Enhancement of efficiency and sustainability of CE by adopting agile management methodologies for professionalization of educational network and program development

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Abstract

The development of continuing education is becoming more complex and more complicated, because the demands to education and training are growing, information overload is getting higher, knowledge is faster outdated, quality standards becomes more important, complex research and work environments require stronger crosslinks, and new technologies open new kinds of methodologies. Single organizations for higher education are going to merge their further activities in networks to be able to cope with the difficult tasks in an efficient and sustainable way. The development of innovative, multinational and interdisciplinary programs of CE is more and more professionalized by using the latest methods of management sciences. Therefore, it is useful to complement the system by adopting the latest development in dynamic system management. The transfer of the SCRUM approach to the planning and realizing of complex international and interdisciplinary programs in networks of higher education will be discussed and related to case studies.

Introduction

The globalization of the processes of various social fields and organizations takes course very dynamically and leads to dramatic changes. The central issue is the lack of professionals, because the development of educational resources clearly lags behind the needs from administration, politics, economy and industry. Therefore many organizations trust in fast growth and pragmatic solutions. This is in a way acceptable to certain developmental stage, when it is understood and exercised in context to a prototypical development. That is why; it is essential that:

- The interests of all stakeholders can be permanently gathered, evaluated and defined.
- The base processes and functions of the educational systems can be developed and tested.
- The risks and errors of the systems can be identified at an early stage.
- The demands from and concepts of the quality management can be formed from scratch.

A serious problem of the current trends in the educational landscape is that this prototypical development is continued evolutionary in many cases. Thereby pragmatic blueprints and solutions are permanently pinned to the systems. If the systems will reach a certain dimension, they become hard to handle with the implemented management methods:

- The systems become more and more inefficient.
- Their complexity and complicacy is not controllable anymore.
- Their efficiency decreases.
- Their sustainability cannot be insured anymore.

That is why; it is reasonable, to set a break after the prototypical approach when carrying out the introduction phase of new systems for education and advanced education. The experiences and findings from the development and application of the prototype are used to create a systematic and periodically funded solution, which then replaces the pragmatic approach. At that point of possibilities of the modern management for design of complex and elaborated application systems in education should be utilized.

Strategic considerations in developing educational concepts and organizations aim first and foremost for the efficiency and sustainability of the solution. Vital challenges are the further development of the networks, in which different stakeholders and target groups act together, as well as modularized and seminal study programs. One possibility offered by new management approaches and methods is derived from developments of systems and software packages in kind of agile approaches which are widely used in the field of project management. They are primarily applied to cope with the dynamics of system development.

The transfer of the agile management methods to the design of educational networks and study programs leads to a professionalization of the development of educational systems in general and of advanced education in particular. The design of global educational systems with various objects and relation between those objects is carried out with the help of modern management approaches which include the agile methods. This represents the only way in which international educational networks and global study cooperation will work successfully, efficiently and sustainably in the future.

**Complexity of global learning and continuing education**

A system is described as a certain amount of elements which have relations with one another. Thus, if it is a large system, it contains a large number of elements and relations. Interdisciplinary awareness models are developed to understand the structure and functionality of systems and to describe and interpret complex phenomena. Global systems for general and advanced education also contain a great variety of objects and relations. Therefore they are complex structures, which phenomena can be predicted through analysis of their composition and functions. The originator of the general system theory assumed that principals being immanent for the system according to the inductive method are also relevant for other systems. Among those principals are complexity, self-organization and feedback. [1]

Therefore, the systematic exploitation and the system theoretical explanation of phenomena in global learning in connection with processes of advanced education require to understand the term of complexity in an organizational context. Due to this approach, complexity is a “Condition of having many diverse and autonomous but interrelated and interdependent components or parts linked through many (dense) interconnections. In the context of an organization, complexity is associated with (1) interrelationships of the individuals, (2) their effect on the organization, and (3) the organization's interrelationships with its external environment.” [2]
The theory of complexity is founded on concepts, which should help to explain phenomena of complex and large systems. It is furthermore connected to a variety of other theories, as there are for example information theory, chaos theory etc.

Therefore, global learning and advanced education are subjects, which:

- can be characterized by attributes of large and complex systems
- interact with a large number of objects and relations
- can be described and analyzed with the help of system theory and complexity theory.

If global learning and advanced educational system are to be enhanced further, implemented and used sustainability, it is necessary to adapt and apply the management principals derived form system theory and complexity theory. There is a direct relation between cybernetics and management. Cybernetics directly influences modern management in organizations. [3]

Following the line of argument, modern management methods have to be used deliberately for large systems and networks as well as complex organizations to improve the continuous learning process efficiently and sustainably. It is possible to adapt and transfer general findings and methods of management studies to the area of education.

**Management approaches in learning organizations and processes**

Recently, the management development is characterized by the shift from improving the effectiveness of the organizations process and managing their operations to project focused organizational culture. Therefore, strategic planning and strategy execution, business operations and project activities, enterprise architecture and information service architecture, etc. will be merged by turning from the operations work (run-the-business) to the project approach (change-the-business). The change is based on a six-pillar framework. [4]

![Critical success pillars for the change in management](image)
Learning organizations are changed from the monolithic study program system to the modular-design system for diversified and target-group-specific flexible offers for the acquisition of defined competences. The objectives for the change of the learning objects and competences are dominant in comparison with learning and teaching processes. The CE as part of the learning systems will be provided in this way and opened for the new developments and challenges of modern management including the complete spectrum of classic operational as well as the new project approaches.

The well-known methodology and methods of contemporary management can be applied for the development and implementation of the systems. They should be adapted for the use in the scenario of network development, knowledge and competence management, etc. In this way for example, mind mapping will get the character of competence or knowledge mapping, multilayer modelling will become multilayer network modelling, the BSC will be used as knowledge transfer score card, and the Adaptive Performance Measurement Systems (APMS) for controlling by KPI’s will adapted to a competence APMS. [5][6][7][8]

Fig. 2: Adapted general methods as particular methods for educational system management

The dynamic of system requires that besides statistical approaches, methods of management have to be used, with which the alterations can be displayed chronologically, with regards to content, as originally planned, etc. The management has to be flexible, adaptable, and ergo agile.
Dynamic system management and agile management methodology

The Dynamic System Management itself is a time-dependent management approach and is based on methods, procedures and tools, with which the dynamic of systems can be displayed. In many areas it becomes more and more important to adjust to constant changes in the ongoing processes, functions, projects, et cetera. The approach requires new forms of management and of the corresponding methods. Principals of the design of dynamic development methods of systems are more and more transferred to the world of management. The Dynamic System Development Method has been designed as a framework for the methodology of software development. Afterwards, it was generalized as agile project framework. Principals like: [9]

- The active user involvement is imperative.
- The teams must be empowered to make decisions.
- The focus is directed on the frequent delivery of products.
- The fitness for business purpose is the essential criterion for acceptance of deliverables.
- The iterative and incremental development is necessary to converge on an accurate business solution.
- All changes during development are reversible.
- The requirements are baselined at a high level.
- The testing is integrated throughout the life cycle.
- The collaborative and co-operative approach between all stakeholders is essential.

can be transferred to other management levels and areas in the organization and are applicable for adjustable systems. [10]

Static forms of modeling are complemented by dynamic methods from the modeling experience. Class and structure diagrams as a display of a static condition together with activity and sequence diagrams as a display of dynamic aspects form a collection of methods, which is designed and used as a holistic approach in context of the Unified Modeling Language. [11]

Nowadays UML is not only used in system and software development, but also as to model work and production systems, planning and control systems, in project management, etc. and is also applicable for specific tasks for the design of learning systems.

While the Frameworks of the Dynamic System Development are developed for the application in specific areas of management, new possibilities arise for the use of agile methods for specific management tasks, for example in the area of continuing engineering education.

A variety of interpretations of the term of agility exist in the scientific literature. Even early definitions of the term contain fundamental statements which are still valid today: “Corporate agility or the ability to react quickly to changing circumstances.” [12]

Over the time the term has been more broadly used and defined under various aspects. An important milestone marks the abstraction, that agility is “an effective integration of response ability and knowledge management in order to rapidly, efficiently and accurately adapt to any unexpected (or
unpredictable) change in both proactive and reactive business/ customer needs and opportunities ... “. [13]

The term of agility is increasingly used more precise and adapted to the essential perceptions of software development via project management up to organization theory. Agility has many attributes, which can be stratified and structured in dimensions like human resources technology, value chain integration, continuing engineering and knowledge management. [14] Conceptual models are derived from these approaches (Fig. 3)

![Conceptual model for agile manufacturing](image)

Fig. 3: Conceptual model for agile manufacturing [15]

An important issue for the application of agile methods in the organization is the reference to organizational theories, self-organization and teamwork, because thereby aspects of continuous learning and knowledge management in context of advanced education have to be viewed in excess of the term of flexibility. [16] Therefore, agile methodology in organizations is already theoretically related to continuing engineering as a dimension and conceptual trait.

**Auf Challenges of global networking and engineering education**

The globalization implies the acceleration of the development of knowledge, technology, cooperation, etc. related to an extreme rapidness of the changes and transformations in all spheres of life. Learning moves center stage in this context. There are five main streams:

- The societies and economies have experienced a profound transformation from reliance on an industrial to a knowledge base.
- There has been a strong focus and progress in measuring the learning results.
- Education has been reformed and reformed again and becomes a continuing process of change.
- The rapid development and ubiquity of ICT influence the further learning environments.
- The research base on learning grows.

Therefore, the framework conditions for the recent development are the global knowledge society, the lifelong learning, the competence outcome orientation, the entrance of the new millennium learners,
the demand for quality-driven reforms, the burgeoning research on learning, and the development of learning environments. The continuing engineering education is a special manifestation of learning, based on:

- Activities carried out by the learner in a proactive way,
- Learning focused on knowledge and competence outcomes,
- Integration of knowledge structures,
- Balance of the acquisition of concepts, skills, and meta-cognitive competence,
- Building complex knowledge structures from basic knowledge objects bottom-up,
- Utilization explicit knowledge from the external world for organizing implicit knowledge in the mind,
- Constrains of capacity limitations of the human information-processing abilities,
- Dynamic interplay of emotions, motivation, and cognition,
- Creation of transferable knowledge structures,
- Requirements with regard to time, space, and efforts.

The cornerstones have direct implications on the design of effective learning environments as well as the development of learning processes and systems by innovative projects. [17]

Distance learning systems are characterized by three main directions: [18]

1. **The credibility** embedded in the behavioral consistence (scale of intermediate theoretical construction), the structuring (scale of modularity, system architecture, and formatting), the explanatory (descriptive power, cognitive penetrating, epistemological adequacy), and the heuristic power (scale of inference, scale of prediction, scale of learning, scale of self-control)
2. **The functionality** composed by the precision (repeatability and verifiability scale, demarcation scale), the economy (scale of economy of methodology and resources, scale of methodological simplicity), and functional efficiency (scale of rules representation, scale of combining procedures with structures)
3. **The effectiveness** characterized by the openness of the systems (scale of extensibility, scale of elasticity), the relative generality (scale of morphology, scale of a range), and the utility (scale of defining the practical implementation, scale of warranty or pragmatic purposes).

If the cognitive approach will be matched with the needs of management, then three levels have to be considered: [19]

1. **Macro level** - Distance systems and theory: access, equity, ethics; globalization of education and cross-cultural aspects, distance teaching and institutions, theory and models, research methods and knowledge transfer
2. **Meso level** - Management, organization and technology: management and organization, costs and benefits, educational technology, innovation and change, professional development and faculty support, learners support services, quality assurance
3. **Micro level** - Management, processes and functions: instructional design, interaction and communication in learning communities, learner characteristics.
All of these approaches, theories, concepts and characteristics must be considered if education networks and programs are developed in an efficient and sustainable way. Therefore, the latest opportunities of the management theory and practice have to be applied in order to succeed with the challenges of the recent development of the education in general as well as the continuing engineering education in particular. The agile management framework is a mighty methodology approach for that.

**Use of agile methods for networking and engineering education**

Agile methods are primarily used in the area of software development, which is mainly carried out in form of projects. Therefore, agile approaches have been inevitably transferred from software development to project management. Guidelines of agile software development can be used in management processes:

- People and their interrelation are more important than processes and tools.
- Efficient systems are more important than extensive documentations.
- Cooperation between the stakeholders are more important than contracts.
- Flexible response to occurring changes is more important than fixation on inflexible planning.

Therefore, the following characteristics of agile methods are generally applicable:

- Iterative-incremental approach: fast design of a functioning system, which is improved and expanded gradually
- Timeboxing: cycle through iterations in defined time segments with a flexible adjustment of the contents
- Self-organizing teams: equality of all members within the team, which works autonomously, that is to say is self-optimizing
- Modification-friendly project culture: simple realization of changes without the restrictions of a change.

A discrete methodical framework for agile project management independent from software development can be focused on two dimensions: customer value through innovative products and collaborative leadership. The procedure in agile project management is influenced by inspiration, the repeating cycle through the step sequence, thinking, trail and error, as well as the completion. Studies show, that agile methods should be mainly used, when the following conditions are existent:

- manageable projects with a limited number of stakeholders and at most medial criticality
- dynamic environment with high change rates
- high rate of highly qualified professionals in the team
- organic business culture with enough creative leeways for the members of the team.

The constraint to professionalization of the management of educational systems and projects, especially in non-classic manifestations like in the target group-oriented continuing education, leads to the necessity to transfer agile methods into this area of application. Mainly the mentioned general requirements of the manageability, the straightforwardness, the dynamic, the variety of changes, the personal qualification, and the unique academic organization culture allow the use of agile process
models and methods on the creation of networks and engineering education. The process is simplified by the affinity of engineering-driven methods in the area of systematic system development, among others by agile approaches, and the educational subjects of continuing engineering education. [20]

Agile methods like SCRUM are considered and used as a challenge and opportunity for the professionalization of management in terms of an efficient and sustainable development of continuing engineering education. SCRUM is a lightweight management process that contains different approaches applied in projects of various extents. Starting point is the release plan supporting the time triggered approval of the achieved stage of development. The real process model is characterized by a product vision, which is the base for a constantly modifiable backlog, from which short sprints are derived and implemented in fixed intervals. The process is cycled until a result is available or a modified requirement compels to realize another cycle. (Fig. 4)

![Fig. 4: Basic model of SCRUM](image-url)
The three main roles in the phase of the implementation are product owner, SCRUM team and SCRUM master. They are complemented by the external roles of user, buyer and management. The following basic characteristics are relevant: [21]

- Manageable teams to support the communication and the exchange of information
- Adaptability regarding changes of all different kinds
- Frequent and repeated creation of new versions
- Partitioning of the main tasks in small, independent sub tasks
- Possibility to finish the project at any appropriate point of time respective to chronological, financial, personal, etc. reasons

SCRUM was for example used in a decelerated form for the development of educational networks in the first phase as well as for curricular development in several study programs.

**SCRUM for educational network development**

Educational networks are becoming increasingly important in order to operate the ever increasing requirements for customer and target group-specific, multi-cultural, national and international educational systems efficiently and successfully using the method of pooling of the resources. Examples are regional partnerships for better profiling of individual educational institutions in the network, regional cooperation networks for the multiple use of existing offers at several locations, and international educational networks for transnational professionals provisioning for the globalized economy. Agile methods of project development related to these networks are well suited due to the high dynamics of development, the complexity of the task and the fluctuating resource provisioning for expanding. If the method "Scrum" is used in this context, then an agile network development can be carried out (Fig. 5)

The Scrum team works together in the project and is responsible for the realization of the project objectives. It consists of the product owner, the scrum master, and the development team. The project owner has the overall responsibility for all development tasks and steps. He forms the team and designs the processes with regard to the scrum framework. The role of the project owner in educational network projects can be assumed by a main coordinator. The scrum master is the coach, the facilitator, and the leader in the project. He takes over the coordination of the activities of the different partners, leads and supports the team in all aspects in order to make the project successful. A part coordinator or a departmental coordinator, for example, could assume the role of scrum master in an educational network. The development team consists of a diverse, interdisciplinary group of professionals who are responsible for pushing the project progress. The different specialists of the educational networks partners form for instance the educational network development team. [22]
| Educational Network Preliminary Planning | The essential requirements and framework for the network development can be defined. For this, a rough planning is carried out including among other things the objectives and the deadlines for the project and innovation processes, for example by using milestones. The stakeholders and the roles in the network are determined. The roles of education providers, of the network developers and operators as well as the education demanders have to be defined. Initial planning concerning the resources will be performed. |
| Educational Network Backlog | A first basic collection of the requirements for the targeting results is created. This includes, for example, the amount of the minimum or maximum of partners included in the network development. Furthermore, the sprint tools, concepts and tools have to be added. The necessary process steps are predefined for the processes. The Network Owner is permanently responsible to maintain and to complement the list of requirements. For example, stakeholder analysis must be performed. |
| Educational Network Sprint Planning | The objectives, requirements, and activities for the current sprint are summarized in a sprint plan for network development. The network master ensures the organization of an effective sequence of the sprint. A multi-level architecture for design decision-making processes will be installed, for example, which may consist of consortium, steering and technical committees. |
| Educational Network Sprint Backlog | The network backlog is generally executed in several stages. The requirements are continuously collected and managed in the sprint backlog in order to be able to incorporate the latest requirements for each sprint. The requirements are organized into lists generated as the results of meetings involving the various educational network partners, the network developers, educational demanders, educational network supporters and other specialists. |
| Regular Scrum Meeting | If the requirements are known and prioritized, they can be gradually fulfilled. The teams will regularly meet with other stakeholders internally or externally to discuss and to determine for example the network structure, the network extension, the demand for education at different locations, the provision of resources for separate knowledge nodes, etc. |
| Educational Network Review | The reviewing for the gradual development of the curricula is required to match the achieved level of development with the requirements for the sprint. The results are provided in several aggregation forms for the various decision-making committees as well as reviewed and approved by technical committees, project teams, consortial sessions, board meetings of stakeholders, etc. The strengths and the weaknesses are considered retrospectively in order to be able to carry out the further manifestation of the educational network even more efficiently. |
| Educational Network Release | If multiple sprints have been passed through and a functioning stage of development of the network has been reached, a release of educational network can go into practical use. For example, a limited number of education providers begin to distribute and to offer a defined choice of educational programs using the network. As new challenges, for example, are presented to complement the network, the agile process of network development is initiated again in a follow-up project. |

Fig. 5: Generic application of Scrum for the development of educational networks
**SCRUM for curricular development**

Knowledge structures and knowledge contents are changed in ever-shorter periods of time, since the recognition process progresses rapidly. Therefore, study programs and content must be adjusted more frequently. The substantive changes are superimposed by new forms of organization in the education sector in the context of the globalization as well as by new possibilities of the methodology and the use of modern technologies. Agile methods are eminently suited to respond to this particular development requirements in education projects. If Scrum will be used as a method in this context, then an agile curricula development could be made (Fig. 6)

| Curricula Preliminary Planning | The essential requirements and framework for curriculum development can be defined. For this, a rough planning is carried out including among other things the objectives and the deadlines for the project and innovation processes, for example by using milestones. The stakeholders and the roles in the network are determined. The roles of education providers, of the content developers as well as the education demanders are defined. Initial planning concerning the resources will be performed. |
| Curricula Project Backlog | A first basic collection of the requirements for the targeting results is created. This includes, for example, the amount of the minimum or maximum of curricula to be developed during the sprint including content, structure and study materials. Furthermore, the sprint tools, concepts and tools have to be added. The necessary process steps are predefined for the processes. The Network Owner is permanently responsible to maintain and to complement the list of requirements. For example, stakeholder analysis must be performed. |
| Curricula Project Sprint Planning | The objectives, requirements, and activities for the current sprint are summarized in a sprint plan for curricular development. The scrum master ensures the organization of an effective sequence of the sprint. A multi-level architecture for design decision-making processes will be installed, for example, which may consist of consortium, steering and technical committees. |
| Curricula Project Sprint Backlog | The curricula development backlog is generally executed in several stages. The requirements are continuously collected and managed in the sprint backlog in order to be able to incorporate the latest requirements for each sprint. The requirements are organized into lists generated as the results of meetings including the various educational partners, the curricular developers, educational demanders, educational supporters and other specialists. |
| Regular Scrum Meeting | If the requirements are known and prioritized, they can be gradually fulfilled. The teams will regularly meet with other stakeholders internally or externally to discuss and to determine for example the curricular structure, the curricular content, the demand for education of different groups of students, the provision of resources for individual modules, etc. |
| Curricula Project Review | The reviewing for the gradual development of the curricula is required to match the achieved level of development with the requirements for the sprint. The results are provided in several aggregation forms for the various decision-making committees as well as reviewed and approved by technical committees, project teams, consortial sessions, board meetings |
of stakeholders, etc. The strengths and the weaknesses are considered retrospectively in order to be able to carry out the further manifestation of the educational offer even more efficiently.

| Curricula Project Release | If multiple sprints have been passed through and a functioning stage of development of the curriculum has been reached, a release of educational program can go into practical use. For example, a limited number of education providers begin to promote and to offer the education program. As new challenges, for example, are presented to complement the curriculum, the agile process of curricular development is initiated again in a follow-up project. |

Fig. 6: Generic application of Scrum for the development of curricula

The roles in the Scrum team are again divided in Product Owner, Scrum Master and Development Team. Their cooperation is organized in the already described manner in analogy to the educational network developments.

Enhancement of efficiency and sustainability of CE

The achievable efficiency and sustainability in projects, which are implemented using Scrum, depend on, to a large extent as all applications, what skills and abilities, what knowledge and skills have the team members to use the methods successfully, effectively, efficient, and sustainable in the entire context of the project. Of course, this is relevant for developments in the area of the Continuous Engineering Education, too.

The major benefits generated by agile methods in particular by scrum in development and application projects influence the effectiveness and the efficiency of the projects directly. Experiences have shown the possible results:

- Fast creation of usable partial solutions or applicable stages of development
- Manageable expenses for the development until the use of the results in the market
- Higher motivation of the concerned parties and thus higher productivity through better communication and transparency
- Better reaction opportunities and shorter reaction times by the continuous involvement of all stakeholders
- Manageable and controllable design of resource, quality and cost planning and realization
- Well-structured processes based on the division of labor with well-defined roles, responsibilities and decision procedures
- Excellent development of the diverse and individual skills and abilities of the participants for improving the innovation capacity
- Continual opportunity of controlling and changing in current development processes.

This means for the development and application projects in Continuous Engineering Education, among others, the following effects:

- The early partial solutions of programs have been put into practical application.
- The education offers with defined resources were quickly placed on the market.
• The stakeholder of the educational systems improved their communication and thus their motivation and productivity.
• The rapid responses to changes concerning the education demand were possible.
• The use of resources, quality and costs were transparent and very well controlled.
• The processes based on division of labor between team members, educational promoters, education providers and education demanders were well structured with obvious roles and decision procedures.
• The varied and different skills of the involved parties and persons concerning the existing education systems could be better developed and applied for innovations.
• The permanent monitoring and controlling in the context of change management for education portfolios and study contents was established.

Scrum provides good opportunities to ensure sustainability in terms of a flexible design of educational systems, without affecting the future activities of the development of educational opportunities negatively. Rather, prerequisite are created to satisfy the needs of both the present and the future in iterative development steps. Education provides the knowledge how the current knowledge development can be transferred to further progress and future innovations. [23]

This is especially true for the continuing engineering education because:

• A responsive system of education and training prejudices an agile approach for its development in the highly innovative technology areas.
• The unity of ecology, economy, and social issues are particularly inherent for education systems in the field of science and technology.
• The development of individual educational levels is realized due to the similar principles required by Scrum in stages including iterative processes.
• The equal opportunities and the distributive justice including the empowerment and decision making are promoted in the processes of the design of the scientific-technical education.
• The operationalization of sustainability in engineering education takes place in a stage process that can be executed in a project-based and agile way in a very effective and efficient manner.

Agile methods and scrum in particular are in contention for the general professionalization by using the existing management know-how for the enhancement of efficiency and sustainability of continuing education.

Conclusions

The complexity and the dynamics of the development in the education sector force the professionalization of the management of the design and the use of educational systems on the stakeholders increasingly. New methods of project management such as the agile approaches are capable to perform future developments in the field of continuing engineering education as a particularly demanding form of training and learning successfully, efficiently and sustainably. The mega trend in education is to create several open learning offers promoted by dynamic networks of educational providers and educational demanders. These complex systems are difficult and usually not efficient predictable and controllable by the classic project management. The use of Scrum as an agile
method has been tested in several cases and has been proved to be promising option. Nevertheless, other management methods will be important for mastering the future development processes in educational systems, too. It will be essential to use a spectrum of different methods and the right mix of Methods for each specific application. Among other things, the continuing engineering education will get an additional push for development by the professionalization of the management and will be made more efficient and more sustainable.

References


