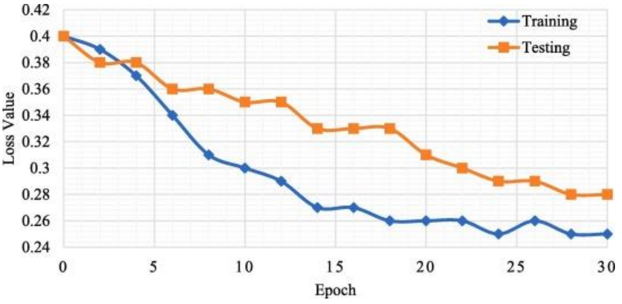


**Fig. 4.** Enabling smart agriculture by implementing artificial intelligence and embedded sensing .

## 2.2 Fuzzy logic:

Fuzzy logic can be loosely included as a member of the artificial intelligence software toolkit (Norm Dingle, 2011). In our life we may come across situations where we cannot be sure whether the state is true or false. Fuzzy logic in AI provides valuable flexibility for reasoning. This part of the article briefly describes the relationship between artificial intelligence and fuzzy logic. We highlight the role that fuzzy logic can play in extending some of the Artificial Intelligence models.

Fuzzy logic (FL) is a method of reasoning similar to human reasoning. FL's method mimics the human decision-making model, which involves all the possibilities in between the YES and NO values. The computer can combine many possible values between YES and NO. These can be:

- CERTAINLY YES
- POSSIBLY YES
- I CAN NOT TELL
- POSSIBLY NO
- CERTAINLY NO

Fuzzy logic (FL) can control machines and consumer products. If the reasoning is not precise, provides at least acceptable reasoning. This helps to deal with technical uncertainty.

**Fuzzy logic architecture:**

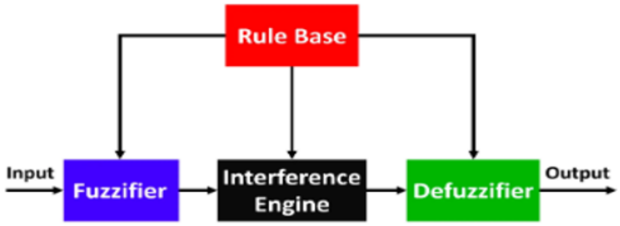


**Fig. 5.**Fuzzy logic architecture

**Rules:** It contains all the rules and prerequisites provided by experts to control the decision making system. The latest update of fuzzy theory provides different methods to design and adjust fuzzy controllers. These developments have reduced the number of fuzzy rules.

**Fuzzification:**The fuzzification step converts the input (net numbers) into fuzzy sets. You can measure the net inputs using the sensors and then pass it to the control system for further processing. It divides the input signal into five steps, for example:

**Inference Engine**: It determines the degree of correspondence between the fuzzy input and the rules. Rules are applied based on the input values received. After that, the applied rules are used to develop control actions.

**Defuzzification**: This is the reverse process of fuzzification. The defuzzification process is performed to convert fuzzy sets into net value. There are different types of technologies available and you need to choose the one that best matches the expert system.

This is a complex process in which methods such as the principle of maximum membership, the weighted average method and the centroid method are used.

Fuzzy logic used in many areas of ecological transition to process complex and uncertain data. Here are some concrete examples:

**Renewable energy:** Fuzzy logic can be used to optimize the production of renewable energy, taking into account factors such as weather and sunlight (J.Yen and R.Langari, 2019). For example, solar energy production forecasting systems can use fuzzy models to estimate the amount of energy produced from meteorological data.

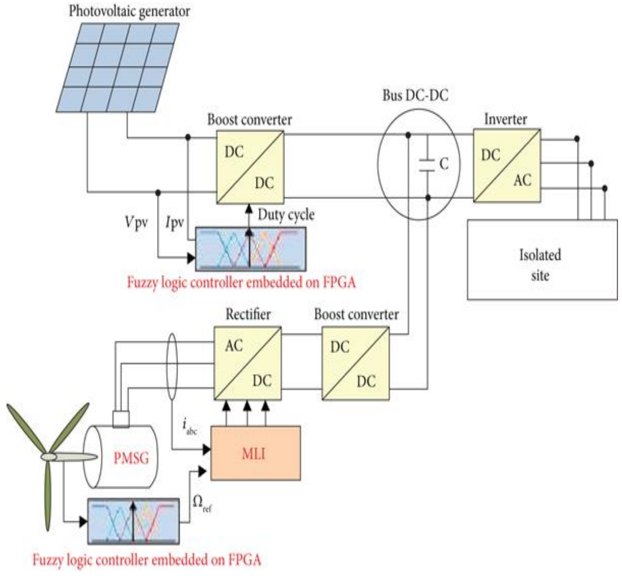


**Fig. 6.** Hardware Implementation of a Fuzzy Logic Controller for a Hybrid Wind-Solar System in an Isolated Site

 https://doi.org/10.1051/e3sconf/202341201072

**Agriculture:** Fuzzy logic can be used to model plant growth, taking into account factors such as humidity, temperature, and brightness, which can vary unpredictably (T.Ross, 2020). For example, an automated control system can be set up to adjust crop watering based on weather emergencies and sensor data in the field.

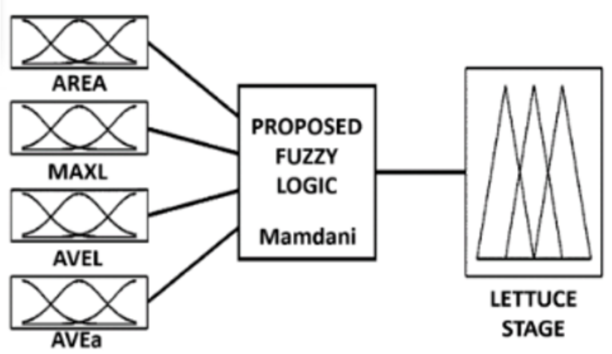


**Fig. 7.** Fuzzy Logic diagram for Identification Lettuce Growth Stage

**Natural resource management:** Fuzzy logic can be used for the management of natural resources such as water, soil, forests (H.Prade and A.Skowron, 2016). These resources are often difficult to quantify and manage due to their evolving nature and uncertainties related to their availability and use. Fuzzy logic can help model the levels of available resources and make adaptive management decisions to preserve their quality and availability. For example, fuzzy logic has been used to model the impact of agricultural practices on water quality in watersheds and to optimize the use of forest resources in forest management.

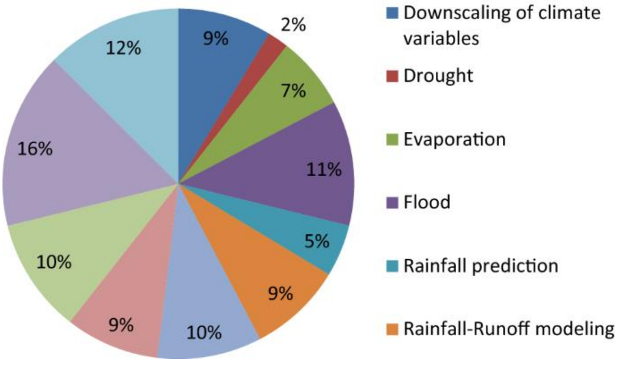


**Fig. 08.** Fuzzy logic applications in hydrology and water resources

### 2.3 Case based reasoning:

Case-based reasoning (CBR) is considered an important method in artificial intelligence, so it is based on the development of practical experience-based problem-solving applications (Janet L. Kolodner, 1992). The heart of every case-based problem solver is a case library, which is a collection of previously created and stored experience items called cases. Case-based problem solving primarily solves new problems by reusing case solutions in the case library. To do this, select one or more relevant cases. The selection process is based on one of the basic assumptions of similar problems to CBR have similar solutions. Once a similar case is selected, the solution of the case will adapt to become the solution to the current problem (Cui-yu Li, 2012). Finally, when a new method for successfully solving a new problem is found, new experience will be gained, which can be stored in the case library to improve its ability, thereby achieving learning behavior.

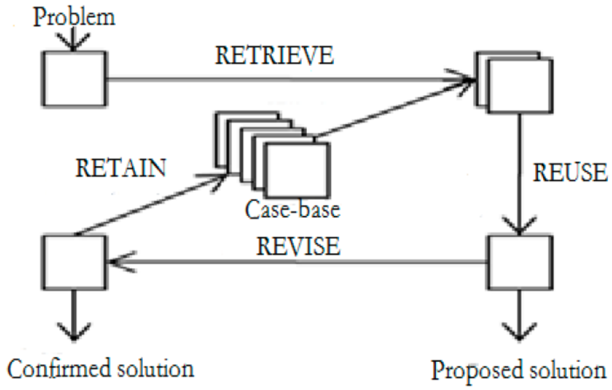


**Fig .09.** case-based reasoning process

There are three main types of CBRs that differ significantly from each other in terms of business representation and reasoning:

**Conversational:** These cases are designed to capture the knowledge contained in the customer / agent dialogue. A case is represented by a list of questions, which varies from case to case.

**Textual:** There is no common case structure, but the case is expressed in free text, which is very useful in areas where there are already a large number of proprietary technical textual documents and where the target user has already used the experience contained in the corresponding documents.

**Structural:** These methods also use the text and conversational CBR functions. For example, it is possible to map text cases to structural representations through automated methods of information extraction and ontology annotations. In addition, the dialog component is used as part of the CBR system to implement specific user interaction strategies.

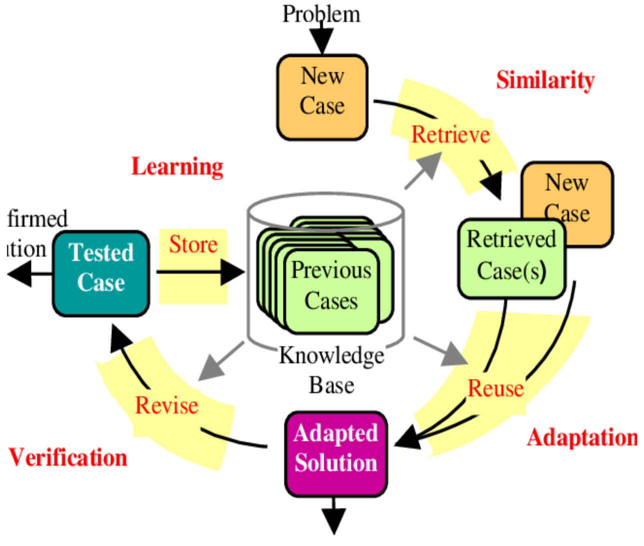

**Fig. 10.** cycle of reasoning based on cases

**Retrieve:** Depending on the similarity of the modeling, select one or more cases from the case library. The extraction task is defined as finding a small number of cases from the cases that have the most similarity to the query.
**Reuse:** Reuse of a recovered solution can be fairly straightforward if the solution is returned unchanged as the proposed solution for the new problem.
**Revise:** In this phase, feedback related to the solution built so far is obtained. This feedback can be given in the form of an accuracy score or in the form of a manually corrected revised case.
**Retain:** The retain phase is the learning phase of the CBR system, the revised case is added to the case library. A clear competence model has been developed to allow selective retention of cases. The modified case or other form of feedback enters the CBR system to be retained later.
Case-Based Reasoning (CBR), or reasoning by cases, can be applied in various areas of ecological transition. Here are a few examples:
**Waste management:** CBR can be used to optimize waste collection and treatment. For instance, by analyzing data on the types of waste, quantities generated, and local environmental conditions, waste management systems can use CBR to identify the best waste management practices in similar situations (S. Li and S. Liang, 2015).

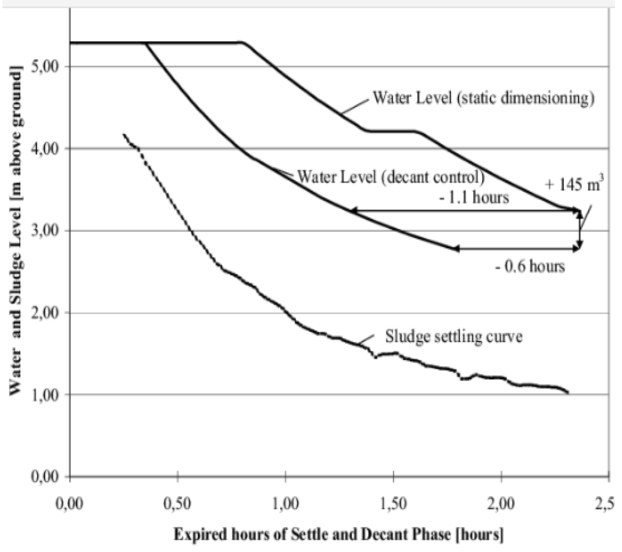


**Fig. 11.** Applying and optimizing case-based reasoning for wastewater treatment systems

**Water resource management:** CBR can be used to identify the most effective water management methods based on previous cases (M. Richter and R. O. Weber, 2016). Historical data on precipitation, groundwater levels, and water use can be used to predict water availability and recommend the most appropriate water management methods, such as wastewater reuse or localized irrigation.


**Fig. 12.** Groundwater Management with Hybrid CBR

**Biodiversity management:** CBR can be used to identify the most effective biodiversity management methods based on previous cases (A. Aamodt and E. Plaza, 2015). Historical data on ecosystem composition, the presence of endangered species, and conservation measures can be used to predict the effects of environmental changes and recommend the best biodiversity management practices.

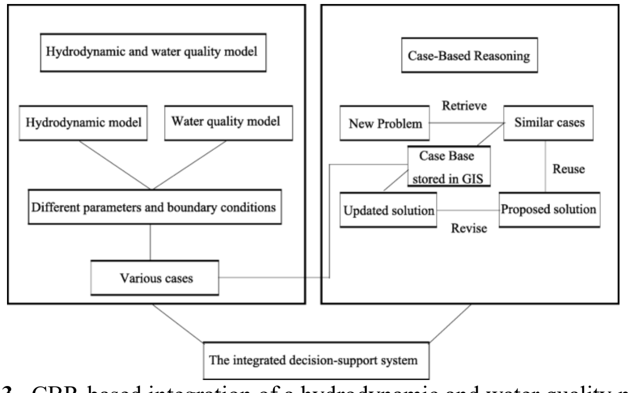


**Fig. 13.** CBR-based integration of a hydrodynamic and water quality model

## 2.4 Multi Agent Systems:

The multi-agent system is a computerized system made up of several interactive intelligent agents. It is an extension of agent technology, in which a group of loosely connected, autonomous agents operate in the environment to achieve a common goal (ARSÈNE SABAS, 2021). Multi-agent systems can solve problems that are difficult or impossible to solve for an individual agent or a monolithic system.

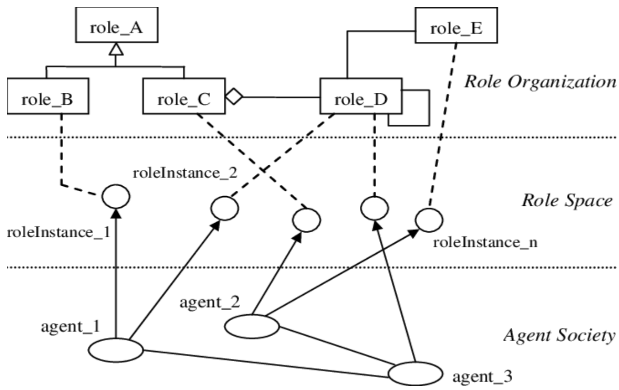


**Fig. 14.** A Generic Model of Role-based Open Multiagent Systems

**MAS Architecture:** The Architecture offers a methodology that allows the construction of an agent based on the construction of a set of components / modules and the definition of their interaction. The architecture illustrates how the inputs (perception of the sensors) and the internal state of the agent (if any) determine the outputs (actions of the effectors) and the future state of the agent. The Architecture to choose depends mainly on the Type of the environment, Type of the agent and the method of perception (passive vs active).

**Simple reactive agent:** The decision depends only on the state of the world (perceived by the sensors).

Multi-agent systems (MAS) are often used in the field of ecological transition to simulate and optimize complex processes involving multiple actors and variables:

**Renewable energy management:** SMA are used to optimize real-time energy production and distribution, taking into account consumer preferences and behavior, environmental constraints, and demand variations(Y. Shoham and K. Leyton-Brown, 2021). For example, in a smart grid, SMA can reduce energy resources to minimize costs and greenhouse gas emissions.

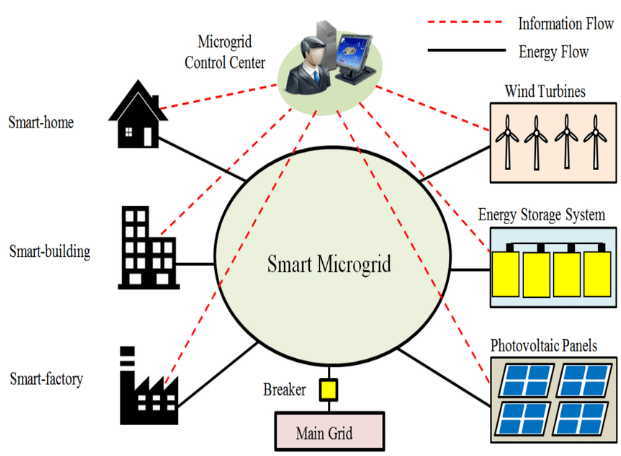


**Fig. 15.** Multi agent system for micro grid system with renewable energy resources

**Waste management:** SMA can be used to optimize waste collection and treatment, taking into account environmental, economic, and social constraints (Y. Shoham and K.Leyton-Brown, 2018). For example, SMA can perform selective waste collection and recycling in a city, considering the habits of residents, treatment facility capacities, and transportation costs.

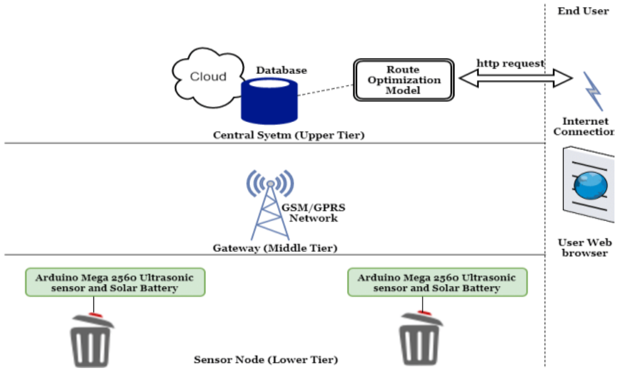


**Fig. 16.** Smart bin and Central systems architecture using SMA

**Sustainable agriculture:** SMA can be used to simulate and optimize sustainable farming practices, taking into account interactions between crops, soils, climatic conditions, and production and sustainability goals (M. Wooldridge, 2019). For example, SMA can be used to optimize resource utilization such as water and fertilizers, crop rotation, and pest and disease management.

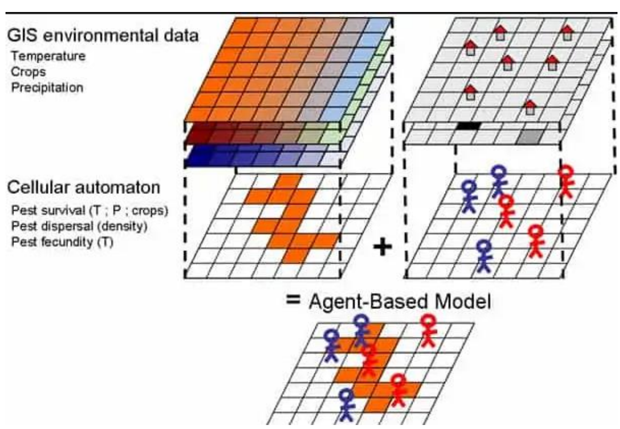


**Fig. 17.** An agent-based model (ABM) analyzes the impact of an individual on a system

## 2.5 Natural Language Processing:

Unlike artificial languages such as programming languages and mathematical symbols, natural languages have been developed from generation to generation and are difficult to be determined with clear rules. Natural language processing refers to the ability of computers to understand human speech (Jason Brownlee, 2017). NLP is a key part of artificial intelligence (AI). It is based on machine learning. Machine learning is a special type of AI that can analyze and use patterns in data to improve the speech comprehension capabilities of the program.

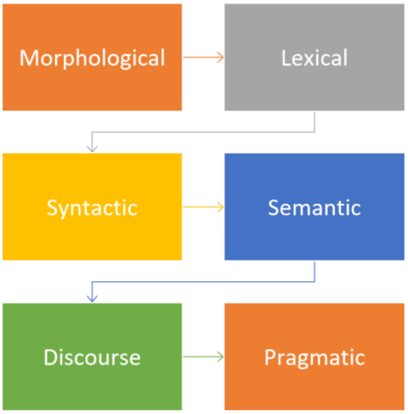


**Fig. 18.** Natural language processing steps

**Phonological Analysis:** This level is only applied when the source of the text is speech. It manages the phonetic interpretation in and between words. The voice can provide important clues to the meaning of a word or phrase.

**Morphological Analysis:** Morphological analysis: treatment of the understanding of different words according to the morphemes of the words. Words can be divided into three morphemes (prefix, root, and suffix), and each morpheme carries some form of meaning: Link morphemes (prefix and suffix) need a free morpheme that can be added, so that 'they cannot appear alone. As a "word".

**Lexical Analysis:** including recognition and analysis of word structure. The language dictionary specifies all words and expressions in the language. Lexical analysis divides the entire text into paragraphs, sentences and words.

**Syntactic Analysis:** Syntax involves the correct order of words and their impact on meaning. It consists of analyzing the words of a sentence to describe the grammatical structure of the sentence. The word becomes a structure, showing the relationship between words.
**Semantic Analysis:** it derives the meaning of the text. Check the meaning of the text. This is done by mapping grammatical structures and objects to the task domain.
**Discourse Integration:** The meaning of a single sentence depends on the sentence that precedes it and also invokes the meaning of the sentences that follow it.
**Pragmatic Analysis:** Pragmatics relates to the whole of communication and the social environment and its influence on interpretation. This means deliberately using the abstraction or derivation of language in specific situations (especially in terms of languages that require understanding of the world).

Natural Language Processing (NLP) can be applied in various areas of ecological transition. Here are a few more examples:
**Environmental risk management:** NLP can be used to monitor social media, online forums, and blogs to identify precursor signals of environmental risks, such as oil spills, toxic emissions, and industrial accidents (D.Jurafsky and J. H. Martin, 2019). This information can help authorities take preventive measures to minimize environmental risks.

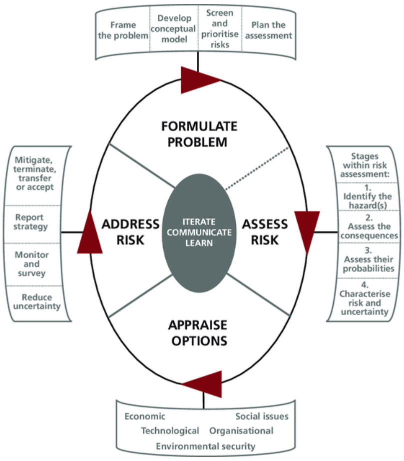


**Fig. 19.** Natural Language Processing for environmental risk assessment and management

**Environmental data analysis:** NLP can be used to extract information from environmental data such as environmental assessment reports, environmental impact studies, and air and water quality monitoring data (D. Manning, and D. Jurafsky, 2018). This information can be used to understand environmental trends, predict future impacts, and make informed decisions regarding environmental management.

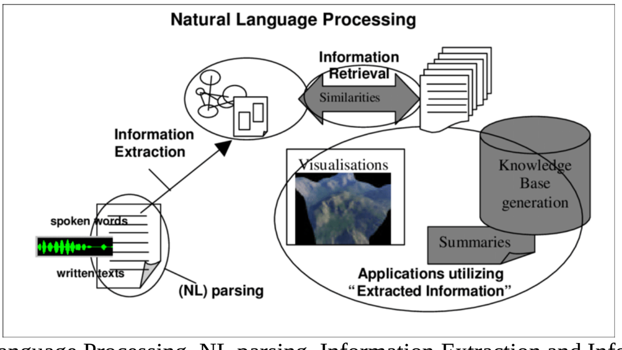


**Fig. 20.** Natural Language Processing, NL parsing, Information Extraction and Information Retrieval

**Environmental communication:** NLP can be used to develop clear, relevant, and persuasive environmental messages (S. Bird, E. Klein and E. Loper, 2019). NLP techniques, such as discourse analysis and theme modeling, can help understand the preferences, attitudes, and behaviors of target audiences and develop environmental messages that are tailored to their context and needs.

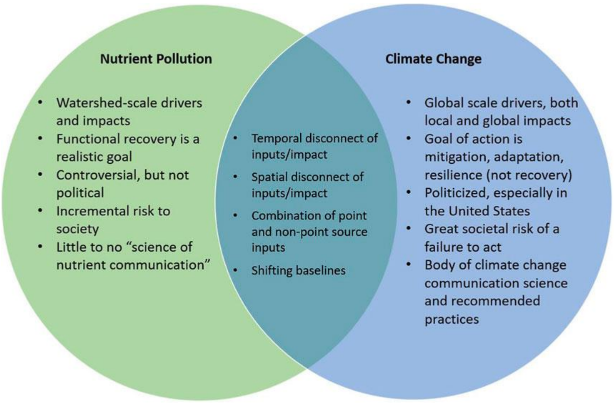


**Fig. 21** Venn Diagram of similarities and differences between environmental issues of nutrient pollution and climate change

NLP can be used to develop effective online learning tools for environmental education(F. Chollet, 2018). NLP techniques, such as text classification and text generation, can help create personalized, interactive, and adaptive educational content that meets individual learning needs of learners.

## 3 Interpretation of results and critical vision

**Artificial Neural Networks** have machine learning capabilities, indeed artificial neural networks learn events and make decisions by commenting on similar events, they also have the capability of storing information across the network: information such as in traditional programming is stored on the network rather than in the database. However there is an inexplicable Behavior of the network especially when the RNA produces a query solution, it does not know the reason and the how. Another disadvantage is Hardware Dependency: The artificial neural network requires the processor to have parallel processing capabilities depending on its structure.
The use of artificial neural networks (ANN) in the ecological transition can offer several benefits by allowing the processing of large volumes of data and detecting complex patterns that cannot be identified by the naked eye. ANNs can be used to predict environmental trends from historical data and to optimize renewable energy production processes, natural resource management, and greenhouse gas emission reduction. ANNs can also help design more accurate environmental simulation models and improve the accuracy of weather and climate forecasts. However, it is important to note that ANN results are not always perfectly accurate and can be affected by biases in input data. It is therefore crucial to use high-quality data and regularly check ANN model performance to avoid forecasting errors and negative environmental impacts. Additionally, the use of ANNs in the ecological transition should be considered as a complementary tool rather than a unique solution and should be integrated into a broader approach that takes into account the economic, social, and political dimensions of the ecological transition.

Finally, artificial neural networks are considered to be simple mathematical models designed to improve existing data analysis techniques. Although it cannot be compared to the human brain, it remains the basic construct of artificial intelligence.

Regarding **fuzzy logics** they have the ability to reduce the costs and complexity of the system because they can use inexpensive sensors. Fuzzy logic is widely used for business and practical purposes. Another Strength When fuzzy input, distorted, or inaccurate is available;

these systems can solve complex problems and make decisions accordingly. Because it sounds like human reasoning.

Finally because of the flexibility, one can modify the fuzzy logic system by simply adding or removing rules to improve or modify the performance of the system. However, it cannot recognize machine learning as well as neural network type models. Another disadvantage is that Fuzzy logic is not always precise. Therefore, the results are seen on the basis of assumptions, so they are suitable for problems that are not very specific. Finally there is no single systematic method for solving problems using fuzzy logic. As a result, there are many solutions to specific problems which lead to confusion.- Sometimes fuzzy logic is confused with probability theory.

The use of fuzzy logic in the ecological transition can offer significant advantages by allowing the consideration of complex and uncertain variables that cannot be processed by traditional binary logic. Fuzzy logic makes it possible to model concepts such as air quality, biodiversity, ecological vulnerability, which are often difficult to quantify precisely. By using fuzzy logic, it is possible to consider qualitative and subjective data, as well as quantitative data, to develop more comprehensive decision-making models. For example, fuzzy logic can be used to evaluate the environmental performance of a project by taking into account factors such as impacts on biodiversity, greenhouse gas emissions, energy consumption.

Although fuzzy logic in artificial intelligence helps mimic human reasoning, these systems still require expert guidance to be built. Fuzzy logic can also be used to improve the execution of algorithms.

Regarding **case-based reasoning (CBR)** they learn by acquiring new cases through use. The process of maintaining knowledge is greatly facilitated by the learning ability of these CBR systems. In many applications, especially where case libraries may already exist, the process of acquiring knowledge is greatly simplified. However a CBR can take a lot of storage space for all cases, then just as efficiency is seen as an advantage; it can also be a disadvantage for large systems with poorly organized or indexed case libraries. In many cases, it can be difficult to calculate the distance between the desired solution and the actual solution. From a conceptual and computer point of view.

In the ecological transition, Case-Based Reasoning (CBR) can be used to solve problems such as natural resource management, environmental disaster prevention, and environmental impact assessment of development projects. By using CBR, it is possible to leverage past experience to solve similar problems that are currently arising. Overall, the use of CBR in the ecological transition can be a useful tool for solving complex problems and leveraging past experience. However, it is important to have high-quality data and regularly check the results to ensure that the decisions made are the best possible.

The combination of CBR with various other technologies in high throughput applications is increasingly attractive to researchers and professionals. In this page we have tried to explain the principles of case-based reasoning and also we have mentioned strengths, weaknesses and areas of application.

For **the multi-agent system**, when one or more agents fail, the system gradually degenerates. Therefore, it increases the reliability and robustness of the system. The reuse agent has a modular structure, which can be easily replaced in other systems and can be upgraded more easily than the overall system adds responsiveness since an ADM perceives and responds to changes in the environment. However predictability, understandability and control are limited. Also the system is prone to accidents, errors and has a lack of reliability which remains limited to the completion of calculation.

The use of Multi-Agent Systems (MAS) in the ecological transition can offer significant advantages by allowing the simulation and optimization of complex processes involving multiple actors and variables. MAS can be used in natural resource management, land use planning, and environmental disaster prevention. By using MAS, it is possible to model the interactions between different stakeholders involved in an environmental problem and optimize the proposed solutions. MAS can also be used to simulate future scenarios and evaluate the impact of different political or strategic choices. MAS can thus help identify the actions that will have the greatest impact on the environment, taking into account the opinions and goals of all stakeholders.

Due to the emergence of new technologies, the complexity has increased dramatically. Agents are widely used to overcome this complexity. Due to the wide range of applications of MAS, it is only reliable in a collective sense. The whole system will not fail if any component of the system fails. This means that the individual agent does not matter.

Regarding **Natural language processing**, it has the advantage of Automatic Synthesis: produces a readable summary of part of the text, plus coreference resolution since it determines which words refer to the same objects in a single sentence, plus discourse analysis: This includes a number of related tasks. One task is to identify the structure of the speech of the connected text. The big downside to NLP, however, is that you need to have a separate version of the product for each language, if applicable, for each dialect of a language. So, for example, Portuguese is quite different in Brazil and Portugal.

The use of Natural Language Processing (NLP) in the ecological transition can offer advantages by allowing the analysis of large volumes of textual data related to the environment, such as news articles, scientific reports, social media data. NLP can be used to extract relevant information about environmental issues, such as greenhouse gas emissions, air or water pollution, climate change. NLP can also be used to identify key stakeholders, such as companies, governments, non-governmental organizations (NGOs), or local communities, involved in environmental issues. By using NLP, it is possible to analyze the opinions, attitudes, and behaviors of stakeholders related to specific environmental issues. This analysis can help understand the key factors that influence stakeholders' decisions and behaviors and develop strategies to address environmental challenges.

Natural language processing helps machines learn and communicate with each other and with humans in a meaningful way. Due to precise requirements and very clear structured voice commands, developing NLP applications can be a difficult task. In general, by providing a more natural human-machine interface and more sophisticated access to stored information, language processing has played a central role in a multilingual information society.

## 4 Conclusion and future research

The techniques used in the field of artificial intelligence are in fact only advanced forms of statistics and mathematical models. All of these models assembled by experts provide us with tools to calculate tasks once believed to be reserved for humans.RNA considered the best artificial intelligence technique; ANNs learn from training cases and capture relationships between data. They are versatile and have had a range of environmental applications for classification, approximation of functions, optimization and prediction. LFs, on the other hand, have been applied to many environmental issues because they can deal with inaccurate and incomplete data. LFs are often combined with other techniques to form hybrid systems. CBRs require similar earlier cases. MAS are often used to simulate complex systems, by agents interacting to solve a common problem. They are often adapted to the management of natural resources. NLP helps machines learn to communicate with each other and with humans in meaningful ways.

Artificial intelligence can play an important role in the ecological transition by assisting in the management of natural resources, reducing greenhouse gas emissions, and producing renewable energy. Areas of application include water management, waste management, precision agriculture, green mobility, renewable energy production, and energy efficiency. The future prospects of AI in the ecological transition include improving forecasting models for natural resource management, implementing autonomous systems for monitoring and managing ecosystems, reducing greenhouse gas emissions through cleaner technologies, and creating intelligent energy systems that optimize the production and distribution of renewable energy.

However, it is important to note that AI itself consumes energy and can have a negative environmental impact if used improperly. Therefore, it is important to ensure that the use of AI is consistent with the objectives of the ecological transition. Finally, researchers and industry stakeholders must collaborate to develop innovative and sustainable solutions that leverage AI to help solve the environmental challenges we face.

## 5 References

1. M. van Assen, S. J. Lee, C. N. De Cecco, *Artificial intelligence from A to Z*: From neural network to legal framework, European Journal of Radiology, Volume **129**, (2022)
2. S. Russell, P. Norvig , Artificial Intelligence: *a Modern Approach* ,(third ed.), Prentice Hall Press, Upper Saddle River, NJ, USA (2009)
3. Z. Ghahramani, *Probabilistic machine learning and artificial intelligence*, Nature, **521** (7553) (2015)
4. European-Commission, White Paper on Artificial Intelligence, (2023)
5. D. Hernandez, D. Amodei, S. Girish, et al., OpenAI.Org AI Comput. (2019)
6. Knapik, M., Johnson, J., *Developing Inteligent Agents for Distributed Systems*. Computing McGraw-Hill, NY:McGraw-Hill,(1998)
7. Brownlee J, *Deep Learning for Natural Language Processing*, Available at:https://cutt.ly/EbjQujj , OCTOBER 17, (2022)
8. A. Kao, S. Poteet, *Text Mining and Natural Language Processing-Introduction for the Special issue*, SIGKDD Exploration **7** (1) (2005) 1.
9. D. M. Bikel, I. Zitouni, *Multilingual Natural Language Processing Applications*, Edited by IBM Press Pearson Upper Saddle River, ibmpressbooks.com ISBN-13: 978-0-13-715144-8, May (2012)
10. S. Bird, E. Klein, E. Loper, *Natural Language Processing with Python, Analyzing Text with the Natural Language* Toolkit, June (2009):O'reilly publication ISBN: 978-0-596-51649-9
11. T. Miwa, R. Minoda, R. Yamaguchi, S. I. Kita, K. Osaka, H. Takeda, S. I. Kanemaru, K. Omori, *Application of artificial intelligence using a convolutional neural network for detecting cholesteatoma in endoscopic enhanced images*, Auris Nasus Larynx, (2022)
12. Kassou, M., Bourekkadi, et al. (2021) . Blockchain-based medical and water waste management conception. E3S Web of Conferences, 2021, 234, 00070

13. El imrani, O. et al (2022). The consumer price index and it effect in the new ecosystems and energy consumption during the sanitary confinement: The case of an emerging country. IOP Conference Series: Earth and Environmental Science , 975(1), 012006
14. Kahraman C., Öztaysi B., Çevik Onar S. *A comprehensive literature review of 50 years of fuzzy set theory*, Int. J. Comput. Intell. Syst., **9** (1) (2016)
15. Zadeh, *Fuzzy sets*, Inf. Control, **8** (1965)
16. Bustince H., Barrenechea E., Pagola M., Fernandez J., Xu Z., Bedregal B., Montero J., Hagras H., Herrera F., De Baets ,*A historical account of types of fuzzy sets and their relationships*, IEEE Trans. Fuzzy Syst., **24** (1) (2016)
17. Hühn J., Hüllermeier E. FURIA: *An algorithm for unordered fuzzy rule induction, Data Min*. Knowl. Discov., **19** (3) (2009)
18. Bing L., Chan K., *A fuzzy logic approach for opinion mining on large scale Twitter data* 2014 IEEE/ACM 7th International Conference on Utility and Cloud Computing, International Conference on Utility and Cloud Computing (2014)
19. Han Y., Zhao S., *Multi-scale clustering algorithm*, Comput. Sci., **43** (2016)
20. Homem T.P.D., Santos P.E., Costa A.H.R., Bianchi R.A.D.C., Mantaras R.L.D. *Qualitative case-based reasoning and learning Artif*. Intell., **283** (2020), Article 103258.1–103258.23
21. Aamodt and Plaza, 1994, A. Aamodt, E. Plaza, *Case-based reasoning: Foundational issues, methodological variations, and system approaches*, AI Communications, **7** (1) (1994)
22. Li C., Wang R. (2012) *The Research and Application of Case-Based Reasoning in Fixture Design.* In: Luo J. (eds) Soft Computing in Information Communication Technology. Advances in Intelligent and Soft Computing, vol **158**. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-29148-7_46
23. Y. Bengio, A. Courville, "Apprentissage en profondeur" , (2016) (Y. Bengio, 2016)
24. M. Nielsen, "Réseaux de neurones et apprentissage profond",(2015) (M. Nielsen, 2015)
25. A. Géron, « Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow », (2019) (A. Géron, 2019)
26. K. Suzuki, "Réseaux de neurones artificiels - Architectures et applications", (2018) (K. Suzuki, 2018)
27. Imrani, O.E.et al. , Impact of industrial free zones on the business environment of emerging countries , cta Logistica, 2023, 10(1), pp. 105–110
28. J.Yen and R.Langari, "Fuzzy Logic: Intelligence, Control, and Information", (2019)
29. T. Ross, "Fuzzy Logic with Engineering Applications", (2022)
30. H. Prade and A. Skowron, "An Introduction to Fuzzy Logic Applications in Intelligent Systems", (2016)
31. D.Toshniwaland V. P. Singh, "Fuzzy Logic in Environmental Sciences: Theory, Applications and Future Research Directions", (2018)
32. D. Wu and J. M. Mendel, "*Fuzzy Logic for Planning and Decision Making*",(2021)
33. M. Richter and R. O. Weber, "*Case-Based Reasoning: A Textbook*", (2016)
34. A. Aamodt and E. Plaza, "Case-Based Reasoning Research and Development",(2015)
35. J. L. Kolodner and D. H. Leake, "*Case-Based Reasoning: Experiences, Lessons, and Future Directions*",(2016)
36. S. Li and S. Liang"Case-Based Reasoning in Environmental Decision Making", (2015)

37. A. L. Rector and A. W. A. Boxwala, "*Case-Based Reasoning in the Health Sciences*",, (2021) (A. L. Rector and A. W. A. Boxwala, 2021)
38. Y. Shoham and K.Leyton-Brown, "*Multi-agent systems: A survey*", (2018)
39. M. Wooldridge, "An Introduction to MultiAgentSystems", (2019)
40. Y. Shoham and K. Leyton-Brown"*Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations*", (2021)
41. M. Wooldridge and N. Jennings, "Engineering Societies in the Agents World", (2017)
42. D. Weyns and T. Holvoet, "*Introducing Multiagent Systems*", (2022)
43. D. Jurafsky and J. H. Martin, "Speech and language processing (3rd ed.)", (2019)
44. C. D. Manning and D. Jurafsky, "*Foundations of statistical natural language processing*", (2018)
45. S. Bird, E. Klein andE. Loper, "*Natural language processing with Python: analyzing text with the natural language toolkit*", (2019)
46. F. Chollet, "Deep learning with Python",(2018)
47. Y. Goldberg, "Neural network methods for natural language processing (Vol. 1)", (2017)
48. C. DManning, "*Introduction to Linguistics and Natural Language Processing*", (2020)