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RETHINKING REUSE OF DATA BY REGENERATIVE MANAGEMENT

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Abstract

This paper introduces a regenerative mindset from Regenerative Agriculture (RA) that fosters robust reuse of information in the Architecture, Engineering, Construction, and Facility Management (AEC/FM) sector. By stacking enterprises and forging virtuous cycles, RA principles highlight synergy, resilience, and resource efficiency. Drawing on engaged scholarship, we demonstrate how outcome-driven data use addresses longstanding implementation barriers by centering on virtuous cycles rather than isolated technological inputs. We propose a new management paradigm that elevates data reuse, expediting meaningful digital transformation while advancing environmental targets, called Regenerative Construction data (RCd).

Introduction

Where is the impact of the digital transformation in the AEC/FM industries? This discussion paper introduces the regenerative mindset to explore why the current way of technology-driven digitalization should be replaced with a regenerative approach.

Bosch-Sijtsema et al. (2021) detail the 11 digital technologies currently in the implementation "pipeline" in the AEC/FM. However, each technology presents unique drivers and barriers, raising the question: Is it necessary to address them individually?

Building Information Modelling (BIM) implementation has been researched extensively, with no apparent solution (Oesterreich & Teutenberg, 2019). Over 20 years have passed since Laiserin (2002). Should we expect the same track for each of the other 10 digital technologies?

Digital technologies are central to achieving the 2030/2050 environmental goals. Wouldn't it be simpler if there was a guiding principle that naturally led to the implementation of these digital technologies, as well as the environmental goals?

Through engaged scholarship (Mathiassen 2017), we are introduced to a participant's (Statnett 2020) trial in using *goats* for clearing vegetation under high-voltage lines. We learn of Regenerative Agriculture (RA) and notice its practice is reliant on digital technologies and tends to result in positive contributions to UN17 goals.

We apply an alternative "research strategy" Turk (2006 p. 664), using abduction[1] and retroduction[2]. Both are sparingly used in AEC/FM/BIM literature (Koskela et al. 2017; Rekve et al. 2025). They enable an "activity-theoretical/evolutionary" view on BIM (Miettinen & Paavola 2014); which in our view is necessary in facilitating transformative change – a goal often repeated in industry reports and prominent academic journals (Glass et al. 2022).

The abduction is a "creative leap to something new" (Koskela et al. 2017 p.174), specifically that RA management principles might be transferred to an AEC/FM context. The retroduction is an attempt at synthesizing what these principles and context *may* be.

RQ1: What are the management principles of Regenerative Construction data (RCd) based on Regenerative Agriculture (RA)

RQ2: How could RCd be applied to the AEC/FM industry?

RQ3: What is the impact of RCd on the AEC/FM industry?

Presentation

The nature of this approach necessitates an exposition of RA. The process of abduction may not be possible to articulate algorithmically. Through rich descriptions of RA, "the whole methodological process" (Paavola 2004 p. 272) of abduction can be gleaned.

Overall purpose

According to David Epstein (2019) in the book "Range" answering these types of questions requires a "Wicked"

[1] See (Koskela et al. 2017) for a critique of AEC/FM bias for deduction and the need for inferential plurality.

[2] See (Fox 2014) on causal mechanisms; and (Succar & Kassem 2015; Succar & Poirier 2020) for examples on use of retroduction in context of AEC/FM/BIM.

learning environment, in contrast to "Kind" learning environment with one single correct answer. This paper does, therefore, intend to initialize a discussion about the mindset for digital transformation.

Our contribution is RCd, modelled after the principles in RA. Where the defining characteristic is that data should have a very high utilization. Furthermore, if this is achieved in a specific way (according to the management paradigm), the effects might have similar positive contributions to UN17 goals as RA.

Theory

What is Regenerative Agriculture?

There is no agreed-upon definition of Regenerative Agriculture (RA). Newton et al. (2020) analyzed 229 academic articles and 25 practitioner websites using the term. Definitions varied, but tended to focus on either the processes or the outcomes.

Outcomes are typically net positives that can be measured in the triple bottom line (economic, environmental, and social), not just in a single bottom line (economic). Additionally, and perhaps most importantly, the processes that produce these outcomes ensure the activities of value production happen within certain boundaries.

As a way of illustrating these boundaries, we suggest Figure 1, Raworth's (2018) doughnut, situating the outcomes and processes of RA between the ecological ceiling and the social foundation.

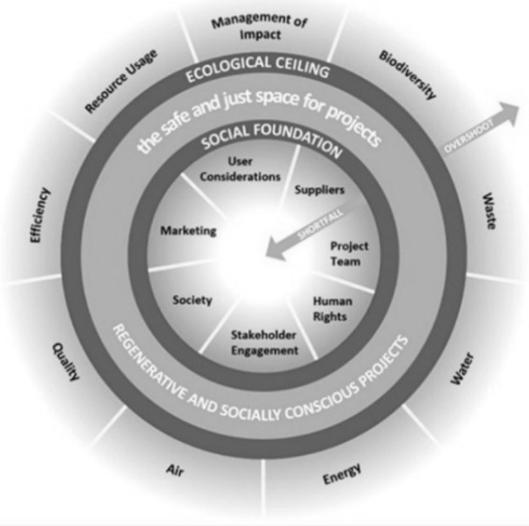

Figure 1: Regenerative agriculture as a holistic approach (Raworth, 2018). The figure is licensed CC BY-SA 4.0.

What is the Regenerative management principles?

Our working definition of RA is: "restoring and enhancing ecosystem function on farms and in landscapes through practices designed to work with the landscape, climate, people and livestock" (NSW DPI 2021).

Which means Regenerative management is a holistic management approach aimed at restoring, renewing, and revitalizing ecosystems, organizations, and communities rather than merely sustaining them. It goes beyond sustainability by actively improving ecological and social systems through deliberate, restorative practices.

What was with the goats?

Our abductive inference, "the creative leap" that RA principles could be applied to matters in the AEC/FM, occurred when a participant informed us about virtual fences for grazing livestock.

Statnett, Norway's National Grid operator, traditionally maintains vegetation under high-voltage lines using heavy machinery and manual labor, incurring high 1) financial, 2) environmental, and 3) social costs. These include greenhouse gas emissions, wildlife disruption, and the high societal value placed on undisturbed nature in Norway.

A trial solution employed Nofence (2025), a virtual fencing system for livestock. Goats were fitted with a neck collar containing a battery, GPS, SIM card, sound emitter, and cattle products, see Figure 2. Operators define virtual pastures via a web browser. As goats approach the boundary, an escalating alarm sounds, stopping only when they return to the designated area. If a goat attempts to breach the fence, the cattle prod activates (Statnett 2020).

Figure 2: Collars from Nofence (2025)

The goats cleared the vegetation underneath the high-voltage lines. The project was not an unbridled success. Primarily because the unwanted vegetation was not killed to the desired extent. But it did illustrate the potential of rethinking how necessary maintenance could be done in a much less invasive and expensive way. This was an innovative way, assisted by technology, where the outcome was that the land or soil was used for multiple purposes. Not only was it used for electricity transport, but it was also used for livestock feed.

Virtuous cycles of Regenerative agriculture management principles

RA processes seem to result in increased utilization of the *medium of production*. The soil is used for multiple purposes through a sentiment of "stacking enterprises".

For example, nut trees can be planted in pastures – providing additional animal feed or produce sales income. The trees provide shade and windbreak for livestock, reducing the need for infrastructure. The tree roots go deeper in the soil, pulling up trace minerals absent in the surface soil. In autumn, leaves fall to the ground and rot. Grasses make use of the released nutrients, resulting in less need for mineral supplementation for livestock.

The key characteristic of the management principle is that it embraces complexity. Care is taken to organize enterprises in such a way that the outputs from one is the input to another: RA processes facilitate the establishment of a virtuous cycle where outputs from one process, are inputs into a new process.

The need to rethink transformation of the AEC/FM

On average, innovations take 17-20 years to implement, with only a 50% success rate (Bauer & Kirchner, 2020). If BIM implementation is any indication, the remaining 10 digital technologies studied by Bosch-Sijtsema et al. (2021) will likely require decades of research to address implementation challenges. The need for transformation in AEC/FM and research is widely acknowledged in leading academic journals (Glass et al., 2022; Chan, 2022). This is further emphasized by the growing complexity of the field, reflected in more inclusive definitions of Construction Management activities (CIOB, 2010). This article follows Tiwana & Kim's (2019) approach of "building an edifice from littered bricks," where empirical studies are the bricks, and theoretical insights form the edifice. We synthesize existing literature on AEC/FM digitalization to create something new. The CIOB (2010) suggested a more inclusive definition of construction management: "The management of the development, conservation and improvement of the built environment". Replacing "built environment" with "soil", corresponds well with our intuitive understanding of what the RA farmer does. The difference between the two is the medium of value creation.

Methodology

Research approach

In this work, we employ abductive and retroductive approaches. Abduction aids in discovering new knowledge, such as by drawing analogies between unrelated fields. Retroduction helps uncover underlying mechanisms. An example of a mechanism is the market function that regulates much of how society works. xamples of retroduction in use within BIM/AEC include Succar and Kassem (2015) and Succar and Poirier (2020).

Our approach is inspired by Rekve et al. (2025), who found that 89% of BIM implementation research relies on deduction and induction. These modes of inference have limitations in addressing paradigm shifts, a context often associated with BIM (Azhar et al., 2008; Sacks et al., 2010; Takim et al., 2013; Zomer et al., 2020). The need to map inference modes is highlighted in Turk (2006), while Koskela et al. (2017) critique the dominance of deduction.

Research design

According to Hanson (1979, p. 86), abduction follows the logic:

"1) The surprising phenomenon, P, is observed;
2) P would be explicable as a matter of course if hypothesis H were true;
3) Hence, there is reason to suspect that H is true."

Through an engaged scholarship (Mathiassen 2017) research project into Information Management Platforms across the lifecycle of Buildings, we trialed an eight-part workshop series with actors in the AEC/FM. One of the participants was Statnett, from whom we were introduced to the goat project.

The surprising phenomenon was that RA often produces outcomes aligned with UN17 goals. This led to the abductive insight that synthesizing a general management principle from RA and applying it to AEC/FM might yield similar results.

According to (Sayer, 1992, p. 107) retroduction is a "mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them". The retroduction in this case is the attempt to define a management principle relevant to the AEC/FM that is capable of producing these results.

Limitations

Motivated by finding "pathways between past and future" (Volker 2019 p.20) and applying an "activity theoretical/evolutionary" understanding of BIM implementation (Miettinen & Paavola 2014), the philosophy of science underlying this article is Critical Realism (CR) – similar to Fox (2014); Succar & Kassen (2015) and Succar & Poirier (2020).

Limitations of the article, specifically regarding the scientific merit, is to a large extent contained in discussions of Critical Realism and the use abduction and retroduction. For space reasons we refer to literature for this discussion (Ritz 2020; Meyer and Lunnay 2013; Paavola 2004; Hanson 1979 and Sayer 1992).

Results and discussion

We find it telling there are no definite definitions of RA, and that their definitions either focus on the outcomes or the processes of RA (Newton et al. 2020). In our investigation, we applied this dichotomy.

Relevant outcomes from exploring RA

RA outcomes are a result of the establishment of a virtuous cycle. The output from one activity is an input into another. Each output is a positive contribution to the three bottom lines; economic; environmental and social. The result is a qualitative judgement that the activity happens within the ecological ceiling and social foundation (Raworth 2017).

RA calls this for "stacking enterprises". Statnett's goat project ended up utilizing the land under the high-voltage lines for multiple purposes. A virtuous cycle is established where the output from electricity transport is landscaping with goats, which is input into meat production, which outputs landscaping done in a socially acceptable manner to the populace. At the same time, machinery usage is avoided and so on.

RA tends to result in increased resiliency. For example, through the practice of no-till, the carbon content of soil is increased. Increased carbon content in the soil increases water infiltration during heavy rainfall, lowers temperatures and more moisture retention during droughts. Greater biological diversity within and immediately above the soil decreases vulnerability to pests and diseases

Regenerative principles applied to AEC/FM

Creating a virtuous cycle by stacking enterprises seems to be achievable by identifying the primary economic activity happening on the *medium of production* and listing the outcomes of that activity across the sustainability dimensions of the triple bottom line (Financial; Environmental; Social).

First, a demonstration, see Table 1, without goats: Electricity transport takes place on the land. The outcome is two negative secondary effects: Clearing land costs money and detracts from the environment because of the process of how this is done. The outcome of clearing the land with machinery has a negative tertiary effect, detracting from the social benefits of nature.

Table 1: Impact levels and sustainability perspectives - Case: Electricity transport

	Financial	Environmental	Social
Primary	Electricity transport		
Secondary	Clearing of land	Clearing of land	
Tertiary			Social benefit of nature

Table 2: Impact levels and sustainability perspectives – Case: Regenerative approach to electricity transport

	Financial	Environmental	Social
Primary	Electricity transport		
Secondary	Landscaping with goats	Landscaping with goats	
Tertiary	Meat production		Social benefit of nature
Quarternary		Sustainable food production	
Quinary			Desirable social goal

In the RA example, the secondary effects are landscaping with goats, see Table 2. This has an economic undetermined impact (likely net positive if done on scale), and a positive environmental effect. The tertiary effect is net positive in economic terms through meat production, and net positive social impact since the clearing of growth was done with goats instead of machinery. The outcome of meat production is sustainable food production, which is again a desirable social goal.

Relevant processes from exploring RA

RA processes appear to maximize the utilization of the medium of value production. Unlike modern agriculture, RA uses fewer inputs, allowing the soil to remain productive for a longer portion of the growing season. For instance, plants may be biologically able to grow in October and November, although not enough to justify additional input investments.

Alternatively, movable chicken coops follow three days after cattle have grazed a pasture. After three days, flies have laid eggs in the cow patties, providing protein-rich feed to the chickens. After this, sheep graze the same pasture again, as they tend to focus on other plants than cattle and chickens do.

Regenerative principles applied to AEC/FM

The medium of value production in the case of digital technologies in the AEC/FM is information. Interestingly, a lot of the information outputs from one of the technologies listed in Bosch-Sijtsema et al. (2021) will be information inputs into another. Such as sensor data to Digital Twin; Drones to 3D Scanning, to the Cloud; with Artificial Intelligence (AI) as an analytical layer encompassing all the technologies.

Providing a systematic approach to information management is in place, it is reasonable to assume that use of one technology will benefit the other. In other words, creating a virtuous cycle. This is not news to the AEC/FM, where increasing the utilization of information has been a goal of the AEC/FM for a long time. Exemplified by efforts with BIM, data interoperability and standardization efforts.

A central problem is a lack of holistic understanding of what information is needed, for which purposes, and servicing which perspectives. In the case of RA, the sole user of information is the farmer making the management decisions. This is not the case in the AEC/FM.

The overall solution to the fragmented nature of the information users is provided by EN-ISO 19650, a relatively new standard for information management in the AEC/FM. The client, or the appointing party, will have many perspectives that need to be addressed. Examples are the organizational management perspective (ISO 9001), the asset management perspective (ISO 55000), the project management perspective (ISO 21500), and so on.

According to EN-ISO 19650, perspectives should detail the purposes for which information is needed. From this, information requirements should be defined. Where these requirements inform suppliers and regulate the information production and exchange processes.

The problem is that NS-EN ISO 19650 does not contain any tools that facilitate the identification of purposes of information. The closest tool is the Information Delivery Model (IDM) EN-ISO 29481 standard, with its emphasis on mapping of work processes. Combined with the Level of Information Need (LOIN) EN-ISO 7817, as well as Plain Language Questions (PLQ) and Actual Digital Questions (ADQ) used by practitioners in EN-ISO 19650 consultancies, a solution can be found.

How could RCd be applied to the AEC/FM industry?

Regenerative Construction data (RCd) enables increased utilization of data. This can be done through a mechanism we call the PLQ-ADQ-Informationbit chain. This provides a 1) simplified tool for identification and documentation of information purposes; and 2) a process and mechanism for increasing the utilization of information.

By using Plain Language Questions (PLQ), which are straightforward questions phrased in normal human-readable language, decisions relevant to management tasks are identified by the people who actually perform the tasks. PLQs can then be broken down into lower-level component questions. At a certain point in breaking down the high-level PLQ into lower-level PLQs, an Actual Digital Question (ADQ) will eventually emerge. This is a question where it is possible to specify a specific and unique piece of information (an "informationbit") that will help inform the PLQ. Figure 3 illustrates the concept.

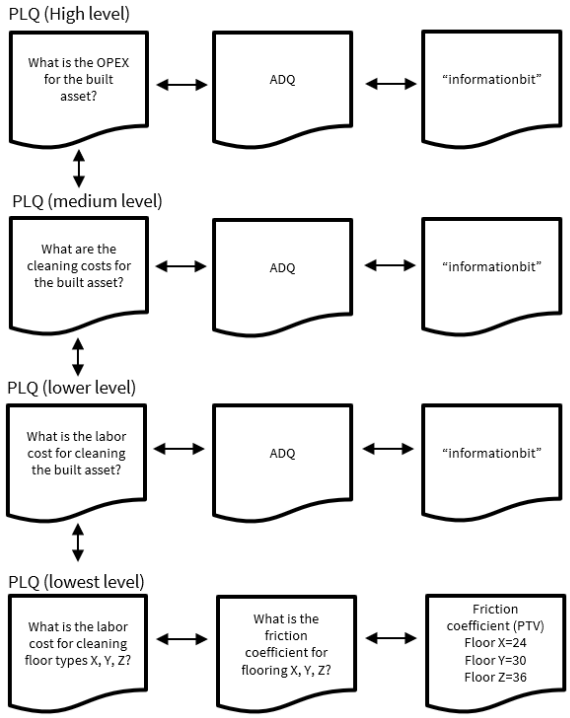

Figure 3: Framework for specification of information at different levels, (Rekve, 2025)

Figure 4 situates the PLQ-ADQ-Informationbit chain into Paul Shillcock's proposal for revision of ISO 19650-2. Shillcock's illustration (not shown in this article) stresses the need for information requirements to be related to a purpose, which again is influenced by the governing perspective.

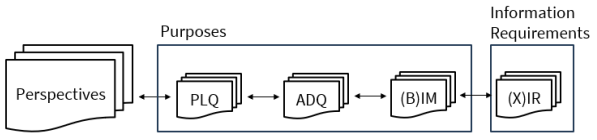

Figure 4: Perspectives, purposes and information requirements (Rekve, 2025)

The key point we want to make is that when roles within the different perspectives start documenting the questions they encounter, using their own "language" (hence Plain Language Question), it is possible to establish a database of relevant questions to the organization/project.

Figure 5 illustrates that when such a database is in place, it is much easier to discover which PLQs and ADQs are informed by the same information bit. The many disciplines and roles involved in the AEC/FM have specialized languages and perspectives. However, even if their corresponding PLQs and ADQs differ, in many cases, the actual information bit will remain the same.

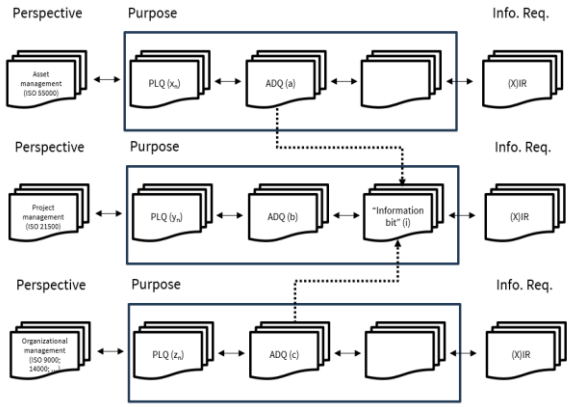

Figure 5: Different perspectives' PLQs will likely be informed by the same "information bit" (Rekve, 2025)

The consequence of this holistic approach to aggregating into relational databases is that it enables scalable solutions. The argument for this approach is based on the premise that "information only has value when it can be reused". If multiple users can reuse its information for multiple purposes, the value of the information increases significantly. Scalability must be embedded by focusing on including metadata (ISO/IEC 11179-1:2023) and interoperability (EIF, 2017).

Hjelseth (2012) describes in Modular BIM guidance how "informationbits" can be combined into task-related modules. This can be done both when the task is predefined, or by describing the process when the task is new. The reuse of information requirement for larger activities is solved by combining modules.

Likewise, when requirements (from EU, nationally, clients) get introduced individually and solved by dedicated (digital) solutions, a minimum solution is, of course, the best way to solve a single case. However, if one prepares for scalable digital solutions, the digital framework becomes critical. An example is included in the next case about information about choices, use and reuse of building products.

Regenerative use of data – Digital Product Passport

The EN-ISO 19650 series of information management standards treats information as a resource, as material, and as work. It is possible to set quality and quantity requirements for data to be delivered to specific

stakeholders at a defined time to meet project needs. The product data sheet is used as an example because it is a required type of documentation used in every project. This has traditionally been paper sheets (often called "safety sheets") following the product. The requirement is driven by laws on health and safety. Table 3 illustrates the paper-based information flow. The driver has been following safety regulations for workers at the construction site. The use of information at each level covers only a fraction of the steps. When this information is digital, individual "informationbits" can be identified and connected to different tasks. As an example can of this information is connected to the users of the building product. This is useful for assembling building products in the production phase. Information is a physical sheet of paper delivered as part of the commercial product.

Table 3: Impact levels and sustainability perspectives - Case: Product data sheet

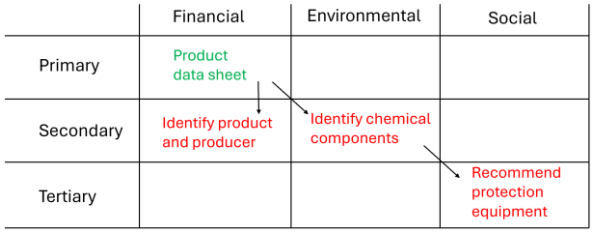

Table 4: Impact levels and sustainability perspectives - Case: Regenerative approach to digital product passport

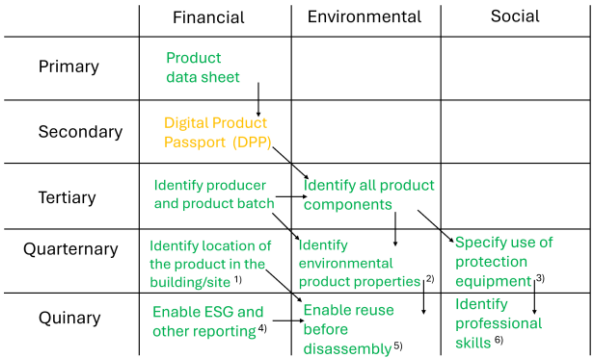

Table 4 illustrates the potential for transforming the information flow in conjunction with regenerative principles for an ecosystem for information reuse.

Supplementary information about Table 4:

1) The use of BIM and GS1 identifications enables location-based identification of each single object.
2) All information, including Environmental Product Documentation (EPD), can be digitally included
3) The use of the product and its environment is known
4) Detailed information elements can be aggregated into defined reporting requirements like the EU-based Environmental, Social and Governance (ESG).
5) All product properties are known, and the product can be marketed for a long time before physical disassembly.
6) Competency to work on the project (like security clearance, certification etc.) is known information.

These capabilities require integrated digital solutions. Almost all of the technological solutions are developed, many are implemented, but not all are integrated. However, the most critical is the change of mindset. The regenerative principles explain how this can be done in practice. The impact of digital product passports today is that without relevant product documentation of the specific product, it cannot be used in future projects.

The result and key takeaway

This method of identifying purposes and information needs has been trialed in the eight-part workshop series with industry participants. It works well because, for most, it is an intuitive illustration of how information always should serve a purpose and serve a particular perspective (project management, asset management, and so on). The link to RA principles is that it sets up the conditions for which the utilization of the medium of value production (information) is increased – using standards and practices already present in the AEC/FM. This again sets up the conditions for which a virtuous cycle of information inputs and outputs from digital technologies.

Practically, "informationbits" can be prioritized and valued. Information has a CAPEX and OPEX. Meaning, it costs money to procure – but also to store and maintain. "Information bits" without a relationship to a PLQ-ADQ are, by definition, not of value, and because of OPEX, a net cost. The associated Information Requirements (IR), if present, can be deleted. In short, "garbage-collection" (computing term) is facilitated. On the other hand, "information bits" with multiple relationships to PLQ-ADQ have increased value. Further investigations can be done to either ordinarily value the "informationbits" – or calculate a specific Return on Investment (ROI) for the "information bit".

It is there interesting to observe (Table 4) that regenerative information management enables (Environmental Social Governance) ESG reporting for "free" as a spin-off at Quinary level due to pervasive digital re-use of "information bits". ESG reporting is, in general (ordered at primary level), regarded as an extra cost. The regenerative management principle for digitalization organizes the information ecosystem in such a way that the outputs from one process are inputs into a new process. This will also contribute to more active use of sustainability, in addition to reduced time and cost.

Conclusions / Summary remarks

This paper intends to initialize a discussion about the mindset for digital transformation and should be seen in the context of calls for transformation of construction (Glass et al., 2022; Chan, 2022). The answers to the research questions are summarized to illustrate the impact of continuing the discussion on both minds for digital transformation.

RQ1: What are the management principles of Regenerative Construction data (RCd) based on Regenerative Agriculture (RA)? – is shortly answered by highlighting the outcomes and processes of RA that lead to an increased utilization of the medium of value creation (soil/land). For RCd, the equivalent management principle would imply the need for outcomes and processes that result in increased utilization of information generated and used by digital technologies.

RQ2: How could RCd be applied to the AEC/FM industry? – is shortly outlining a mechanism (PLQ-ADQ-informationbit), which is in line with existing information management standards in the AEC/FM. A few outcomes of the mechanism are: 1) information needs can be identified and documented independent of specialized knowledge; 2) valuation and prioritization of informationbits are facilitated; and 3) scalable information management can be achieved.

RQ3: What is the impact of RCd on the AEC/FM industry? – is shortly answered by the impact of increased numbers of users, as illustrated in Figure 6.

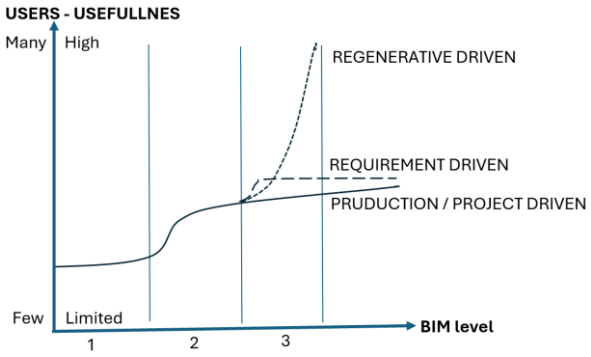

Figure 6: Perspectives for different mindsets for digitalization

- Production/project driven: Use of data is based on support to ongoing activities within the project
- Requirement driven: Can be illustrated by new sustainability requirements, giving an increase in information exchange
- Regenerative driven: Pervasive information exchange resulting from an increase in users and use cases across the entire society. Information is reused, likewise reuse of material and other resources

The locus of management in digitalization within the AEC/FM industry focuses on the content of information in BIM, supporting the economic outcome of the current project. This mindset encourages minimizing the amount of information that must be exchanged between stakeholders in the current project. However, data is only valuable when it is shared. Increasing both the number of users and the purposes for reusing data will, therefore, increase the value of pervasive digital solutions.

A shift towards a regenerative management mindset will, therefore, likely be the most efficient action to increase the reuse of information.

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