BESLI
Business, Economics, Sustainability, Leadership and Innovations
UKRAINIAN-AMERICAN CONCORDIA UNIVERSITY
Joint Scientific Journal

UDC 33.330
JEL Classification Q01

Joseph J. Jacobsen

Diffusing Sustainability

Accelerating the adoption of more sustainable solutions is at the crux of avoiding a complete climate catastrophe. Every nation, industry, business, and individual can improve their sustainability performance. The issue of willingness, perceived and real costs or not knowing how to start may be causal. In this article, methods are given about how adopt sustainability performance improvements impacting respective aggregated adoptions. The objectives surrounding sustainability can be boiled down to three general improvement outcomes: economic/financial, social, and ecological. This article focuses on ecological improvements with emphasis on the human and financial cost avoidance of catastrophic climate change. These methods can be used for social and financial performance by including new data.

Keywords: *sustainability, sustainable diffusion, six sigma, lean*

DOI 10.37659/2663-5070-2022-9-18-26

Introduction

The pandemic clearly demonstrates just how interconnected nations are and that we all directly share in one another's fortune and misfortune. Economic downturns are not confined to national borders, wars effect distant nations while locally they devastate those who had nothing to do with the decision. Natural disasters know no national bounds. Pollution of the environment and depletion of natural resources impacts everyone, some people more than others. Population growth continues at 8 billion today and is scheduled to reach 11.2 billion by 2100. Most of this growth will take place in nations that are the poorest while the very wealthy nations' populations will slow and even decrease (UN, 2019), furthering the wealth gap.

Climate change is an obvious case in point with international consequence, as was chlorofluorocarbons and acid rain. Yet, the issue of greenhouse gas persists and intensifies as people on earth knowingly depend on and accelerate energy use that is largely fossil fuel driven. Accelerating combustion reduction technology, thereby reducing CO_2 emissions, is the only response available that could successfully offset the current increase in demand for energy. And as the 8 bil-

lion people grow to 11.2, they will concurrently increase their consumption of natural resources, all manufactured, delivered and operated by energy. This author is not suggesting a decrease in quality of life or to stop using energy. It is suggested that we use smarter technologies generate power and smarter end use technology that uses less power. Sustainability as an accepted and embraced permanent state of the general economy.

Sustainability is a process and therefore it is not a fixed or predetermined outcome. Our concept of sustainability is consistent with the robustness and flexibility of complex adaptive systems as applied to problem solving within localities, rather than management toward certain specific goals that are preconceived outcomes. Even though there are limits to being unsustainable with respect to ecological systems, the answer to the problem of sustainability is not technology but, diffusion [1]. The diffusion of sustainable technologies and practices throughout world may offset climate change.

Applied difference in diffusion models

Four fundamental diffusion models based on Mahajan and Peterson [2] and Meade and Islam [3] are considered next. What they have in common is that the rate of diffusion is proportional to the number of potential adopters (adaptors of carbon reducing technologies and practices) at a given time *t*. Applied to a sustainable technology or practices, we can measure where we are and and how far we have to go as a simple difference. The principal diffusion differential can be expressed with Equation 1:

$$\frac{dN(t)}{dt} = g(t)[\bar{N} - N(t)] \qquad (1)$$

with boundary condition N(t = t0) = N0, where N = 0. N(t) = commutative number of sustainability adopters at time t:

$$N(t) = \int_{t0}^{t} [n(t)dt, n(t)] \qquad (2)$$

N(t) being the number of sustainability adopters at time t, $\bar{N}$ *= total number of potential sustainable adopters in the system, dN(t)/dt = rate of diffusion at time t, g(t) = coefficient of diffusion, and N0 = cumulative number of sustainability adopters at time t (at time step 0).*

The diffusion differential presented in the equations above is a deterministic rate. It posits that the rate of diffusion of an innovation, sustainable or not, at any time *t* is proportional to the gap of the difference between the total number of possible adopters at that time and actual adaptors [$\bar{N}$ — *N(t)*]. A consequence of this model formulation is that as the cumulative number of prior adopters, *N(t),* approaches the total number of possible adopters in the system $\bar{N}$, the rate of diffusion decreases because fewer are left to adopt.

The form or nature of the relationship between the rate of diffusion and the number of potential adopters existing at *t*, [$\bar{N}$ — *(t)*], is represented or controlled by *g(t)*, the coefficient of diffusion. The specific value of *g(t)* depends on such characteristics of the diffusion process as: (a) the nature of the sustainable technology or practice, (b) communication network employed, (c) social system attributes and of course we can't forget (d) funding. Politics may play into it for nations with low education or bribery by certain industries under the guise of lobbying. In addition, *g(t)* can be interpreted as the probability of an adoption at time *t*. If this interpretation is used, then *g(t)*[$\bar{N}$ — *N(t)*], represents the expected number of adopters at time *t*. Furthermore, if *g(t)* is viewed as the number of system members transferred from potential adopter status to adopter status at time *t*, then *g(t)* can also be considered a transfer mechanism, a conductivity coefficient or a coefficient of conversion. Accelerating the adoption of more sustainable practices and technologies would result in an increase in *g(t)* before tapering off as the difference between potential adopters and those who already have adopted gets closer to zero.

The phrase "carbon footprint" is the same as the phrase "greenhouse gas inventory." Carbon is frequently referred to (I do this too) CO_2 is the predominant GHG emitted from humans as the dominate source of GHG is combustion. However, methane (CH_4) and nitrous oxide (N_2O) are also contributors to global warming or climate change [4].

Sustainable economic decision and development

Energy availability and pricing have become a major determinant of economic development [5]. It should be quite evident, to even the casual

observer, that energy will continue to draw more attention than all other operating costs of supply networks of products and services throughout the world. Between the coal fired steam generators that drove commerce during the industrial revolution and the precisely controlled expert systems of today is an enormous inventory of scientific and technological innovations that have tested the ability of organizations and individuals to adapt to change. One study explains why individuals and organizations avoid change, even when faced with voluminous evidence of impending environmental and economic disaster. Jacobsen and Guestello [6] found that organizational resistance to change, is why energy system actors (data from power and large industrial plant operations) do not adopt clean energy technologies or practices. Conversely, the same study suggests actors in charge of large scale energy users or energy generation would adopt sustainable technology into their operations if the organization was open to such change.

The decision to adopt a clean technology or practice is not always simple. Like most decisions in intelligent organizations that carefully measure and analyze data before moving forward with major projects, the decision to adopt sustainable practices and technologies, should be carefully measured and analyzed. In addition, one practice or technology does not fit all organizations. Adopting the right practice and technology that fits into the existing operational structure could be the difference between success and failure. Therefore, sustainable technologies should be flexible and have an open architecture in their respective expert systems. Relative expert systems are energy management, asset management, maintenance management, fire life safety and access, along with many others that will share data.

Financially, socially, and environmentally responsible organizations are proactive. They respond to changes in their environment and make decisions for the long run that are based on a wide variety of criteria, so they (people and systems) tend to be more intelligent. Because they make decisions for the long run, they tend not to artificially prop up profits and other signals for the next quarter but instead make decisions that result in positive long-term fiscal, social, and environmental health. Additionally, these more robust businesses construct a system that can withstand various pressures from outside sources and turn these pressures into opportunities for themselves and others outside the organization. They naturally gravitate toward reducing energy, water, and materials used in a process, thereby reducing costs and exposure to both political and supplier volatility. They promote the health and well-being of their employees because they are concerned about social justice. Therefore, the employees tend to be more dedicated and work harder because they believe in their organizations. Responsible organizations' values and beliefs have a positive correlation with their actions, as it should be.

Investors and customers are insisting on businesses that demonstrate integrity and responsibility. Responsible people, organizations and even nations are in a state of continuous change and improvement, the improvers are aspiring to be the best they can be. This means assuming responsibility for failures or what might be less than the best practice and doing their best to correct mistakes and become better as a wholly adaptive system [6].

Established economic theory is supposedly based upon the notion of rational actors acting in their own interest, quite linear. Individual actors know about their preferences often based and measured on a utility function concluding with the best decision [7]. Glaser [8] talks about human character traits, multiplicity of existing goods, technologies, emissions, services, etc., making it apparent that the world is not one-dimensional. Thereby, the reasons for gathering and analyzing data rich criteria in the decision and resulting forecast is best served with diverse decision problems. Indeed, the multiplicity of criteria is important just as the multiplicity of actors' perspectives while entering the decision-making process. Criteria is meaningful and plentiful if you consider social and environmental impact.

The first or local internal stakeholders is the most obvious because the problem is likely local and the problem is also why the project begins. The second or semi-global are supply chains that can go in both directions, suppliers that feed the organization or the organization is a supplier who feeds other organizations.

Figure 1 does not represent scale in proportion. It does show that the businesses we try to improve are inside the larger industry sector

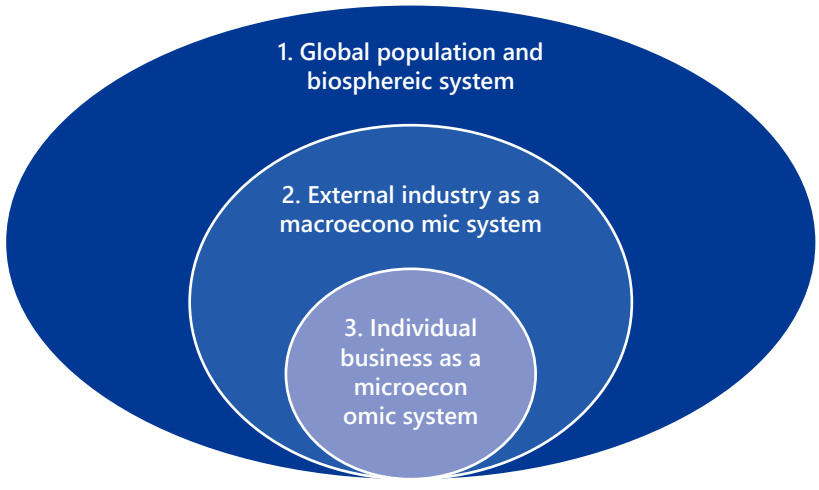

Fig. 1. Solids, liquids and gases continuously entering and exiting three systems

while being connected by a network of supply chains that serves the businesses and the other businesses within the relative industry (education, manufacturing, government, health care are but a few). These industries reside within the larger human population and biosphere. It is the biosphere we extract resources from to make and deliver our products and services (the economy). When those products and services are past their service life, they don't just disappear but rather they return to the biosphere as high-entropy waste, they are pollution that enters the same biosphere we extracted resources from earlier to produce it. Population times per capita resource consumption is the total flow (throughput) of resources from the biosphere to the economic subsystem then back to the biosphere as waste [9]. Matter and energy cannot be created nor destroyed as the sum result remains constant. This means the same amount of energy and matter exits as enters, unless we reintroduce energy and matter to another economic process, circumventing the biosphere for as many cycles that are made with these same atoms. Think about business improvement and often it is about reducing operating costs by being more efficient. We can measure the 1) supply, measure the 2) cost in dollars, measure the reduction of 3) raw resource use from the biosphere and thereby a measure the reduction in 4) waste going back to the biosphere. Efficiency with resources is another way to reduce waste, in fact, efficiency means reduce waste. Businesses' working to reduce the negative effects of climate change measure their CO_2 by a simple conversion ratio. As organizations engage in projects and improvements using methods like Six Sigma and Lean to reduce cost they can easily include CO_2 and other waste pollutants as key performance indicators in the same project.

FESUP

In conventional everyday conversation when you hear fess-up, it suggests that one admits or confesses (hence fess up) to something they did that was wrong and should thereby make it right. It implies that someone lives up to his/her confession with obligation to correct the problem that he or she contributed to. In terms of sustainability, it is only fitting that we all take responsibility because we all contributed to these problems along with the help of billions of people. We all have contributed in one way or the other to environmental problems such as climate change, for example. We also contributed to social injustice because sometimes we don't speak out or do business with businesses that may be unethical.

The Financial, Environmental and Social Unity Project or FESUP is a stretching devise used for improvement projects that use data for decision making. The concept is to engage in an economic/financial improvement project that expands (stretching) to social and/or environmental improvement. Measurement is at the center of every meaningful FESUP [5]. If we fail to measure in specific units, we have no real solid evidence to see or show to others that the improvement project rendered specific positive results.

FESUP with Six Sigma

Projects involving model testing, experimentation, numerical simulations, or some real-world application can be constructed in the standard Six Sigma format. A skeletal Six Sigma project outline should be like in Figure 2.

Six Sigma is fundamentally a specific method that organizes an improvement project into five sequential sections with preliminary and ending matter (see Figure 2). You will see this throughout higher level Six Sigma and other continuous improvement literature as the DMAIC process. Like an econometrics, operations research or other type of quantitative scientific research project, the Six Sigma method relies upon measures in specific units. Empirical (real-life) data is collected through an instrument such as sensor signaling using digital technology, a survey, expert system, human observation monitoring, history files, billing statements and invoices, records, test results and the list goes on. The data is used to populate a spreadsheet where descriptive and inferential statistics can be used to show differences and relationships as well as create tables and figures to help people understand what changes will take place and after the improvement, evidence of success or not. The most important positive attribute of Six Sigma is that it can yield successful results from every industry known, thereby a good fit for reducing CO_2. Costs, energy, distance traveled and materials converted to CO_2 separately to report out several important consequences concurrent.

Six Sigma projects can be used in manufacturing, health care, government, business operations, education, utilities, agriculture, logistics i.e. virtually every kind of industry and respective organization imaginable. Below in Table 1 are some examples of Six Sigma projects to go after when selecting a project and drafting the respective project prospectus or proposal.

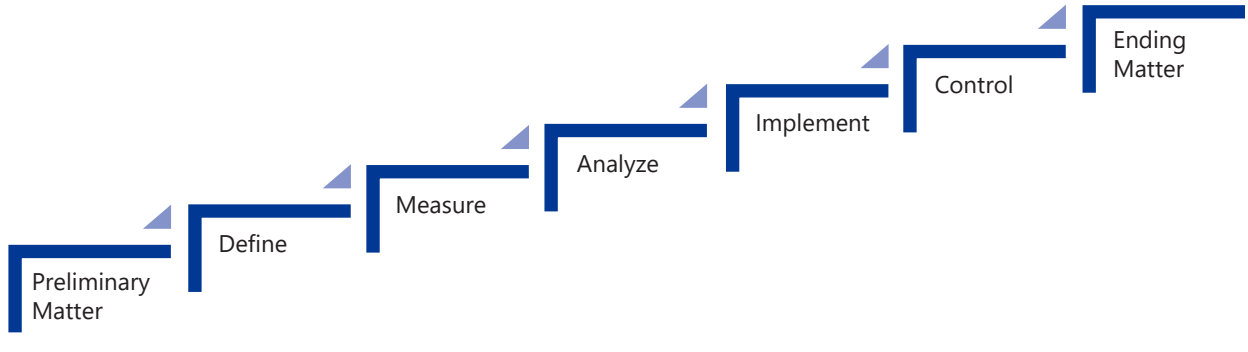

Fig. 2. Six Sigma paper structure

Table 1. *Examples of possible projects using Six Sigma and Lean*

The project improves efficiency of process (transportation and distribution issues, materials, water and energy throughput, streamlining, excessive distance, weight issues and other un-necessary cost)
The project improves an existing process (a series of activities that creates some sort of output/result for internal or external customers)
The project attacks quality issues (defects, scrap, rejects, returns, rework, customer complaints, warranty costs, late receivables, lost business, lost time, excess inventory, unplanned expediting, data redundancy, product nonconformance)
The project attacks specific waste
The project attacks cycle time, throughput, transactional, or hand-off issues
The project focuses on processes that affect what the customer views as valuable
The project attacks highly variable process outputs or processes that have excessive "firefighting" by management, or are only resolved by throwing money at the symptoms. A slogan appears often in Six Sigma literature: variance is your enemy
The project attacks internal or external compliance issues (meeting quotas, standardization alignment, accident frequencies, environmental sustainability, codes or other regulations)

The essence of Sig Sigma is data. The measure and analysis sections are the foundation for the right decision. Six Sigma brings new quality and productivity improvement and its fundamental principles are grounded in total quality relative to errors, waste and efficiency.

Initially reducing environmental degradation was not the primary objective of Six Sigma. Yet, it is capable of achieving environmental performance such as reducing air emissions, energy consumption, water consumption, wastewater [10] materials and food waste. Process variation has a negative impact on overall sustainability performance of an organization as deviating from the specifications results in defective products as well as unnecessary resource and energy consumption. The environmental impacts of Six Sigma are viewed as a "by-product" [10]. These by-products in economics are commonly referred to externalities. In essence, we are concurrently collecting economic data, converting the respective resource reduction and reporting both, killing two birds with one stone. Table 2 below briefly explains the DMAIC structure.

FESUP with Lean

While Six Sigma is a distinct structure (DMAIC) used to organize and execute improvement projects, Lean is a toolset where you use the right tools and techniques for the job and thereby the selection of the appropriate tools and techniques to solve a problem and reduce waste [11] that, in our case, will result in improving sustainability performance. In addition, if the project's objective is to reduce waste, especially when considering a sustainabile technology or practice improvement like being more efficient, Lean should also be considered. Both Six Sigma and Lean (Lean Sigma is often used when combining methods and tools) organize and implement improvements resulting in a higher coefficient of diffusion of sustainable technologies and practices. Eight sources of waste [5] have been identified as frequent offenders in business and industry (see Table 3). The waste can be financial, social and environmental or any combination.

Most managers would like to develop an ability to detect and identify waste as a matter of routine as they move about during daily activities. Waste sources have been identified by top Lean experts [12]. Knowing these eight sources will help us recognize potential waste and actual waste. The first source of waste is an important because it relates to peoples' health.

By reading through these 8 sources of waste (table 3), you can clearly see the connection between Lean and Sustainability. In fact, Lean implies reduced fat, unwanted throughput, that when corrected, results in a more sustainable business or industry.

Efficiency is never 100 % so it is our goal and responsibility to come as close to 100 % as possible with the resources we use, be they physical or social. The laws of thermodynamics are clear that no process is 100 % efficient and we always incur some loss of usefullness. Efficiency (Figure 3) projects are good for the financial bottom line and the environmental bottom line. Efficiency is simply 100 % input in the numerator

Table 2. *A condensed explanation of DMAIC*

Define — Introduction to the problem, history, context, importance, proposed solution/s, actors, SIPOC figure
Measure — Specific units of measure, sample gathering, where your data came from, issues with data, spreadsheet population, show all relative descriptive statistics with tables and/or figures
Analyze — Inferential testing, for example: paired sample t-text, regression modeling, ANOVA, correlations, chi square. Additionally: tables and figures, explanations and interpretations, APA documentation of tables and figures, if modeling — formalize equation
Improve — Based upon the analysis, make the decision to move forward or not, describe how you will implement, potential obstacles, describe how you will handle obstacles, people involved and how they will be informed and how they can help, and fully implement the improvement. Develop a new SIPOC process after improvement has been made
Control — describe how you insure the new system will continue to deliver, provide a quantitative limit figure (run chart with limit imposed), describe if it will be a digital signal, flag, auto message, self-correcting sequence of operations, or some other monitoring system (human for example) or some other way. Describe how you will collect performance data to insure the solution continues

Table 3. The Lean eight sources of waste

1. **Injuries** are considered the highest level of waste because it compromises an organization's most valued resource, people. From an ethical and social responsibility perspective, injuries are at the top of the prevention list. A great deal of our understanding of accident analysis and prevention can be drawn from the workplace, although, there are plenty of examples we can learn from by examining the causal mechanisms of accidents at home and in the public way [13]
2. **Inventory** is another source of waste. Racks, off-site storage, space planning and usage, warehousing and materials handling and transportation overages are all added expenses that eventually impact the price of the final product thereby creating a competitive disadvantage for the business
3. **Overproduction** is similar because overproduction winds up in storage and storage is ultimately inventory
4. **Waiting time** is a departure from the physical properties of overstocks. Waiting time imposes a burden upon the next step in the production or service process or worse than that, it imposes a added burden on the customer
5. **Motion** is another culprit in the cost chain. Hands, arms, legs, walking, running and such are many times ignored because of the difficulty in requesting that people change their physical movements. It is very personal and unless there is a positive relationship between the worker and the person asking the worker to change their movement, tension and resentment may emerge
6. **Processing** must be designed properly. Oversized machines are common and use too much energy and have larger amounts of scrap. Scrap bins and too many machine steps are both the result of poor process design
7. **Transportation** is an obvious cost factor at many levels. Forklifts, pallets, racks, conveyors, trucks and carts are all added expenses and using energy to transport materials from one point to another does not add value to the end product. At a larger scale, trains, busses, planes and ships use tremendous amounts of energy and time and therefore add considerable cost to the end product. The mango I ate last night at my kitchen table had a final cost one dollar and thirty cents. The farmer who grew the mango received about a penny
Suppressed 8. **Talent** is source of waste that affects the entire organization, is usually structural and is the most emotionally harmful source of waste a business has. This is the kind of waste is very difficult to rectify because its effects on employees persists over extended periods of time. Many times, this kind of human waste is a function of jealously, gender, race and age preference or other demographic discrimination. This is a common source of human waste in male dominated organizations or businesses that actively indulge, give preference to and promote people within the same demographic profile. As a result of these limitations in diversity, innovation and creativity are stifled, groupthink endures and therefore responsiveness, inventiveness and competitiveness are reduced and profits forgone. Organizations that give preference to demographic groups constrain talent and therefore fail to reach their highest potential

and the respective output in the denominator rendering the efficiency rating. The loss is our target. Before and after an improvement is made we measure the efficiency to determine exactly how much better the system is performing in specific units of measure.

Both the Six Sigma and Lean proposal is brief but it is important because it means you put a steak in the ground and are prepared to move forward with a project. The proposal will be reviewed by others such as classmates, instructor, black-belt, work peers, subordinates or bosses, for example. You should solicit feedback and take into consideration what they are saying, be it positive or negative. The basic proposal structure I have used for years while teaching working adults Lean and Six Sigma is a simple one page document:

- Title — standard APA student research paper title page.
- Abstract:
  - one paragraph (with key words under abstract).
- References:
  - one book and one academic peer reviewed journal article.

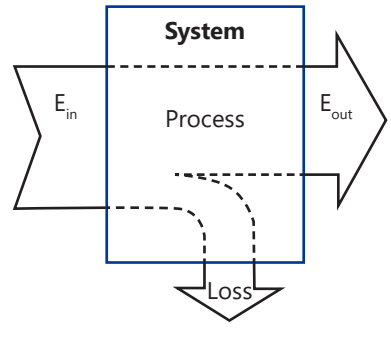

Fig. 3. Process efficiency: Ein is always 100 %, Eout is the useful output and loss is waste

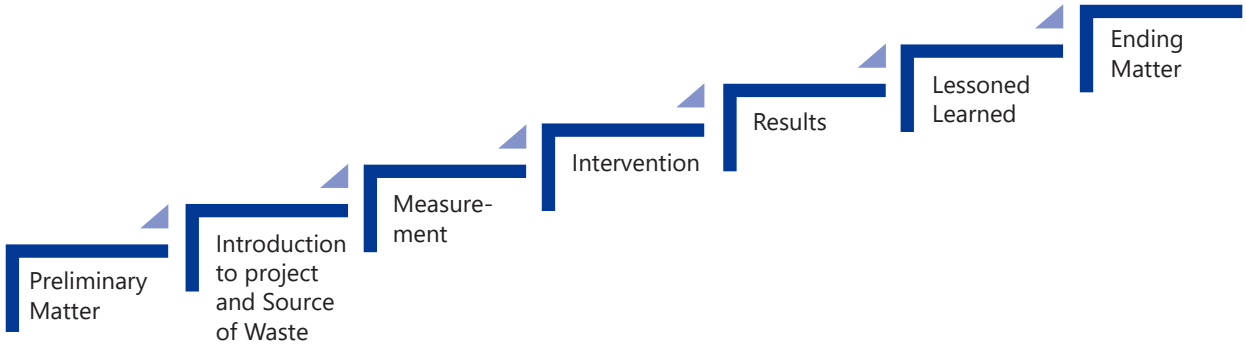

Fig. 4. Lean paper structure

- Indicate the measures, where data will come from and what results will be expected.

The write-up of the Lean project follows the kind of structure you see in Figure 4. Variations are possible. A very high level project that requires extended research may require the formality of the scientific method. This is reserved for those who would like to publish in academic peer reviewed journals. If a Six Sigma or Lean project has very important outcomes that others may benefit from, it is possible to convert the Six Sigma or Lean structure to a more formal scientific structure.

It is suggested that this brief overview of how to use two traditional methods of continuous improvement that have stood the test of time will help to diffuse or spread more sustainable technologies and practices in business and industry, private or public, profit or nonprofit. I hope this article helps you and others to enter a FESUP.

References:

1. Jacobsen, J. (2010). Some basic concepts from sustainability. Society for Chaos Theory and Psychology and Life Sciences Newsletter (special themed article collection on nonlinearity and sustainability), 18(1), 7–11.
2. Mahajan, V., & Peterson, R. A. (1985). Models for innovation diffusion. Sage University Paper Series on Quantitative Applications in the Social Sciences. Sage Publications.
3. Meade, N., & Islam, T. (1998). Technological forecasting — Model selection, model stability and combining models. Management Science, 44, 1115–1113.
4. Franchetti, M., & Apul, D. (2013). Carbon footprint analysis. CRC Press.
5. Jacobsen, J. (2011). Sustainable business and industry. Quality Press.
6. Jacobsen, J., & Guastello, S. (2007). Nonlinear models for the adoption and diffusion of innovations for industrial energy conservation. Nonlinear Dynamics, Psychology, and the Life Sciences, 11(4), 499–520.
7. Ballari, F., Thomas, F., Alexia, P., & Scheffran, J. (2006). Agent-based computational modeling: Applications in demography, social, economic and environmental sciences. Springer.
8. Glaser., B. (2002). Efficiency versus sustainability in dynamics decision making: Advances in intertemporal compromising. Springer-Verlag.
9. Daly, H., & Farely, J. (2011). Ecological economics: Principles and applications. Island Press.
10. Chugani, N., Kumar, V., Garza-Reyes, J. A., Rocha-Lona, L., & Upadhyay, A. (2017). Investigating the green impact of Lean, Six Sigma and Lean Six Sigma. International Journal of Lean Six Sigma, 8, 7–32.
11. Summers, D. (2011). Lean Six Sigma: Process improvement tools and techniques. Prentice Hill.
12. Farrukh, A, Mathrani, S, & Taskin, N. (2020). Investigating the theoretical constructs of a green lean six sigma approach towards environmental sustainability: A systematic literature review and future directions. Sustainability, 12(19).
13. Guastello, S. (2006). Human factors engineering and ergonomics: A systems approach. Lawrence Erlbaum Associates.
14. Breyfolge, F., Cupello, J., & Meadows, B. (2001). Managing Six Sigma. John Wiley & Sons, Inc.

Якобсен Дж. Дж.

Поширення сталого розвитку

Прискорення прийняття рішень для забезпечення сталого розвитку є ключовим фактором попередження повної кліматичної катастрофи. Кожна країна, галузь, бізнес та окрема людина можуть покращити свої показники сталого розвитку. Однак питання готовності, передбачуваних і реальних витрат або незнання, з чого почати, можуть бути ключовими факторами, що цьому перешкоджають. У цій статті пропонуються методи впровадження вдосконалень у системі забезпечення сталого розвитку, що впливають на сукупні обсяги впроваджень. Цілі, пов'язані зі сталим розвитком, можна звести до трьох головних наслідків підвищення ефективності: економічного/фінансового, соціального та екологічного. У статті розглянуто передусім екологічні вдосконалення й акцентовано увагу на уникненні людських і фінансових витрат, пов'язаних з попередженням наслідків глобальної зміни клімату. За умови включення нових даних пропоновані методики також можуть бути застосовані для оцінки соціальної та фінансової ефективності.

Ключові слова: *сталий розвиток, поширення сталого розвитку, шість сигм, six sigma, ощадливе виробництво, lean*