Chapter 2: Industrial Ecology Globally and in Algeria

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2.1. Introduction

Industrial ecosystems, which emulate nature by using the waste of one company as raw materials for another, represent an appealing theoretical concept but remain mostly at the proposal stage. It is critical to emphasize that process changes to close material loops should not be confused with "end-of-pipe" waste treatments.

Industrial ecology has existed in an intuitive form for a long time. However, over the past 30 years, attempts in this area have largely remained on the fringes.

2.2. The Recent History of Industrial Ecology

The concept of industrial ecology has emerged intuitively for decades. In the past 30 years, most attempts in this area have remained marginal. The term first appeared in the early 1990s among industrial engineers associated with the National Academy of Engineering in the United States.

Many authors do not clearly distinguish between industrial metabolism and industrial ecology. However, this distinction is meaningful both methodologically and historically. The "industrial metabolism" analogy was common in the 1980s, especially in Robert Ayres' pioneering work in the U.S. and later at the International Institute for Applied Systems Analysis with William Stigliani and colleagues, and subsequently at INSEAD. Around the same time, Peter Baccini pursued the metabolic analogy independently. Historically, organic metaphors have long played a role in evolutionary economics.

2.3. Industrial Ecology: State of the Art

The concept of industrial ecology predates the term itself, which sporadically appeared in the 1970s literature. The term referred either to regional economic environments of industries or as a "green" slogan by industrial lobbies reacting to the establishment of the U.S. Environmental Protection Agency (EPA). However, the idea of industrial ecosystems appeared implicitly in the writings of systems ecologists like Odum and Hall.

For decades, systems ecologists studying biogeochemical cycles viewed industrial systems as subsystems of the biosphere. However, this perspective was not widely pursued except in agroecosystems. Modern industrial ecology acknowledges diverse industrial ecosystems, varying in their interactions with the biosphere—from near-natural agroecosystems to artificial environments like spacecraft.

The earliest mention of "industrial ecosystems" in the current sense in English literature appears in a 1977 article by geochemist Preston Cloud, dedicated to bioeconomist Nicholas Georgescu-Roegen. Georgescu-Roegen highlighted the thermodynamic perspective on material flows in human economies and technological dynamics.
Despite limited success, notable efforts to establish this field began in the 1980s, such as Charles Hall's teachings on industrial ecosystems at New York State University and Jacques Vigneron's work in Paris, which received minimal attention.

2.4. Industrial Ecosystems

By the mid-1970s, industrial ecology was in its infancy, inspired by the intellectual environment of the United Nations Environment Programme (UNEP). Robert Frosch, an early contributor, revived the concept, alongside similar developments in other circles like the United Nations Industrial Development Organization (UNIDO) and the UN Economic Commission for Europe (UNECE). Seminars like UNECE's 1976 event on "Waste-Free Technology and Production" prefigured modern clean production and industrial ecology literature.

Concepts like "ecologically balanced industrial complexes" from the early 1970s are precursors to eco-industrial parks and zero-emission clusters. However, similar ideas, especially in countries like the former USSR and East Germany, remain under-documented. In Moscow, for instance, an "industrial ecology department" has been active at the Mendeleev Institute of Chemical Technology for nearly two decades. East Germany also pursued resource optimization within its planned economy framework.

While industrial attempts to reduce waste and close material loops date back to the Industrial Revolution, industrial ecology encompasses more than waste reduction. It involves integrated resource management framed within scientific ecological principles.

2.5. Ecosystem Case Study: Belgium

In 1983, a Belgian group published *The Belgium Ecosystem: An Essay on Industrial Ecology*, focusing on analyzing Belgium's economy through material and energy flows rather than traditional monetary terms. This interdisciplinary team identified key industrial sectors (iron, glass, plastics, lead, wood, paper, and food) and highlighted the disconnection between stages in material flows.

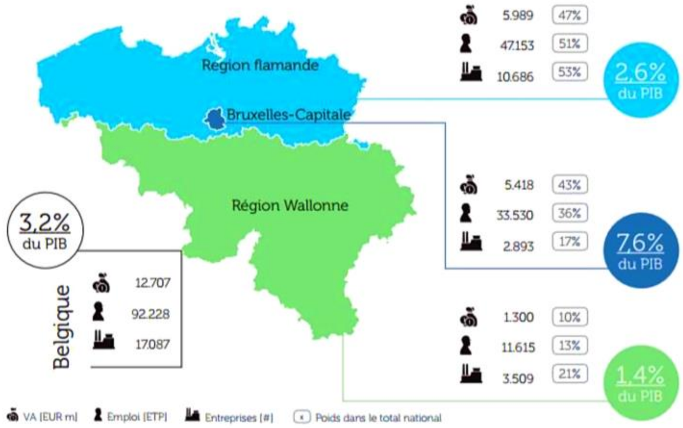

Figure 2.1: Digital sector in Belgium: overall summary by region (2013) (Source: Roland Berger Strategy Consultants)

For instance, 80% of Belgium's steel production is exported due to European market dynamics, disconnecting the steel industry from domestic metallurgical needs. Similarly, the modernization of agriculture separated farming from livestock activities, creating waste management issues as animal waste exceeded agricultural needs.

The group concluded that Belgium's economic internationalization led to three key dysfunctions:

1. **Material Cycle Disruption**: Open material cycles turned potential resources into problematic waste.
2. **Energy Consumption Patterns**: The industrial structure necessitated high energy expenditure, shaped by the organization of energy chains and industrial systems.
3. **Pollution**: Structural issues in material flows caused environmental degradation, such as water pollution from agricultural practices.

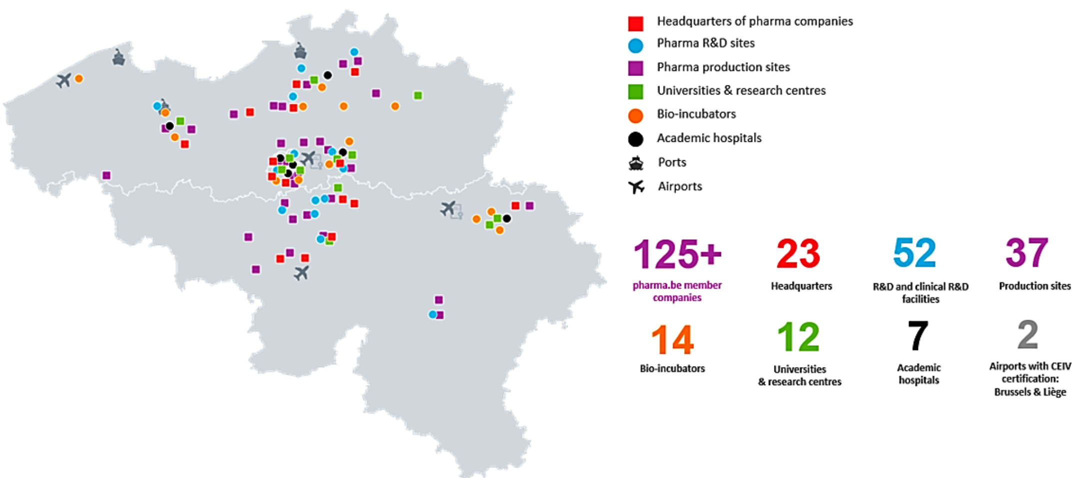

Figure 2.2: shows an example of an ecosystem in Belgium

The study highlighted that waste arises not just from increased production but also from systemic material circulation structures. Recycling challenges stem from production system constraints rather than collection or sorting issues. These findings later influenced ecological research, such as Gilles Billen's application of industrial ecology concepts to the Seine Basin in the late 1990s.

2.6. Ecosystem Experience in Japan

In the late 1960s, Japan's Ministry of International Trade and Industry (MITI), recognizing the significant environmental costs of industrialization, commissioned one of its independent advisory bodies to conduct a forward-looking analysis. About fifty experts from various fields (industry leaders, senior officials, consumer organization representatives, etc.) explored ways to shift the Japanese economy toward activities less reliant on material consumption and more focused on information and knowledge.

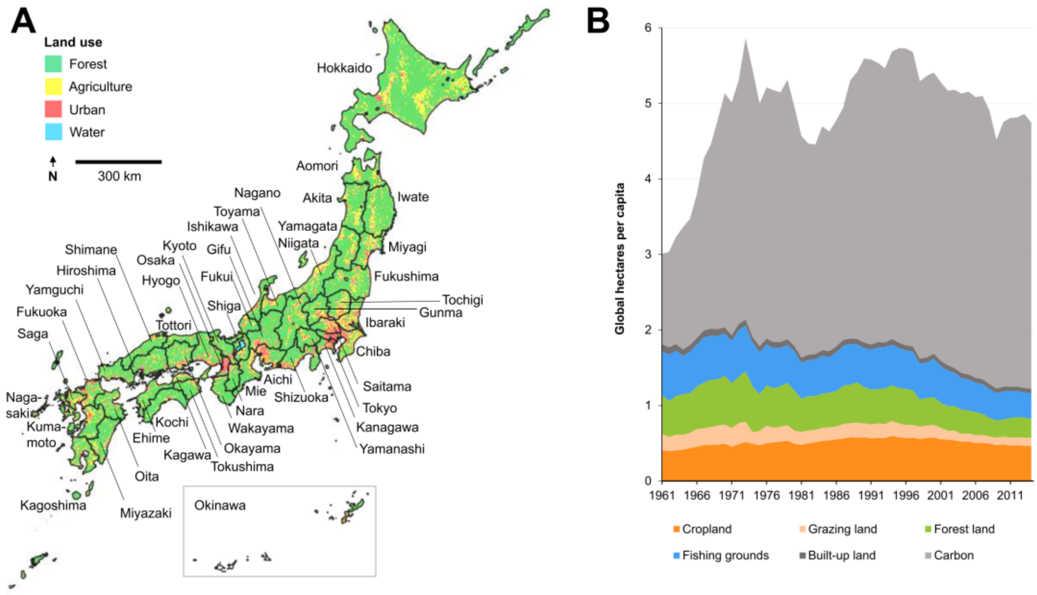

Figure 2.3: Land use, Japan's 47 prefectures, and ecological footprint

- **A)** Land-use map and prefectures (MLIT Japan 2014).
- **B)** Ecological footprint from 1961 to 2014 (Global Footprint Network 2018).

During a 1970 session of the Industrial Structure Council, the idea arose to consider economic activity within an "ecological context." The Council's final report, titled *A Vision for the 1970s*, was published in May 1971. In response, MITI immediately created about 15 working groups, one of which—the Industry-Ecology Working Group—was tasked with advancing the idea of reinterpreting the industrial system through the lens of scientific ecology.

The Industry-Ecology Working Group began by systematically reviewing scientific literature and consulting leading international experts.

In 1993, the *New Sunshine Program* was launched, focusing on advanced energy technologies with goals that included significantly reducing greenhouse gas emissions. The outcomes of these efforts are noteworthy. Japan aims to maintain its status as a major economic power through technologies developed under an economy fully incorporating ecological constraints. A core principle of this strategy is substituting material resources with technology, placing technological dynamism at the heart of Japan's approach to industrial ecology.

2.7. Industrial Ecology and Cleaner Production

Cleaner production is an environmental management approach aimed at promoting new processes, products, and services that are cleaner and more resource-efficient. It emphasizes a preventive approach, considering impacts across the entire lifecycle of products and services.

There are clear conceptual overlaps between industrial ecology and cleaner production. Both address concerns about the growing environmental impacts of industrial economic systems and emerged around the same time in the evolution of environmental management. Each has its own journals and literature, which reveal significant intellectual synergies. For example, the *Journal of Cleaner Production* (published by Elsevier Science) defines its scope as including:

- Pollution prevention,
- Source reduction,
- Industrial ecology,
- Lifecycle analysis,
- Waste minimization,
- Sustainable development.

Similarly, the *Journal of Industrial Ecology* focuses on industry's potential role in reducing environmental burdens across the product lifecycle, from raw material extraction to production, use, and waste management. Despite not explicitly using the term "cleaner production," its subject matter overlaps significantly.

Although these concepts share similarities, they emerged from slightly different contexts and reveal distinct nuances in their approaches, reflecting their historical sensitivities.

2.8. Ecosystem Experience in Algeria

2.8.1. Biodiversity and Ecosystem Services

Algeria boasts a rich biodiversity, with around 16,000 known species in total. Its marine biodiversity includes 3,183 known species across 720 genera and 655 families. Marine flora consists of an estimated 713 species, reaching up to 4,150 when considering coastal and island vegetation as well as marine birdlife.

However, Algerian biodiversity faces significant threats. The country has 121 species listed under CITES, including 75 endangered species. These include 23 fish species, 14 mammals, and 11 birds. Threatened plant species include the Tassili cypress (with only 200 remaining in the Tassili Biosphere Reserve), black pine, and thuja juniper. Among the most endangered animals are wild ungulates, the cheetah, monk seal, and Barbary macaque.

Marine ecosystems provide vital income sources, with many livelihoods relying on small-scale fishing and trade.

2.8.2. Main Pressures and Drivers of Biodiversity Change

Key threats include habitat destruction, overexploitation of biological resources, agricultural expansion, urbanization, pollution, tourism, and hunting. These pressures are exacerbated by climate change, leading to desertification and narrowing habitats, which could influence commercially important species such as sardines and anchovies.

2.8.3. Measures to Improve SPANB Implementation

Algeria developed a National Strategy and Action Plan for sustainable biodiversity use (SPAN) in 1997, reinforced by the 2002 National Action Plan for Environment and Sustainable Development (NAPE-SD). These initiatives prioritize habitat and ecosystem protection by expanding protected areas.

2.8.4. Measures Taken to Achieve the Aichi Biodiversity Targets 2020

Algeria has largely met the first global biodiversity target for 2010. A vast network of protected areas is in place, covering 36.5% of the national territory and representing most of the country's ecosystems. Additionally, 10% of ecological regions now benefit from genuine conservation and protection systems. Management plans for national parks have been developed and implemented. Over the next 20 years, no fewer than 25 new protected areas are planned for species and ecosystems critically endangered, along with 11 marine and coastal parks and 21 marine and coastal reserves.

Protected species in Algeria include 125 bird species, 56 mammal species, 46 reptile species, 144 insect species, and 550 plant species. National plans and action programs have been developed for certain species, such as the Mediterranean monk seal and red coral, and national legislation relating to CITES is underway to regulate the trade of vulnerable species. The Ministry of Land-Use Planning, Environment, and Cities (MATEV) developed a national integrated coastal management strategy in 2005, outlining management guidelines for the sustainable use of marine and coastal resources.

Several monitoring programs have been established to observe, prevent, and mitigate the impacts of marine water pollution on biodiversity. Specific programs have also been conducted on inland waters, arid and semi-humid zones, forests, and mountains. Lastly, extensive reforestation programs have been launched, targeting a reforestation rate of 18% over the next 20 years. A national biosafety framework has been implemented to protect agricultural systems, human health, and traditional knowledge from the potentially harmful effects of GMOs.

2.8.5. Support Mechanisms for National Implementation

A law on protected areas was adopted in 2011 within the framework of sustainable development. This law aims to protect representative samples of Algeria's biodiversity, from terrestrial to marine biodiversity, including fragile or rare zones and habitats of endangered or vulnerable species.

In February 2011, Algeria also became a signatory to the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization, adopted at the tenth meeting of the Convention. Algeria has also established a legal framework setting the conditions for access, movement, transfer, and valorization of biological resources. Within this framework, in addition to the sovereign rights of the state over the biological resources of its territory, biological resources and associated knowledge are considered intellectual property rights granted to the concerned populations, households, and individuals.

Various sectoral programs contain specific measures for the conservation of biological diversity. In agriculture, a national integrated agricultural and rural development plan was developed, along with the Sustainable Development Strategy in 2004. Furthermore, 5,578 integrated rural development projects were developed, of which 1,110 have already been implemented. Many of these focus on protecting agricultural plants and local livestock diversity. In urban planning, the National Land-Use Planning Scheme (Schéma National d'Aménagement du Territoire - SNAT 2030), approved in June 2010, emphasizes integrating ecological concerns into territorial planning.

The Ministry of Agriculture and Rural Development (MADR) incorporates environmental protection and the conservation and enhancement of local biodiversity into its collaborations with rural communities as part of integrated development projects. Biodiversity conservation is also a key axis of the Rural Employment Program (PER) implemented in seven mountain provinces. Finally, global objectives have been integrated into the Water Master Plan, the Tourism Organization Plan, and the Guidelines for Industrial and Commercial Activity Zones.

Between 2000 and 2002, capacity-building efforts were ensured through the establishment of several institutions by MATEV to strengthen environmental governance and biodiversity conservation. These institutions include the National Conservatory of Environmental Training (CNFE), the National Observatory of Environment and Sustainable Development (ONEDD), the National Center for the Development of Biological Resources (CNDRB), the National Coastal Commission, and the National Climate Change Agency.

2.8.6. Monitoring and Review Mechanisms for Implementation

An example of a monitoring tool to evaluate biodiversity conservation progress is the list of protected species developed by MATEV, which currently includes 125 bird species, 56 mammal species, 46 reptile species, 144 insect species, and 550 plant species.

2.9. Industrial Ecology: Governance, Laws, and Regulations

Industrial ecology primarily deals with environmental sciences, technology, and technological systems, but these do not exist in isolation. Therefore, industrial ecologists must be familiar not only with the techniques and principles of the field but also with the cultural and legal context in which they operate. These dimensions are generally tied to economic and other political issues. Together, they are integrated into general policies, practices, laws, and regulations that vary significantly across jurisdictions.

In many fields, discussions about laws and regulations are straightforward, even if detailed. However, industrial ecology presents a more formidable analytical challenge for two main reasons.

First, it represents the evolution of environmental policy from a general to a strategic priority for society and businesses. As overhead, the environment was essentially an afterthought, addressed only after the main activity—whether producing gadgets in business or conducting national security policy as a nation-state—was already completed. For example, installing scrubbers in a manufacturing plant is a general approach; indeed, such environmental expenses appear in corporate accounting systems under overhead costs (Todd, 1994).

However, designing a personal computer to be cost-effective in a jurisdiction requiring product "take-back" is a strategic function. In the United States, for example, systematically assigning all "environmental" issues to the Environmental Protection Agency, regardless of the underlying governmental function involved, indicates these issues were considered overhead.

However, this is changing, as illustrated by ongoing (and often conflicting) dialogues between the environmental community and other political structures, such as trade or national security. This period of difficult adjustment is expected as political communities that were previously separate—such as the environmental community and the national security community—attempt to work together to achieve integrated approaches.

Additionally, it is now clear that the most pressing environmental disruptions, such as global climate change, biodiversity loss, and the degradation of oceanic and water resources, are transboundary in nature. They neither reflect nor respect human jurisdictional boundaries. This makes industrial ecology, which addresses the relationships between these systems and related human systems, particularly sensitive to jurisdictional effects and prevailing global governance structures.

The current international political structure, dominated by state sovereignty for hundreds of years, is undergoing significant transformation. This dynamic is crucial for industrial ecology. Indeed, the contours of a more complex, emerging international governance system are becoming evident, and it is vital for industrial ecologists to adapt to this evolution.

2.10. Conclusion

The legal context in which industrial ecologists operate is complex and varies by jurisdiction. Moreover, once it is recognized that the environment is becoming increasingly strategic rather than peripheral for businesses and society as a whole, it follows that the traditional discipline of environmental law is becoming less critical for the practice of industrial ecology. Instead, industrial ecologists must broadly familiarize themselves with legal structures and issues affecting development, trade, economic and technological policy, and navigate an evolving and unclear global governance system.