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Companies are increasingly using environmental management information systems (EMISs) to systematically gather, process and make available information on their environmental impact. However, the strategic and environmental impact of an EMIS mostly remains limited. Based on a case study of a shadow EMIS implemented by a major German chemical products company that produced planned and unexpected benefits, we provide recommendations for IS leaders on how to design and implement an EMIS that promotes eco-sustainability and provides business value.[1,2]

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Turning Sustainability Obligations into Strategic Opportunities

Improving the eco-sustainability of corporate practices is on the agenda of most companies. A study involving more than 1,000 global executives found that 99% of the respondents agree that "sustainability issues are important to the future success of their businesses."[3] Climate change, environmental degradation and the finiteness of natural resources are forcing company leaders to adopt organizational strategies, business models and practices that will enable them to thrive in carbon-neutral and renewable economies. Adapting to these challenges requires that decision makers have access to relevant information on their companies' environmental

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3 See: 1) Lacey, P. "UNGC: Accenture Strategy CEO Study on Sustainability," Accenture, September 2019, available at https://www.accenture.com/us-en/insights/strategy/ungcceostudy; and 2) Winston, A. "What 1,000 CEOs Really Think About Climate Change and Inequality," *Harvard Business Review*, September 2019, available at https://hbr.org/2019/09/what-1000-ceos-really-think-about-climate-change-and-inequality.

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effects. This is where many companies' good intentions to increase their eco-sustainability falter, because acquiring detailed information on corporate supply chains' eco-sustainable impact is difficult and costly.[4] As a consequence, only 41% of corporate executives[5] are actually taking action to decarbonize their supply chains.

The increasing complexity of supply chains makes it difficult to achieve transparency on the environmental impact of raw materials and supplies that companies use. Nevertheless, transparency is a crucial first step toward making environmentally sound decisions. However, many decision makers— not to mention their customers—simply do not have detailed and comprehensive information about the environmental effects of their companies' products. The information on products' eco-sustainability impact is not available to them or it is dispersed in ways that limit coherent access. It is either distributed in the minds of various employees or is siloed in information systems used by different corporate functions, business units, subsidiaries or companies.[6] Because of limited knowledge and information sharing, corporate decision makers often do not have a unified view of their products' eco-sustainability to inform their decisions. Thus, improving corporate eco-sustainability is essentially an information challenge[7] that requires the information systems (IS) department "to assist individuals and organizations to make better—that is, more environmentally sustainable—decisions and to facilitate environmentally sustainable (rather than environmentally unsustainable) work practices."[8]

In this article, we describe a bottom-up initiative—a shadow information system developed outside corporate IS guidelines and routines[9]—that established a unified view of raw materials' and products' environmental effects through crowdsourcing information. This environmental management information system (EMIS)[10] was accessible to all employees of ChemCo, one of Germany's largest producers of chemical products, which wishes to remain anonymous, and quickly gained popularity and broad support. Our case study offers meaningful lessons and advice for IS leaders who aim to implement EMISs that go beyond fulfilling eco-sustainability obligations (e.g., for reporting or ensuring compliance), but are effectively used by employees and help companies to institutionalize eco-sustainable practices and gain differential strategic value.[11]

Although many companies are using EMISs, these systems mostly have a limited impact on business performance.[12] The ChemCo case study provides valuable insights into how to design and implement an EMIS that promotes cross-functional action and thus creates strategic and environmental benefits. Although ChemCo's shadow EMIS was initially intended to improve transparency and decision-making on eco-sustainability, we show how its use was extended to communicate and collaborate with external stakeholders on sustainability goals included

4 For insights on closing the loop on sustainability information, see *PwC Technology Forecast* (4: Building Sustainable Companies), 2011, available at https://www.pwc.com/gr/en/publications/assets/technology-forecast-issue4-2011.pdf.

5 Lacey, P., op. cit., September 2019.

6 For a good primer on the transformative power of information systems to create ecologically sustainable societies, see Watson, R. T., Boudreau, M. C. and Chen, A. J. "Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community," *MIS Quarterly* (34:1), March 2010, pp. 23-38.

7 DeGarmo, T., Parker, B., Scott, R., Nieland, K. and Delaye, N., op. cit., 2011.

8 For an empirical study on the antecedents and benefits of Green IT and IS initiatives, see Loeser, F., Recker, J., v. Brocke, J., Molla, A. and Zarnekow, R. "How IT Executives Create Organizational Benefits by Translating Environmental Strategies into Green IS Initiatives," *Information Systems Journal* (27:4), January 2017, p. 506.

9 For information on the management and effects of Shadow IS, see: 1) Fürstenau, D., Rothe, H. and Sandner, M. "Shadow Systems, Risk, and Shifting Power Relations in Organizations," *Communications of the Association for Information Systems* (41), August 2017, pp. 43-61; and 2) Györy, A., Cleven, A., Uebernickel, F. and Brenner, W. "Exploring the Shadows: IT Governance Approaches to User-Driven Innovation," *Proceedings of the 20th European Conference on Information Systems*, June 2012, available at https://aisel.aisnet.org/ecis2012/222/.

10 For a conceptual overview of EMISs, see: El-Gayar, O. and Fritz, B. "Environmental Management Information Systems (EMIS) for Sustainable Development: A Conceptual Overview," *Communications of the Association for Information Systems* (17), May 2006, pp. 756-784.

11 For an analysis of sustainability performance and its impact on financial performance indicators, see, for example, Ameer, R. and Othman, R. "Sustainability Practices and Corporate Financial Performance: A Study Based on the Top Global Corporations," *Journal of Business Ethics* (108:1), June 2012, pp. 61-79.

12 For more information on how combining human, supply chain and IT resources enable organizations to develop sustainability capabilities, see: Dao, V., Langella, I. and Carbo, J. "From Green to Sustainability: Information Technology and an Integrated Sustainability Framework," *The Journal of Strategic Information Systems* (20:1), March 2011, pp. 63-79.

in the United Nations' sustainable development goals.

Our findings are based on an in-depth case study of ChemCo for which we conducted 36 semistructured interviews with ChemCo employees, competitors and industry experts. We also analyzed secondary material relating to ChemCo and the industry covering a time span of 13 years. Our research methodology is described in the Appendix.

Origins of ChemCo's Journey Toward Organizational Sustainability

ChemCo is a globally operating company in the chemical industry, which specializes in flavors and fragrances, employs over 10,000 people and generates about $4 billion in revenue annually. Its customers are B2B clients that use ChemCo's ingredients in foods and consumer products such as cosmetics and perfumes. ChemCo's journey toward organizational sustainability was triggered in 2005-2006. At that time, the company had less than half the number of employees it has now and generated only about a third of its current revenue.

Back then, companies in the chemical industry were not known for emphasizing eco-sustainability; rather, they merely did what regulators demanded. However, in ChemCo's specialized markets, where its products are used in consumer goods such as food, beverages, cosmetics and personal care, consumer expectations and demand for sustainable products were beginning to grow. Consumers' awareness of eco-sustainability was growing more strongly than on average in the chemical industry:

> *"We're part of the food industry and sustainability resonates with food, I think, because people eat this stuff. They put it inside their bodies. They're concerned about what they're eating, whether it's safe, ... whether or not it's been grown in a way that actually will harm individuals. So, they certainly don't want any impression that children were involved in growing a particular food or that slave labor had been used, or that the environment had been damaged. ... There is a greater emotional attachment with food and that's why I believe that sustainability can sell when it comes to food and fragrances."* (Interviewee 13, ChemCo)

ChemCo's major B2B customers began demanding verified sustainably developed and organically grown products. This was a challenge for ChemCo because it lacked reliable information on its products' eco-sustainability. Most strikingly, ChemCo's main customer—a leading multinational consumer goods manufacturer—threatened to stop purchasing from ChemCo unless it could provide verified organic and sustainable products. This caught ChemCo's management off guard. Although it did not object per se, until then, sustainability had not been a big concern to ChemCo. Suddenly, it was pivotal.

ChemCo's initial response was to begin sourcing eco-sustainable vanilla—a main ingredient in the major customer's products. While this might sound like a rather easy task now, in 2006 almost all vanilla was produced in developing countries using precarious working conditions and was associated with a reprehensible environmental impact. ChemCo managers soon realized that purchasing sufficient quantities of vanilla produced at guaranteed high ecological standards was virtually impossible. Thus, they decided to integrate vanilla production in ChemCo's value chain by working closely with local producers. By taking this unprecedented step in 2009, ChemCo became the first corporation in its industry to offer products originating from fair-trade certified and eco-sustainable vanilla.

This move enabled ChemCo to meet its key customer's demand, but none of the managers expected the economic success that followed. Multiple other B2B customers began purchasing the sustainable vanilla extracts, turning it into one of the most successful and most profitable products in ChemCo's product portfolio. Thus, vanilla became the lighthouse project for effectively integrating sustainability and corporate performance.

The success of eco-sustainable vanilla raised ChemCo management's awareness that sustainability could be strategically important and extraordinarily profitable. At that time,

however, ChemCo only selectively sourced its raw materials sustainably, despite having a product portfolio that relied on more than 1,200 chemicals and incorporated over 20,000 products. Making management decisions about sustainable sourcing was especially challenging, not only because of the large product portfolio but also because of the high degree of specialization and adaption needed to meet customer demands. Almost none of the resources purchased by ChemCo were assessed for their eco-sustainability. The fragmented value chain often relied on small and changing suppliers from developing countries for scarce materials. Combined with opaque purchasing structures, this made sustainability exceptionally challenging at ChemCo.

Moreover, information on sustainability was not readily available to managers or the R&D departments that developed synthetic alternatives for critical products. Thus, ChemCo had scant knowledge of its products' eco-sustainability impact, which made it almost impossible to provide B2B clients with extensive and truthful information about products' eco-sustainability. While ChemCo recognized the importance of sustainability and the strategic prospects for sustainable products, identifying distinct and effective opportunities for sustainability seemed largely beyond management's control.

Brief History of the Evolution of the Shadow EMIS

The lack of industry-wide action on eco-sustainability and ChemCo customers' increasing demand for sustainable products encouraged a ChemCo employee, who was not part of the IS department (he was employed as a manager in ChemCo's supply chain management), to act. He sensed that the established industry logic needed to change, as awareness of eco-sustainability and people's wishes to consume natural and sustainable products, were increasing. He was personally pro-environmentally minded and wanted to make a meaningful contribution to preserve the natural environment at ChemCo's production sites and at places where the company sourced its raw materials.

His motivation and commitment to do something good for the company and the environment encouraged him to start developing an information system during his leisure time. Although he was tech-savvy, he was not an IT professional with formal education and training. He created a spreadsheet-based EMIS for one division of ChemCo that, in his view, addressed the core problems of ChemCo's sustainability efforts.

From frequent exchanges with his co-workers, he learned that essential information on the eco-sustainability effects of raw materials and final products is not equally distributed among employees in different departments. For example, sales managers did not have the information they needed to answer questions their customers had about products' environmental footprints. R&D employees, in trying to develop more eco-sustainable compositions for final products, did not consider the environmental impact of raw materials. Production engineers lacked information on products' life cycle effects on eco-sustainability. Purchasing managers were not aware of the multifaceted consequences their sourcing decisions had on the livelihoods of local communities. Thus, the EMIS creator recognized that to improve ChemCo's eco-sustainability and to satisfy increasing market demand for more eco-sustainable products, it was crucial to address the issue of missing information about the environmental impact of raw materials that the company purchased, processed and eventually sold as products.

The EMIS therefore started as a bottom-up initiative outside of the traditional routines of the corporate IS department. ChemCo had an ERP system that included standard data (e.g., price, quantity, chemical composition) for raw materials but lacked information on their environmental impact. Because of a high degree of IT outsourcing, the internal IS department did not have many in-house resources, and any additional change requests needed to be lengthily negotiated with the outsourcing provider. To avoid the tedious process of getting budget approval, the EMIS creator set about addressing the unsatisfied need himself. Thus, in 2013, he began developing the EMIS for one division by collecting sustainability information.

He was convinced about the value of the system he was developing and was keen to make it as useful and popular as possible. He realized that the system's usefulness depended heavily on information being readily available and reliable. First, he started to gather information about the most important raw materials and, in 2014, when the sustainability information was readily at hand, he confirmed, revised and expanded it with the help of interested co-workers. Once he felt that the EMIS contained enough reliable information, he began to make it available to a selected group of co-workers in diverse functional areas whom he thought would be interested in his solution. To accelerate adoption, in late 2014 and early 2015, he promoted his EMIS as a "sustainability scorecard" at formal and informal company meetings whenever possible. He listened closely to co-workers' feedback and continuously updated and improved the EMIS on the basis of this feedback. He also encouraged crowdsourcing of sustainability information by asking co-workers to check, refine and add information.

As the EMIS continued to grow in usefulness and popularity, ChemCo employees routinely used it for their work. For instance, the EMIS was used by:

- R&D employees to compare the eco-sustainable impact of different product compositions
- Purchasing agents to investigate alternative sourcing options
- Supply chain management employees to identify scarce or problematic input materials
- Production staff for life cycle assessments
- Marketing and sales employees to inform clients about products' eco-sustainability.

Because the EMIS had a demonstrated proof of concept, several departments began to actively support its development by providing personnel and financial resources and contributing feedback about raw materials and products. The information stored in the EMIS was continuously extended to include, for example, new sustainability impact indicators based on the United Nations' sustainable development goals, which were then examined by an external auditor to increase the validity and reliability of the information.

> *"We needed a tool [the EMIS] like this one. A lot of colleagues were looking for information about sustainability but did not know where and how to find it. This information is now available due to the implementation of the EMIS."* (Interviewee 9, ChemCo)

As the shadow EMIS eventually appeared on the radar of top business and IS management, ChemCo decided to professionally redeploy and maintain the EMIS and to integrate it into the corporate IS architecture. In 2015, management sanctioned a project to further develop the EMIS as an integrated component of ChemCo's company-wide ERP system. External IT providers supported the integration and rolled out the EMIS throughout the whole company, making sustainability information readily available. The information was subsequently expanded, allowing an ever-increasing number of products and materials to be assessed for eco-sustainability. Although the original shadow EMIS was eventually completely reworked, important features and properties that were crucial for its success were retained. Since 2016, corporate sustainability reports have frequently mentioned the EMIS as a central tool in ChemCo's eco-sustainability endeavors.

Core Features of the Shadow EMIS

In line with his goals to increase co-workers' awareness, knowledge exchange and accumulation and, eventually, ChemCo's eco-sustainability and business success, the creator of the shadow EMIS emphasized five features of the system (monitoring, analysis, visualization, information access and interaction). From a technical point of view, these were standard features, but they satisfied hitherto unfulfilled needs of employees working in different functional areas and, taken together, triggered ChemCo's sustainability transformation.

Monitoring

The shadow EMIS enabled ChemCo's employees to monitor data on the ten environmental impacts of input materials

13 Measuring units are given where applicable

Table 1: Environmental Impact Indicators and Measurement

Environmental Impact Indicator	Measurement Information [13]
Toxicity	Measure of the toxicological risk involved for living organisms, tissues or cells that can arise from handling hazardous substances.
Eco-Toxicity	Measure of the toxicological risk involved for aquatic, sediment and terrestrial organisms (e.g., urban air, agricultural soil, freshwater) that can arise from handling hazardous substances.
Scrap (e-factor)	Measure of the mass of waste per mass of product [kg waste/kg reactants].
Water Intensity	Measure of how much water is used in sourcing and production [m^3/ltr].
Biodiversity	Measure of the ethical impact sourcing has on the habitat, its population and species, considering habitat features such as size, ecological condition and location.
Land Use	Measure of the manufacturing method—the impact that changes have on the natural area of land used for manufacturing, e.g., on soil properties and microbial communities [hectare/ton].
Renewability	Measure of the mass of renewable material in total materials used (raw materials, associated process materials, materials for packaging, etc.) per unit produced [%].
Traceability	Measure of supplier information—the ability to associate materials with the impact of their provenance, sourcing and journey and the accuracy of such information.
Biodegradability	Measure of a product's percentage degradation at a time *t*.
CO_2 Emissions	Measure of the carbon dioxide emissions in sourcing, production and transport [kg CO_2/kg product].

set out in the United Nation's sustainable development goals—traceability, land use, water intensity, biodiversity, toxicity, eco-toxicity, CO_2 emissions, scrap (e-factor), renewability and biodegradability (see Table 1 for measurement information). By 2016, the EMIS covered 1,200 raw materials, and thus enabled the detailed measurement of the environmental effects of 85% of ChemCo's production output.

> *"Based on the United Nations' sustainable development goals, we developed these indicators to measure the eco-sustainability of our products. As we try to cover eco-sustainability extensively, we included the whole supply chain, including all sourcing processes, in our analyses."* (Interviewee 8, ChemCo)

Analysis

The shadow EMIS provided advanced analysis features for different user groups. Any substance, product or eco-sustainability characteristic of interest could be selected and analyzed independently. Users could analyze the sustainability of almost any product and compare it with the characteristic of interest. For instance, ChemCo's employees often used the EMIS to compare the environmental impact of naturally produced substances with an equivalent synthetic product. Formulas provided by R&D employees linked to the environmental impact of input materials in the EMIS system allowed users to calculate the eco-sustainability of input materials and products. For example, R&D employees interested in the carbon emissions of an individual substance could analyze the entire

Figure 1: EMIS Eco-Sustainability Analysis of Natural vs. Synthetic Products

Criteria	Natural Product (ex India)	% *	Synthetic Product by ChemCo	% *
Toxicity	▪ *GHS classification*	66.7	▪ *Some critical raw materials are used during synthesis*	72.5
Eco-Toxicity	▪ *Preventive measures for pomace and human health not always given*	75.0	▪ *Processes are closed and highly automated*	94.0
Scrap (e-factor)/ Biodegradability	▪ *Waste from production will spread to fields (Substance oil is toxic for aquatic life with long term effects)*	100.0	▪ *All waste will be treated (e.g. incineration)*	100.0
Water Intensity	▪ *Cultivation is water-intensive (100m³/ltr. substance crude oil)* ▪ *Groundwater is used for irrigation*	0.0	▪ *Not relevant because water is always available in Germany (1.5m³/ton substance in ltr.)*	100.0
Waste Water	▪ *Wastewater from distillation plants will spread back to fields (containing residues from distillation, e.g. herbicides)*	0.0	▪ *Will be treated by clarification plant*	90.3
Biodiversity	▪ *India has two biodiversity hotspots (Western Ghats + Eastern Himalayas)* ▪ *Deforestation for agricultural land (+40% in 25 years)* ▪ *Herbicides and pesticides are used for cultivation*	0.0	▪ *Not relevant*	100.0
Land Use	▪ *~6.25 ha/ton substance*	25.0	▪ *~0.00025 ha/ton substance*	100.0
Renewability	▪ *100% renewable*	100.0	▪ *CO_2 renewable*	0.0
Traceability	▪ *No traceability to field given.* ▪ *Distilleries work with oil from several farmers and middlemen*	0.0	▪ *Traceability back to m-Cresol*	100.0
CO_2 emissions	▪ *~87 kg CO_2/kg product*	0.0	▪ *~6.5 kg CO_2/kg Product*	34.7
Eco-sustainability Score **		36.7		79.2

** Percentage scale ranging from 0 % (worst) to 100 % (best).*
*** Calculated as unweighted mean of the eco-sustainability criteria.*

supply chain at the level of individual molecules. Thus, the EMIS made it possible to determine which substances have a particularly large impact on eco-sustainability or to compare the eco-sustainability of the same substance produced naturally or synthetically (Figure 1 shows the results of such a comparison).

Visualization

The shadow EMIS provided visual representations of products' or substances' eco-sustainability (see Figure 2, which shows the environmental impact analysis of a) comparative products and b) a single product). Users often generated these radar charts to visually display the multivariate data as a two-dimensional chart of the ten eco-sustainability indicators.

The EMIS also provided additional visualization techniques (e.g., tables, diagrams) to support users in understanding different substances' complex effects and interactions.

> *"The tool [the EMIS] provides you with a great overview. You can see the available data for the product displayed as a ratio, the eco-sustainability index displayed in a table, and a spider diagram can exactly show how well the product performs in relation to each eco-sustainable category."* (Interviewee 8, ChemCo)

Information Access

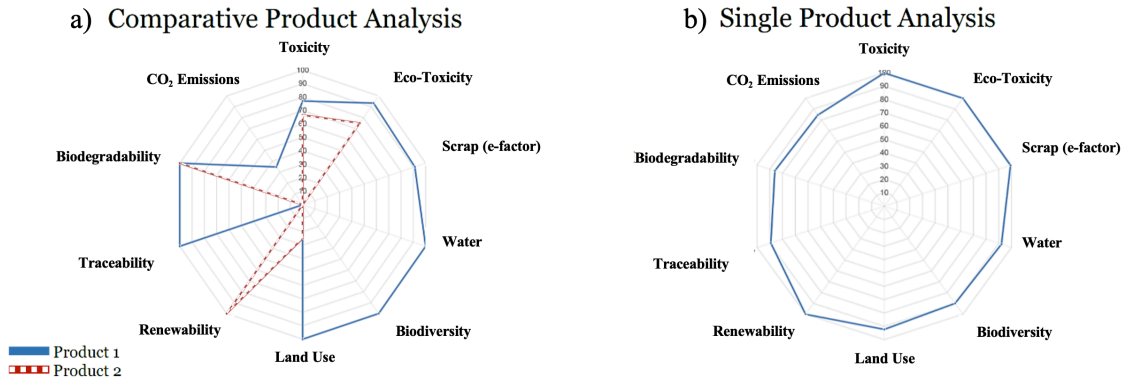
The shadow EMIS provided all ChemCo employees with access to eco-sustainability information regardless of their position in the corporate hierarchy, their function, unit or country. Hence, all employees had equal access to the sustainability information contained in the EMIS. As a consequence, barriers for employees to use and contribute to the EMIS were low: "The information provided is accessible to everyone in the company and especially relevant for our personnel in sales, research and development, and production." (Interviewee 11, ChemCo)

Because the shadow EMIS was built using standard spreadsheet software, users did not have to be specially trained to use it—an average IT literacy level was sufficient to use the EMIS effectively.

Interaction

The EMIS creator emphasized the interaction features provided by the system. In his experience, employees within and across functions did not communicate enough and needed to share more insights on the eco-sustainability of ChemCo's products. The corporate information systems did not particularly support interaction between ChemCo's employees. To overcome this constraint, later versions of the EMIS allowed users to directly annotate and comment on

Figure 2: EMIS Visualization of Products' Eco-Sustainability



information in the system[14] or share analyses with others via email or internal communication platforms such as the intranet.

Unique Properties of the EMIS that Spurred Firm-Wide Adoption and Use

Below, we describe the three unique properties we identified that encouraged ChemCo's employees to adopt and integrate the EMIS in their work routines: 1) simplicity and standardization, 2) accessibility and openness, and 3) versatility and flexibility.

Simplicity and Standardization

The EMIS creator made a virtue out of focusing on the bare necessities. Because he had no budget, and no formal education or experience in software development, he had to keep the EMIS simple. In practice, however, the simplicity of the EMIS was a strength because most employees could use it easily through a standard user interface and without additional training. The minimalist design of the user interface and the simplicity of the user experience design made interacting with the EMIS straightforward. Nothing distracted users from the EMIS's primary purpose of providing them with detailed and hitherto unavailable eco-sustainability information. The core functionalities demonstrated the solution's business and environmental value to employees.

No additional costs were incurred in creating the baseline version of the EMIS because it used standard software and ran on ChemCo's standard IT infrastructure, which meant that all employees could use the system without any additional costs to the company. They could access the EMIS without restriction and without additional costs for training, infrastructure or software. The low entry barriers and the clear-cut focus on core features proved to be an important enabler and accelerator of user adoption.

Accessibility and Openness

In developing the EMIS, the creator sought to incorporate knowledge otherwise held in silos within individual functions, departments or subsidiaries across the globe. From the start, he emphasized that the EMIS should be accessible to all employees and allow all users to comment, tag, share and discuss the information. He promoted the EMIS to co-workers whenever possible and encouraged crowdsourcing of sustainability information by asking co-workers to check, refine and add information. All employees had equal rights for editing and commenting on information, contributions that, in the early stages of development, were collected and incorporated by the EMIS creator into his master file—the single version of truth. The EMIS creator frequently updated and uploaded his master file but, at the beginning, only he could change the master data because a software-as-a-

14 This was made possible when ChemCo switched to a software-as-a-service spreadsheet solution in 2014, as described in the next section.

service (SaaS) solution was not available at that time. Thus, before ChemCo switched to a SaaS spreadsheet solution in 2014, if users wanted to change or comment on information in the EMIS and send it back to the creator, they had to download the most current version of the EMIS and store a local copy. However, employees rarely did this and instead used email, telephone or intranet forums to provide feedback.

Making the EMIS accessible to all employees meant that the creator could tap into various, sometimes previously unknown knowledge sources across all ChemCo's global locations, mostly from departments such as R&D, sales, production and procurement. Given the complexity of ChemCo's input materials and operations, the EMIS's open access and crowdsourcing approach ensured that information on the environmental impact of raw materials and end products flowed seamlessly across the organization, and that it was constantly updated and refined. An important byproduct of the open access approach was the emergence of a grassroots spirit of empowerment and participation that helped the EMIS grow in scope, scale and popularity.

Versatility and Flexibility

From his frequent interactions with co-workers, the EMIS creator learned that many decision makers at ChemCo, across functions and hierarchical levels, lacked unified and essential information about the environmental impact of the company's raw materials and products. Either the information was not available to them or it was scattered throughout the organization in the minds of employees or in different information systems used by single departments or subsidiaries. He therefore designed the EMIS to serve all stakeholders within the organization and encourage their participation in further developing and promoting the system.

Moreover, because the EMIS creator was keen to accommodate the interests of as many employees across as many departments as possible, he was open to change requests and recommendations from employees working in different application domains and departments. He listened carefully to co-workers' feedback and built the EMIS in a way that allowed him to transfer the information back and update and improve the system.

Overall, the EMIS's versatility and flexibility ensured that increasing numbers of employees with a wide range of professional backgrounds found the EMIS useful and contributed to improving and extending it. When the shadow EMIS was professionally redeveloped, ChemCo insisted that it maintained the versatility and flexibility needed to avoid fragmentation of the common knowledge base, to support various organizational stakeholders' evolving needs and to develop applications related to eco-sustainable decision-making.

Leveraging the EMIS to Increase ChemCo's Eco-Sustainability

The way that employees used the EMIS triggered a shift in ChemCo's operations and eco-sustainability strategy. As now described, employees leveraged the EMIS's features and properties to improve awareness of eco-sustainability, for knowledge sharing, to question established beliefs and practices, and to develop sustainable practices. The EMIS features also supported the development of strategies consistent with sustainability.

Creating Awareness and Participation

Process industries such as the chemical industry use and produce a wide range of raw materials and end products. The EMIS creator knew that the specialized knowledge of the environmental impacts of myriad, often rare and specialized raw materials meant that he had to rely on the broad support of ChemCo's employees to gather eco-sustainability information. Thus, with the help of co-workers he knew to be knowledgeable and eco-sustainably minded, he started crowdsourcing information on materials and products. This group became key EMIS advocates who promoted the system in their intrafirm networks whenever possible. By making the EMIS accessible to all employees and open to their contributions, the system's user base grew, and with it, the validity of information. Users frequently shared EMIS-enabled analyses with their co-workers, which increased firm-wide awareness and participation, especially among those who had previously not been especially interested in eco-sustainability topics.

Sharing Knowledge across Departments and Partners

Once the SaaS spreadsheet solution became available in 2014, the creator modified the EMIS so users could access, refine and unrestrictedly comment on information about the eco-sustainability of different substances and products. This was an important development because ChemCo's organizational structure comprised silos characterized by limited intersilo communication and limited sharing of knowledge and information. Thus, to prevent the EMIS from becoming yet another silo, the creator designed the system to be useful for almost any organizational role and department. He understood that the EMIS's strength depended on tapping into different knowledge sources dispersed across ChemCo's organization. The system's versatility and accessibility, together with low entry barriers for using it, attracted a broad and diverse user base that generated cross-departmental value. In particular, the EMIS enabled company-wide knowledge exchange, whereas knowledge on the various raw materials was previously dispersed globally among organizational entities and individuals. The EMIS helped employees to understand, interpret and frame the complex and multifaceted kinds of information about the eco-sustainability impacts of input materials and products.

ChemCo's customers and suppliers also showed great interest in the EMIS. Salespeople and purchasing agents responded by selectively granting well-known and long-term partners access to the information accumulated in the EMIS by showing them relevant excerpts, for example in the form of PDF files or printouts: "Our customers started to ask for eco-sustainability measures as a selection criterion for our products. When we presented the output of the system and highlighted eco-sustainability aspects, our customers were willing to pay even more." (Interviewee 4, ChemCo)

Based on the feedback and discussions with external partners, ChemCo further refined the EMIS. Sharing and discussing EMIS sustainability information with partners resulted in customers and suppliers changing their decision-making processes, because they had increased awareness and knowledge of sustainability issues within ChemCo and its business ecosystem. Thus, the EMIS was a catalyst for intra- and interorganizational knowledge sharing.

Reflecting on Established Beliefs and Practices

Employees used the EMIS to reflect on and question established beliefs and practices and to test new ideas for less environmentally harmful substances and products. Using the EMIS, they could access, evaluate and visualize related information quickly and easily. Often, employees used the EMIS to compare different raw materials for final products. This was especially useful in new product development: "Employees in product development use the EMIS actively. … They already prefer sustainable raw materials and formulas based on the insights of the system" (Interviewee 4, ChemCo).

Furthermore, the EMIS allowed employees to analyze ChemCo's product portfolio to identify products with a large negative environmental impact. They used the EMIS discussion features to share their findings with colleagues. The results were regularly discussed with internal and external co-workers and with experts to increase the sustainability of existing products, reduce waste, streamline processes or experiment with more sustainable product innovations. For instance, through using the EMIS, R&D employees discovered that a substance thought to be environmentally friendly was not:

> *"We found out that a so-called green molecule was not green at all. The EMIS showed very bad results for this molecule. So, we asked our colleagues in Asia about this problem. … Now we cooperate with local universities and, together with scientists and farmers, work on a solution."* (Interviewee 11, ChemCo)

Customers with a strong environmental agenda were especially intrigued by the information the EMIS provided because, for the first time, they could assess and compare the impact of their products and specific materials. In some cases, the EMIS information changed their views about a certain product's impact on the environment and local communities. The EMIS also allowed ChemCo to discover counterintuitive information on particular products. As a consequence, some customers reconsidered

which products they procured from ChemCo, asking which raw materials were used to produce them:

> *"The customers asked for eco-sustainable solutions and products. When they saw the EMIS results, they were surprised that, from a sustainability point of view, it would be better to replace some natural products with synthetic products. Consequently, they ordered the synthetic product and changed their established beliefs about the eco-sustainability of some products."* (Interviewee 3, ChemCo)

Developing Sustainable Practices

The EMIS increased awareness, knowledge integration and organizational learning about the eco-sustainability of ChemCo's operations and strategy across the company's functional silos. In particular, ChemCo and its employees were now paying more attention to sustainability issues. Because employees with diverse backgrounds and knowledge used the EMIS, it created a platform for knowledge sharing and joint reflection, and for leveraging the know-how that was dispersed across ChemCo and its partners along the value chain. By facilitating these interactions, the EMIS provided ChemCo employees with a cross-functional platform to jointly work on solving hitherto unknown or little-understood problems. The EMIS inspired cross-functional, cross-country and cross-organizational collaboration for reducing negative environmental effects throughout the complete value chain. These collaborations resulted in constant optimization of the product portfolio, the launch of new eco-sustainable product innovations, more sustainable sourcing of raw materials, enhanced relationships with local communities and improved production environments: "Thanks to the tool [the EMIS], we realized how eco-sustainable our product portfolio is, and we are constantly improving for sustainability" (Interviewee 11, ChemCo).

Developing Sustainability-Consistent Strategies

As well as greening its operations, ChemCo's managers used the EMIS to help them develop sustainability strategies. Based on the insights from the EMIS information, environmental—and later also social— impacts related to sourcing and producing goods became important strategic decision-making criteria for framing eco-sustainability as a legitimate corporate goal. As the importance of sustainability increased in the entire food and fragrances industry, the EMIS helped ChemCo to take strategic decisions in line with its new differentiation strategy of being the industry's leader in sustainability. Incorporating sustainability-related information as a key criterion in strategic decision-making has also had a tremendous impact on the company's organizational culture and operations. Environmental impacts and issues became routine components of ChemCo's strategic decision-making processes. The EMIS enabled and triggered changes in organizational strategy and culture that mutually reinforced each other.

Planned and Unexpected Benefits from ChemCo's EMIS

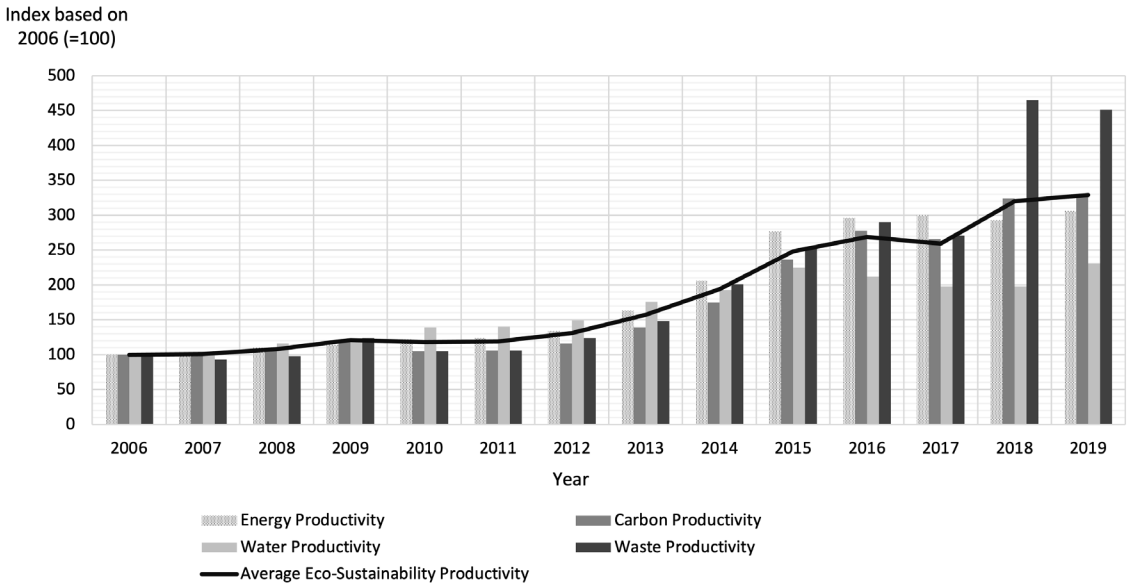
In addition to realizing the planned benefits, Chemco's EMIS also produced unexpected and meaningful benefits.

Planned Benefits

The implementation of the EMIS resulted in the planned benefits of greater product transparency, an improved environmental footprint, and legitimizing sustainability-oriented decisions.

Greater Product Transparency. The EMIS enabled users to easily assess materials' and products' environmental impact, which greatly improved sustainability-related product transparency. By making environment impact information readily available and introducing a consistent evaluation system, the EMIS facilitated the use of eco-sustainability key indicators and raised employee awareness. ChemCo's employees increasingly discussed sustainability and contributed suggestions and information for improving the EMIS. The open accessibility gave employees sustainability information for their particular products and processes and enhanced decision-making in two particular areas. First, ChemCo could now—based on the EMIS evaluation—identify and substitute non-eco-sustainable resources with sustainable

Figure 3: Development of Eco-Sustainability Productivity at ChemCo



Note. Data is shown as index based on the performance in 2006 (=100). Performance was calculated in a two-step process. First annual sales (in thousands of euros) were divided by gigajoules for energy, by tons for CO_2, by cubic meters for water and by tons for waste. Second, the total relative improvement from 2010 to 2019 was averaged by the number of years.

alternatives, thus lowering the environmental impact of the product portfolio. Second, ChemCo could present this information to the buyers of its products and provide them with comparative analyses of alternative products, thus enabling them to make informed choices about the eco-sustainability impact of their purchases, while also increasing ChemCo's reputation for eco-sustainability. Based on this information, customers could evaluate purchasing decisions based on a comprehensive set of eco-sustainability indicators.

Improved Environmental Footprint. Implementing the EMIS improved ChemCo's sustainability performance and reduced the company's overall environmental footprint. Over the years, ChemCo had substituted nonsustainable resources, reduced waste, invested in synthetic alternatives for non-eco-sustainable ingredients and optimized the resource sustainability impact and the sourcing process. As a result of these initiatives, the company has improved its energy and water efficiency, reduced its carbon emissions and substantially enhanced its waste productivity (see Figure 3).

Legitimizing Sustainability-Oriented Decisions. Another planned benefit of the EMIS was that it legitimized sustainability-oriented decision-making, efforts and investments. Based on information provided by the EMIS, strategic sourcing decisions and investments could now be evaluated based not only on financial performance but also on eco-sustainability indicators. For instance, after the shadow EMIS was integrated in ChemCo's ERP system, employees could track data on waste creation in the production process:

> *"We have a very complex ERP system, where all flows of goods, including waste flows, are recorded accordingly. ... Of course, we use the system again and again as a source of information: How much of this and that material is produced or how much will be needed. That way, we think about what we can do with some of the [waste] streams."* (Interviewee 6, ChemCo)

The increased transparency and availability of eco-sustainability information for all of ChemCo's employees stimulated them to improve the

efficiency of established business processes. The EMIS supported these efforts by making it possible to calculate the extent of processes' waste production and the potential gains of process innovations.

> *"Every year 6,000 tons of onions are processed here ... and 10,000 tons in France. The onions are squeezed out [leaving] a pomace [the solid remains after pressing]. This pomace can either be used in the biogas plant or spread on the fields. ... Yet, dumping 1,000 tons of pomace just somewhere is simply not trivial. That's a cost issue and it's also ultimately really a sustainability issue."* (Interviewee 3, ChemCo)

By making inefficiencies—such as the onion waste problem—visible, the EMIS inspired efforts for waste reduction, as well as for local sourcing and processing. Referring to the processing of onions, one manager explained that ChemCo extracted only 2% of the raw material with the remaining 98% treated as waste. Once the EMIS made this problem visible, ChemCo decided to use the onion pomace to generate renewable biogas energy for its operations.

A wide range of other ChemCo resources faced similar issues because extracting essences often creates large amounts of waste compared to the small percentage of final product. These issues attracted increasing attention from management, who addressed them by investing in more eco-sustainable raw material production processes, R&D projects and process innovations. Growing management support and the availability of transparent information on eco-sustainability provided by the EMIS transformed eco-sustainability indicators into important decision-making criteria. These factors also enhanced the legitimacy of eco-sustainability in decision-making at ChemCo.

Unexpected Benefits

The unexpected and meaningful benefits of the EMIS included a growth in demand for verified, eco-sustainable products, strategic differentiation, superior turnover and profitability growth rates, and more robust sourcing, as well as an increase in bottom-up sustainability initiatives by employees.

Growth in Demand for Verified, Eco-Sustainable Products. The EMIS provided ChemCo with the ability to transparently show its products' sustainability in contract and purchasing negotiations with B2B customers, and, somewhat to ChemCo's surprise, the customers were extremely interested in this information. In fact, ChemCo was overwhelmed by the resulting huge increase in demand for verified, eco-sustainable products, particularly for items used in food and personal care products. ChemCo's clients were facing increasing consumer sustainability expectations in these categories, but they had few options to purchase sustainably because the necessary information was not available in the industry.

Strategic Differentiation. ChemCo's management board gradually realized that the EMIS provided a competitive advantage because it provided the information that enabled clients to meet consumers' growing sustainability demands. Not only did this lead to increased purchasing volumes from existing B2B customers but it also attracted new customers, thus boosting ChemCo's overall sales. This unexpected positive business development removed any remaining doubts among corporate decision makers about the emerging opportunity of achieving strategic differentiation by combining sustainability and profitability. Thus, ChemCo strategically realigned its operations and adapted its product portfolio toward eco-sustainability. "At some point, the board of management was no longer able to resist, and realized how sensible and right this is and that there is a lot of money to be made from it [sustainability]" (Interviewee 1, Chemco).

Superior Turnover and Profitability Growth Rates. The sustainable products not only boosted ChemCo's revenues but were surprisingly profitable as well. Initially, sustainability was perceived as a niche market, but the EMIS allowed ChemCo to effectively meet a vast and previously overlooked demand from its B2B clients, which contributed to it outperforming its three main competitors, as the following comparisons show. Averaged over the years 2006 to 2019, ChemCo's compound annual growth rate (CAGR) for sales was 8.18 %, while Competitor 1's was 6.00%, Competitor 2's was 4.05 % and Competitor 3's was 3.43%. Over the same period, ChemCo's CAGR for earnings before interest and taxes

Table 2: Comparative Annual Sales Improvement per Resources Consumed (2010-2019)[15]

	ChemCo	Competitor 1	Competitor 2	Competitor 3*
Energy Productivity (Annual sales divided by gigajoules of energy consumed)	15.09%	6.71%	5.93%	7.32%
Carbon Productivity (Annual sales divided by metric tons of CO_2 emissions)	21.12%	15.17%	12.30%	16.33%
Water Productivity (Annual sales divided by cubic meters of water used)	6.64%	5.66%	31.69%	6.67%
Waste Productivity (Annual sales divided by metric tons of waste produced)	32.85%	22.60%	20.54%	11.33%
Average Eco-Productivity (Mean of energy productivity, carbon productivity, water productivity, waste productivity)	30.78%	21.16%	18.91%	12.07%

Note. All data in percentages showing the average annual improvement in sales per unit of resource consumption (the way in which performance was calculated is explained in the note for Figure 3). ChemCo for example generated about €904 revenue per gigajoule of electricity in 2010 and improved this to €2,269 in 2019. The average annual improvement therefore is calculated as ((€2269/€904)-1)/10) = 0.1509.
*Reporting period covers 2011 to 2019 as Competitor 3 did not report sustainability indicators earlier.

(EBIT) was 7.82 %, Competitor 1's was 4.58% and Competitor 2's was 5.14% (Competitor 3 does not report EBIT). As shown in Table 2, Chem Co also outperformed its competitors in terms of eco-productivity for energy, carbon, water and waste.

Thus, ChemCo managed to combine sustainability and improved financial performance effectively, showing that its substantial efforts and investments provided large paybacks. ChemCo's leadership in eco-sustainability and its superior financial performance caused others in the industry to take notice, resulting in an increase in the importance of eco-sustainability throughout the entire food and fragrance industry. The EMIS played a significant role in enhancing ChemCo's credibility and reputation as the industry's sustainability leader: "These are the things [referring to the EMIS] that have hugely advanced our market differentiation" (Interviewee 4, ChemCo).

More Robust Sourcing. Most unexpectedly, the transparent information on eco-sustainability provided by the EMIS raised awareness of problematic input materials. To assess the degree of renewability—an important key performance indicator provided by the EMIS—ChemCo employees reflected extensively on the availability of resources. They identified multiple materials, such as sandalwood or citric oils, that are essential for a wide range of products but were becoming increasingly scarce because of changing climate conditions. In the case of sandalwood, planting through to harvesting requires at least 15 years, which means an immediate scarcity cannot be rapidly resolved.

> *"Consider Indian sandalwood. We already knew that this is on the red list and that this is not so easy to get and will cause problems in the future. But now it is strictly regulated by the government in India—that we did not know. So, there are always things like that, partly we knew it, but we hadn't yet considered how strongly we would be*

15 For more information on calculating eco-productivity, see Ameer, R. and Othman, R., op. cit., June 2012.

affected by it in the end." (Interviewee 12, ChemCo)

Connecting decentralized information, which was previously available only to buying agents, and making it easily accessible to other employees via the EMIS, raised awareness about the scarcity of some of ChemCo's most important resources. This subsequently triggered strategic investments to ensure resource supply and to research synthetic alternatives or to improve the efficiency of extraction processes. Thus, the EMIS made employees aware of problematic input materials and promoted forward-looking adaptations. By proactively countering approaching scarcities and developing robust sourcing strategies, ChemCo gained a competitive advantage over its rivals.

Growth in Bottom-Up Sustainability Initiatives. The EMIS was also an important trigger for ChemCo's internal sustainability transformation because it increased interest in and the legitimacy of employee-driven bottom-up sustainability initiatives. These initiatives included specific product and process innovations directly related to ChemCo's core business (e.g., finding a use for onion waste), and more general employee-driven initiatives such as a corporate sustainability day, planting bee-friendly meadows at ChemCo's headquarters, carpooling initiatives, educational programs for farmers in Africa, and revising internal travel policies to encourage more eco-friendly traveling.

Recommendations for Designing and Implementing an EMIS

The ChemCo case shows that an EMIS can evolve into more than just a tool for fulfilling sustainability obligations such as reporting and compliance, becoming a critical tool for addressing the sustainability information challenge and turning good intentions into action. Based on the lessons learned from this case, we provide five recommendations for IS leaders on designing and implementing an EMIS that can be used to increase employees' awareness and knowledge about their company's environmental impact. By following these recommendations, firms will be able to improve their operational practices to make them more eco-sustainable and even create differential strategic value.

1. Keep the EMIS Simple and Grow It Slowly

The creator of ChemCo's shadow EMIS was tech-savvy but not an IS professional. He developed the system in his spare time and with limited resources. By today's standards, the user experience was simple, but the EMIS was usable and served its main purpose. The creator's lack of IS knowledge, time and budget helped him to focus on the essential features of the EMIS, which ensured that it was useful for a diverse group of co-workers. We can only speculate what the outcome would have been if the EMIS had been developed using traditional IS practices with proper funding. However, the likelihood is that the resulting EMIS would have had a less positive effect on the company and its ecosystem. We say this because the creator was forced to start lean and had to incrementally develop the EMIS. Initially, he had to start the EMIS with only limited information because the environmental impact of input materials and products was not available. Moreover, the hours he could spend developing the EMIS in his leisure time were limited. He therefore concentrated his efforts on gathering information on the most relevant input materials and products whose environmental impact was, in his view, most significant.

Similarly, he incrementally added features that he prioritized according to their usefulness based on many conversations with his co-workers. To ensure that the EMIS would be broadly useful, he talked with employees with diverse backgrounds in terms of, for example, function, business unit, geographic location or organizational tenure. He leveraged his large personal network because, in Gladwell's terms, he was a connector, or the human equivalent of a computer network hub, who was curious and vigorous and liked to socialize and bring people together.[16] He listened closely to others' feedback, synthesized it, and used it to update and improve the EMIS. His scarce resources forced him to explicitly prioritize

16 See Gladwell, M. *The Tipping Point: How Little Things Can Make a Big Difference*, Little, Brown & Company, 2006, p. 12. Gladwell says that connectors are recognized as rare and special psychological types that create tipping points defined as "the moment of critical mass, the threshold, the boiling point" that spur viral trends in business and society.

the most valuable and pressing sustainability issues.

Thus, the creator's approach was to keep the EMIS lean and simple, so as not to inflate the system, and to focus on a small but relevant and reliable set of information. Alhough he could easily have incorporated more (but perhaps less reliable and relevant) information, he did not, because he did not want to overload users. Rather, he wanted to keep the EMIS clean and easy to use. He recognized that understanding and making sense of materials' and products' impact on eco-sustainability is a multifaceted and complex challenge, and his decision to launch the EMIS with a small set of relevant and reliable information and limited features proved to be effective. The simple and intelligible design of the EMIS encouraged usage and made using it intuitive and straightforward. Thus, entry barriers for users were low and the clear-cut focus on core features and information was an important enabler and accelerator of user adoption.

Although he was unaware of formal IS development methods, his approach was similar to agile or lean methods such as SCRUM or minimum viable products,[17] which emphasize learning, continuous user feedback, and incremental and iterative development. These methods also ensure that stakeholders' feedback is integrated broadly and early, which is important for areas such as sustainability that cut across a company's entire value chain. The requirements for an EMIS are often heterogeneous and not well understood at the beginning of a project. Thus, the creator's approach of selecting co-workers in different functional areas whom he knew were receptive to the idea of an EMIS and of continuously requesting and incorporating feedback ensured that he did not waste his scarce resources and focused on what mattered most to users.

2. Leverage and Nurture Employee-Driven Eco-Sustainability IS Initiatives

Increasing numbers of employees care about their company's purpose, which has been defined as "a firm's benevolent and pluralistic approach to its stakeholders beyond its focus on shareholders."[18] Some researchers even see a firm's purpose as "the secret ingredient of extraordinary companies,"[19] which has been linked to improved financial performance, employee satisfaction, productivity and talent acquisition.[20] The ChemCo case shows that employees were motivated and willing to engage in sustainability initiatives that provided their work with greater meaning, even if it required sacrificing a considerable amount of leisure time. This applies first and foremost to the EMIS creator but also to his co-workers, who supported the crowdsourcing of information, promoted knowledge sharing, and spurred firm-level adoption and redeployment of the EMIS as a corporate system rather than as a shadow system.

The ChemCo case therefore shows that IS leaders should not condemn shadow IS out of hand. Instead, they should assess shadow initiatives with an open mind because these initiatives most likely address a misfit between employees' actual work needs and the corporate systems designed to support them. All too often, however, we observe that shadow systems are judged as bad for technical reasons (e.g., security, architectural consistency) and social reasons (e.g., power, vanity).[21] Although the EMIS creator in the ChemCo case deviated from official IS governance rules and responsibilities, he created a system in a short amount of time and with limited resources, which kick-started the company's sustainability transformation. Thus, the shadow EMIS provided something very useful for the company, even though it did not meet ChemCo's technical standards. However, this shortcoming was later corrected when the EMIS was professionally redeveloped.

17 For information on agile methods, see: 1) Schwaber, K. *Agile Project Management with Scrum, Microsoft Press*, 2004; and 2) Eric, R. *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*, Crown Business, 2011.

18 For a thorough review and unifying definition of a firm's purpose, see: George, G., Haas, M. R., McGahan, A. M., Schillebeeckx, S. J. D. and Tracey, P. "Purpose in the For-Profit Firm: A Review and Framework for Management Research," *Journal of Management*, April 2021, available at https://doi.org/10.1177/01492063211006450.

19 For information on how to define and benefit from a clear firm purpose, see Spence, R. and Rushing, H. *It's Not What You Sell, It's What You Stand For: Why Every Extraordinary Business Is Driven by Purpose*. Penguin Random House, 2009.

20 DeGarmo, T., Parker, B., Scott, R., Nieland, K. and Delaye, N., op. cit., 2011.

21 See, for instance, Walterbusch, M., Fietz, A. and Teuteberg, F. "Missing Cloud Security Awareness: Investigating Risk Exposure in Shadow IT," *Journal of Enterprise Information Management* (30:4), July 2017, pp. 644-665.

We are not arguing that shadow IT is universally good, but that IS leaders should not, as a matter of course, judge an employee-initiated system as inadequate because it does not conform with corporate guidelines or where the idea originated. Rather, the system's usefulness to generate business value should be the most important criterion for judging it. ChemCo's IS management could easily have dismissed the EMIS because it had been developed and implemented outside IS governance guidelines. However, even though IS management did not anticipate or prioritize the need for an EMIS (which could cast a shadow on IS strategy and demand management), it was open to further developing the shadow EMIS. Thus, ChemCo's IS leaders disregarded these social issues when they decided to professionally redevelop the EMIS in accordance with IS technical guidelines.

The democratization of access to powerful on-demand computing resources (e.g., through cloud computing or more recently the "API economy") and the increasing tech-savviness of non-IT employees are creating more opportunities for IS innovation outside internal IS departments (a phenomenon known as "IT consumerization").[22] Instead of seeing shadow IS as a threat, IS leaders should think of shadow initiatives as opportunities for IS innovation. To leverage such innovation, IS departments need to monitor their firms' IS landscapes to identify shadow IS (e.g., through automated web and network traffic monitoring or through human boundary spanners). Rather than routinely condemning the originators of shadow initiatives, IS leaders should try to understand why the shadow system was built and how it solves a business need and creates value. And, if the shadow system addresses a significant business need and the business case is positive—implying that the costs for redeveloping and integrating it in the corporate IS infrastructure are lower than the expected value—IS departments should work closely with the originators and users of the shadow IS. Doing this will ensure that the unique properties of the shadow IS are not diluted and that users won't see the redeveloped system as having been "hijacked" by the IS department and therefore resist adopting it.

Furthermore, we believe that many firms have resourceful employees who are motivated and willing to contribute to a greater purpose such as eco-sustainability or other corporate social responsibility activities by taking on unscripted roles. IS leaders should identify those employees and leverage their motivation and knowledge. For instance, involving them in developing and introducing an EMIS ensures greater problem-solution fit and ensures these employees' support, which is crucial to the successful adoption of an EMIS and its effective use. Moreover, providing intrinsically motivated employees with extra time and small budgets can nurture innovative "skunk work" IS projects that can improve a company's eco-sustainability and strengthen employees' commitment, motivation and advocacy. Even though these employees may be highly valued in performing their regular work tasks, giving them some creative leeway will pay off in the long run for the organization because they will likely stay longer and produce more innovation.

3. Design the EMIS to Promote Cross-Functional Interaction and Collaboration

In many organizations, EMISs are used only by a small number of employees whose roles are related to eco-sustainability. Typically, most employees do not have access to the information in an EMIS—if they know about its existence at all. The ChemCo case shows that this approach is detrimental to eco-sustainability at the wider firm level. ChemCo's sustainability transformation depended crucially on the EMIS being accessible to all employees and used across functional areas. From the beginning, the creator emphasized the EMIS's accessibility and its ability to be used by all employees, providing features to support users' comments, tagging, sharing and discussion of eco-sustainability matters, as well as features for the collection of sustainability information.

This open approach promoted interaction between co-workers from diverse functional backgrounds and countries that would otherwise not have happened. In addition to providing opportunities for joint knowledge creation, the EMIS promoted collaboration between

22 For more on IT consumerization, see Gregory, R. W., Kaganer, E., Henfridsson, O. and Ruch, T. J. "IT Consumerization and the Transformation of IT Governance," *MIS Quarterly* (42:4), December 2018, pp. 1225-1253.

diverse employees—e.g., on experimenting with more eco-sustainable product compositions or gathering information on the effects raw materials have on local natural ecosystems.

Improving a firm's eco-sustainability requires many organizational functions to work together to find solutions that go beyond local optima, and achieving this requires a joint knowledge base and platform that links functional departments and enables collaboration. Hence, the EMIS creator did everything he could to ensure broad, cross-functional adoption of the EMIS to prevent a silo mentality from stifling interaction and collaboration between functions. The cross-functional adoption and usefulness of the EMIS helped to achieve that goal. Moreover, the integrative and joint approach helped to prevent institutionalized behaviors such as dependence or power relations from interfering with EMIS adoption.[23] Preventing these behaviors is important because organizational sustainability transformations involve a complex interplay of intraorganizational factors such as organizational values, routines and cultures. To avoid resistance, these factors need to be considered in the design and implementation of an EMIS.

4. Open the EMIS to External Stakeholders Once It Is Sufficiently Mature

Improving eco-sustainability requires not only intraorganizational collaboration, but also collaboration with the larger group of stakeholders in a company's value chain (e.g., suppliers, customers) and beyond (e.g., industry associations, nonprofit organizations, local communities, governments). EMIS developers should therefore consider when and which external stakeholders should be involved in using the system.

ChemCo was surprised at external stakeholders' interest in the eco-sustainability information in the EMIS. However, the creator's development approach helped to incorporate them into the EMIS. First, gradual information access was granted to outsiders, as ChemCo's salespeople began presenting the tool in client negotiations—but only after the EMIS was sufficiently mature. To use the EMIS in contract negations and sales activities successfully, its usability and the reliability of information first had to be improved. Because the tool provides a product's eco-sustainability impact based on the resources used in its manufacture, taking account of only selective resources would have provided an incomplete picture. It was therefore necessary for the information to be updated so it covered the range of resources necessary to provide comprehensive and valid information about the eco-sustainability of final products. Although it was tempting to make the EMIS information accessible to outsiders earlier, the creator decided to wait until it was sufficiently mature. This decision was vital for establishing ChemCo's reputation in the marketplace as a trusted and reliable partner of verified sustainable products.

Companies should also think about which external stakeholders to collaborate with first. ChemCo prioritized key accounts with long-standing relationships and with an interest in making their products more eco-sustainable. That approach meant that the resources needed to explain the information were not too burdensome. Also, focusing on large customers well-known in the industry sent a signal of ChemCo's value to smaller customers, thus helping the company increase its market share of sustainable products. Additionally, ChemCo's larger customers had internal experts working on eco-sustainability themselves. The knowledge and insights shared with those experts helped ChemCo to further develop its EMIS and to establish dialogs and relationships with these important customers. Through these dialogs, ChemCo realized that its customers were extremely interested in sustainability information and that its reputation and transparency could be further improved through acquiring accepted industry certificates.

Although ChemCo did not publicly publish the sustainability information for every product, it did provide this information to interested B2B clients on request. ChemCo also joined the Supplier Ethical Data Exchange (SEDEX), a global nonprofit organization that supports companies like ChemCo in sharing sourcing information with buyers, including sustainability audits and certifications. Joining SEDEX helped

23 For more on structural and psychological barriers of pro-environmental behavior, see Gifford, R. "The Dragons of Inaction: Psychological Barriers That Limit Climate Change Mitigation and Adaptation," *American Psychologist* (66:4), May-June 2011, pp. 290-302.

ChemCo further improve the visibility of its eco-sustainability efforts and allowed ChemCo to also be independently accredited for doing so, which in turn helped ChemCo's clients to communicate their sustainability efforts to their own customers. The detailed documentation provided by the EMIS helped ChemCo acquire independent accreditation certificates—for example, it acquired Fairtrade certifications for its product value chain and was granted 100 "A" certifications by the Carbon Disclosure Project.[24]

As a result of ChemCo's open and transparent collaboration with external stakeholders, its reputation as a pioneer in eco-sustainability in the market and beyond grew. This reputation was reinforced by the company winning the most prestigious German prize for sustainable companies twice. ChemCo's open and collaborative strategy on improving eco-sustainability also helped transform its relationships with suppliers and customers—from keeping them at arm's length to developing close relationships with them. Moreover, the more trusted and frequent interactions not only provided ChemCo with more secure supplies of rare raw materials but also helped the firm outperform its competitors and increase its market share. In other words, ChemCo performed better by doing good for and with its stakeholders.

5. Use the EMIS as a Strategic Differentiator, Not as an Obligatory Tool with Little Business Value

ChemCo's EMIS evolved from a tool to increase operational eco-sustainability to becoming a strategically important system that differentiated ChemCo from its competitors. Certainly, not all companies' EMIS implementations will evolve in this manner. Nevertheless, IS leaders should consider how an EMIS could evolve into a tool that enables corporate leaders to make better decisions about eco-sustainability risks and opportunities. For instance, by using the EMIS as a risk management tool, ChemCo's leaders became aware that the supply of a key resource would soon be threatened. In response, ChemCo took action long before its competitors and opened up a new, highly profitable market segment for a sustainably sourced product that it could control.

The EMIS also provided strategic differentiation because it enabled ChemCo to offer stakeholders detailed information about the eco-sustainability impact of products. Market demand for information on eco-sustainability impacts was rapidly increasing, and ChemCo was able to satisfy this demand and outperform its competitors both financially and in terms of eco-sustainability productivity. The EMIS became strategically important because competitors could not offer customers similarly detailed data on sustainability impacts like ChemCo could.

Undoubtedly, the expectations and pressure of governments and customers worldwide regarding firms' eco-sustainability will increase in the coming years, and these pressures will cause the strategic importance of EMISs to also increase. Many companies, however, still see implementing EMISs as a chore that creates little more value than, for instance, enabling sustainability reporting compliant with GRI (Global Reporting Initiative) standards. Companies that see more value in an EMIS often focus on increasing eco-efficiency—i.e., doing more with less. Only a minority of companies use EMISs with the goal of increasing eco-effectiveness—i.e., ensuring long-term ecological viability through transformative changes fueled by renewable, carbon-neutral and recycled material flows.[25] An EMIS that is broadly used by a firm's employees and stakeholders can trigger these transformative innovations because it creates opportunities for cross-functional knowledge sharing, reflection and collaboration.

Eventually, as whole industrial ecosystems transform their products and material flows so they "form a supportive relationship with ecological systems and future economic growth,"[26] EMISs will evolve into vitally important information systems. Hence, implementing an EMIS should not be seen as a box-ticking exercise but as creating a strategic resource. CIOs

24 For information on Fairtrade certifications see, https://www.fairtrade.net; for information on the Carbon Disclosure Project, see https://www.cdp.net/en.

25 For a comprehensive analysis of how IS can support circular economy principles, see; Zeiss, R., Ixmeier, A., Recker, J. and Kranz, J. "Mobilizing IS Scholarship for a Circular Economy: Review, Synthesis, and Directions for Future Research," *Information Systems Journal* (31:1), August 2020, pp. 148-183.

26 For a comparison of eco-efficiency and eco-effectiveness, see "Efficiency vs. Effectiveness," Ellen MacArthur Foundation, October 9, 2012, available at https://www.ellenmacarthurfoundation.org/news/efficiency-vs-effectiveness.

therefore need to play a more active role because supporting corporate sustainability through adequate information systems is essentially an information challenge. Moreover, because of their experience of providing cross-functional technical support, CIOs are uniquely positioned to identify synergies and business problems across functional areas of an organization.[27]

Concluding Comments

Because of a shadow EMIS initiated and developed by a motivated, resourceful and pro-environmentally minded employee, ChemCo emerged as the sustainability leader in its industry—a position it still holds in 2021. Over 80% of its products are now produced eco-sustainably, and ChemCo aims soon to have a 100% eco-sustainable product portfolio. In addition to eco-sustainability indicators, ChemCo now also incorporates a wide range of other indicators in decision-making processes to account for all environmental, social and governmental goals included in the United Nations' sustainable development goals. ChemCo's sustainable strategy is providing significant pay-offs. Its strong market performance and annual growth and profitability rates outperform competitors, and its share price has increased six-fold over the past ten years. The ChemCo case shows that an EMIS that is broadly and effectively used can become a strategic differentiator and set an organizational sustainability transformation in motion. Based on our analysis of this case and the lessons learned, we have provided recommendations for IS leaders interested in implementing a new EMIS or updating an existing one. Following these recommendations will help organizations develop and implement EMISs that enable eco-sustainability and create business value.

27 For a description of the potential of IT to help shape organizations' responses to growing sustainability challenges, see Clark, T. "Unlocking Sustainability: Why the CIO Should Hold the Key," in *The Global Information Technology Report 2009–2010*, Dutta, S. and Mia, I. (Eds.), World Economic Forum, 2010, pp. 71-79.

Appendix: Research Methodology

Data Collection

For our in-depth case study, we collected data from 36 semistructured interviews. Sixteen of these interviews were conducted with ChemCo managers in a variety of departments and at different hierarchical levels (see the table below). We recorded, transcribed and coded all of these interviews. To better understand the context and scale of ChemCo's operations, we conducted an additional 20 interviews with respondents from the company's three major competitors. Together, these interviews provided a profound understanding of the contextual factors that influenced ChemCo's organizational sustainability transformation, its actions and its success. The average length of all 36 interviews was 64 minutes (median 57 minutes).

We also gathered secondary data on ChemCo, its major competitors and the industry from corporate and sustainability reports, press releases, videos and newspaper articles. These secondary sources covered a period of 13 years. The multiple data sources provided us with rich information on ChemCo and its eco-sustainability transformation, as well as knowledge about industry characteristics and ChemCo's competitors.

Data Analysis

We analyzed the data using NVivo (produced by QSR International) to identify emergent themes and topics raised by our respondents.

To ensure coding comprehensibility and comparability across researchers, the initial coding was carried out independently by the researchers. We discussed coding divergences and then controlled and refined the coding, thus strengthening intercoder reliability. To further strengthen intracoder reliability, we coded the data four times, with at least one week between each round of coding.

To analyze the secondary data, we skimmed the documents to identify relevant passages for detailed analysis. These documents and the interviews with ChemCo's direct competitors provided additional insights on the growing industry pressure for sustainability and which

Overview of Interview Respondents

Interviewee Number	Interviewee Position
	Interviews at ChemCo
1	Head of Human Resources EMEIA
2	Key Account Manager Sales Fla
3	Head of Research & Development Fla
4	Chief Sustainability Officer
5	Global Head of IT
6	Division Manager Production NFP
7	Division Manager Site & Service Management
8&11	Manager Corporate Sustainability
9	Head of Research & Development S&C
10	Travel Agent
12	Global Fragrances & Ingredients Director
13	Sustainability Director
14	Manager CI/CD Labeling & Packaging Cosmetics
15	Senior Vice President Sales Central & Eastern Europe
16	Sales Representative
	Interviews at Competitors
17	Global Business Manager Enzymes
18	Business Manager Home Care Germany
19	Sales Representative
20	Sales Manager
21	Sales Manager Europe
22	Business Development Manager
23	Business Development Manager
24	Sales Representative
25	Manager Campaign Marketing Germany
26	Global Business Manager
27	Head of Marketing & Sales EMEIA
28	Key Account Manager Cosmetics EMEIA
29	New Business Manager
30	Customer Engagement Manager Germany
31	Sales Manager
32	Marketing Manager
33	Account Manager Germany
34	International Marketing Manager
35	Marketing Manager
36	Sales Representative

benchmarks for sustainability were in place. We compared key performance indicators of sustainability by calculating scores for energy, carbon, water and waste productivity and including a score for the company's average eco-productivity (see Table 2). We also assessed the profitability and sales growth of ChemCo and its three main competitors based on annual sales figures.

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