Knowledge integration strategies within a smart specialization cluster: enabling sustainability in the water-energy nexus

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Abstract

Cultivating learning in a cluster is directly impacted by the ways in which knowledge from various sources is integrated. In this study, we address the question of how to apply knowledge integration strategies in a smart specialization cluster made up of a large network of organizations. The purpose of this paper is to analyze and identify the knowledge integration strategies applicable for the dissemination of knowledge in a collaborative cluster. This paper explores a case study of a specific collaborative network of organizations in Ireland and Wales in the EU-funded water-energy project, Dŵr Uisce. The findings point to evidence of the application of a selection of knowledge integration strategies to disseminate and deploy knowledge efficiently in a smart specialization cluster.

Keywords: Knowledge integration, strategies, sustainability.

Introduction

In the current era, the topic of sustainability takes center stage as humanity faces its ultimate challenge (Griggs et al., 2013). The challenge that threatens our survival, and by extension our existence, is created by two major problems; overpopulation and the degradation of natural resources (Brown et al., 1987, Ferreira et al., 2008, Hart, 1997). Setting aside overpopulation, the degradation of natural resources is a subject that affects the entire planet, and therefore requires immediate attention (Hoel and Kverndokk, 1996, Dunlap and Jorgenson, 2012). Conservation of natural resources has become a collective initiative involving not only legislators and businesses, but also societies and people (Williams, 2011, Bodin and Crona, 2009). One such valuable natural resource is water (Vörösmarty et al., 2000). Responsible supply and distribution of water is not a new topic (Lambooy, 2011), however, the rapid development of research and technology in the water sector is now leading to exploration of ways to conserve or produce energy in the supply and distribution networks of water (Yüksel, 2010, Nautiyal et al., 2011, Hussey and Pittock, 2012, Ramos et al., 2010).

This paper examines the Dŵr Uisce project which aims to improve the long-term sustainability of water supply, treatment and end-use in Ireland and Wales through the development of new innovative technology platforms and developing policy and best practice guidelines to facilitate the implementation of integrated low-carbon and smart energy solutions. One of the objectives of the project is to develop a cross-border smart specialisation cluster to stimulate collaboration, knowledge exchange, innovation and economic growth. Cultivating learning in such a cluster is directly impacted by the ways in which knowledge from various sources is integrated (Newig et al., 2010). The availability of and access to knowledge alone is insufficient to moderate learning in a large and wide cluster consisting of public and private sectors working toward shared goals (Tortoriello and Krackhardt, 2010). One way to capture and deploy learning effectively throughout and in such a network is to identify appropriate strategies to integrate the knowledge (Verburg and Andriessen, 2011).

In this study, we address the question of how to apply knowledge integration strategies in a smart specialization cluster made up of a large network of organizations. The purpose of this paper is to analyze and identify the knowledge integration strategies applicable for the dissemination of knowledge in a collaborative cluster.

Theoretical Background

This section explores the theoretical concepts relevant to the research question of the paper.

Knowledge Integration

The integration of knowledge acquired in a cluster is necessary for subsequent dissemination and deployment. Such integration is, in this paper, defined as *"continuous interdisciplinary sharing of data, knowledge and goals among project participants"* (Fischer et al., 1998)(p. 31). The strategies for knowledge integration are adapted from (Becker and Zirpoli, 2003) and (Griffin and Hauser, 1996), and are applied in the analysis of this study. Conceptually, we build upon the five strategies of knowledge integration by Becker and Zirpoli (2003): organization structures, substitute knowledge by access to knowledge, competency to fill in the knowledge gap, decomposition, and physical and virtual artifacts. To complement this view on functional integration, the framework is extended by two integrating mechanisms from Griffin and Hauser (1996), namely organizational structures and co-location. Table 1 summarizes these six strategies and mechanisms of functional integration of knowledge and expertise.

Table 1 – Knowledge integration strategies and mechanisms (adapted from Becker & Zirpoli, 2003 and Griffin & Hauser, 1996)

Strategy	**Examples of operationalization in a product development context**
Organization Structures	Multifunctional teams, concurrent engineering, coordinating groups, matrix organization, cross-functional project teams
Substitute Knowledge by Access to Knowledge	Gatekeepers; new managerial roles such as platform or program managers
Competency to Fill in the Knowledge Gap	New examples identified to create capacity to fill in knowledge gaps
Decomposition	Integration by standardized interfaces allows for decomposition of complex designs or tasks

Physical and Virtual Artifacts	Use of artifacts to elaborate, develop, test, and industrialize concepts that will later be exploited by product managers
Co-location	Relocation of personnel and physical facilities, personnel movement

First, *organisational structures*, as an integration mechanism, refers to conditions that support knowledge integration by, for example, providing incentives that foster coordination between members of the network, but do not equate to creating knowledge integration (Becker and Zirpoli, 2003). Accordingly, to cultivate knowledge integration, it is necessary to organise individuals with different knowledge into a group. Second, *substituting knowledge by providing access to knowledge* is based upon the strength of 'knowing-whom' rather than 'know-how'. Such a relational strategy also requires the organisation of people with knowledge into a group where discussion and exchange of knowledge is practicable. Third, *the competency to fill in knowledge gaps* may be applicable in a group where members have worked together previously, and therefore, possess the knowledge required to fill in the gaps (rather than just transfer knowledge) based on past experiences. However, this approach poses a challenge to any newcomers in the group (Becker and Zirpoli, 2003). Fourth, *decomposition* refers to knowledge integration by dividing it into smaller tasks that can be delegated to individuals. This relies upon contemporary coordination and standardisation. Fifth, *artefacts* can be an architecture that can relate to different subsets of knowledge; hence, it is used to structure and store knowledge from individuals.

Finally, organising a large network of organizations into knowledge units may not prove to be a successful integration strategy if there is a lack of cooperation amongst them (Griffin and Hauser, 1996). Reducing the physical distance between team members through *co-location* is one way to increase communication, contributing to the success of a smart specialization cluster.

Methodology

The research question focuses on the application of knowledge integration strategies in a smart specialization cluster comprising a large network of organizations. In order to be researchable, a selected network should comprise organizations with similar or different structures, be engaged in activities that have a knowledge base, have a range of competencies across the organizations with the potential to fill in the knowledge gap, be engaged in tasks that may be divided, and have an opportunity to develop and deploy physical and virtual artifacts to advance the network agenda. For the purposes of this paper, we have selected a large network made up of organizations within the water and energy sectors in selected regions of Ireland and Wales. All are engaged in an EU-funded water-energy project, Dŵr Uisce, which is based on a collaborative network of organizations in these two countries.

The setting of Dŵr Uisce is one where various organizations in the water sector are brought together from Ireland and Wales, in a collaborative development of new technologies. It is suitable for a case research and study of a current phenomenon provided by multiple sources of evidence (Leonard-Barton, 1990). This study aims to explore and identify knowledge integration strategies suitable for a large collaborative network. Finally, case research is also suitable in the attempt to contribute to theory development (Meredith, 1998), where the relevance of this study adds to the current knowledge in the areas of knowledge integration and large networks.

Qualitative data sources for the case included project documentation, observations of project-related activities, interactions with and feedback from key individuals in the project. The collection method involved interaction with and participation of actors in networking and breakout sessions in the project. Detailed notes were taken during these sessions, and compiled for analysis (Voss et al., 2002).

Findings

The Dŵr Uisce project background is briefly outlined in this section proceeding the findings from the knowledge sharing project activities.

Project Background

Dŵr Uisce aims to improve the long-term sustainability of water supply, treatment and end-use in Ireland and Wales through the development of new innovative technology platforms and developing policy and best practice guidelines to facilitate the implementation of integrated low-carbon and smart energy solutions. This shall be achieved through the following objectives:

1. Building the innovation capacity of the water sector in Ireland and Wales.
2. Developing new, innovative energy-saving technology platforms, including prototypes, processes & services.
3. Developing a cross-border smart specialisation cluster, Dŵr Uisce, to stimulate collaboration, knowledge exchange, innovation and economic growth.
4. Innovating to reduce the impacts of climate change on the water industry in Ireland and Wales.

The Dŵr Uisce project is structured according to three work themes, namely Technology Platforms, Policy Support & Guidance; and Dissemination & Collaboration. Central to the three themes will be the establishment of the cross-border Smart Specialisation Cluster under the umbrella of which all project activities will fall. Figure 1 illustrates the design of the Dŵr Uisce Project Structure and the interactions among the differing themes and elements within the project. Climate change is also seen in the project as a cross-cutting theme which is featured in all aspects of the project work.

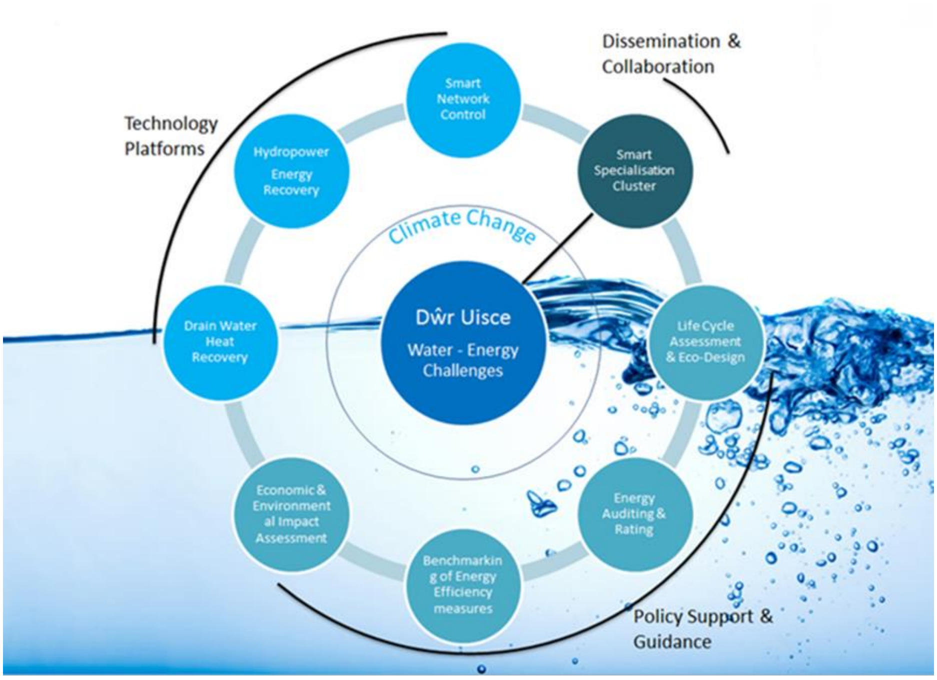

Figure 1: The Dŵr Uisce Project Structure

One of the objectives of the project is to develop a cross-border smart specialisation cluster to stimulate collaboration, knowledge exchange, innovation and economic growth. In the context of this project, a smart specialisation cluster can be defined as a learning network of organisations aiming at increasing knowledge or capacity to act, working through representatives acting as a loosely-coupled peer system, who meet to explore and to exploit learning opportunities (Coughlan and Coghlan, 2011, Foray and Goenaga, 2013). A cross-border cluster can facilitate knowledge transfer from Higher Education Institutes (HEIs) to Small and Medium Enterprises (SMEs), government and other elements of the water sector in relation to water-energy challenges. This is being achieved through the development of cross-border workshops and demonstrations, information-sharing sessions, online media and focused short courses. The objective of the smart specialisation cluster is to facilitate contribution to the project activities and uptake of the findings of Dŵr Uisce by the water industry, to raise public awareness of the work being carried out by the project in relation to the water-energy challenge.

This water-energy cluster focus is on the commercial application of research and innovation in the water sector, and the development of transferable business models to assist internationalisation and trade. As such, the cross-border cluster focus includes three technology platforms being developed in the project and existing and emerging technology, policies, regulations and other measures with the potential to contribute to achieving greater sustainability of commercial activity in the water sector.

Project Activities

Action learning is being used as an innovative tool in Dŵr Uisce to accelerate the transfer of knowledge among HEIs, SMEs and larger enterprises in the water sector. Revans conceptualized learning through action in his Action Learning formula, L=P+Q, where learning is a combination of Programmed knowledge (P), and Questioning insight (Q) derived from fresh questions and critical reflection (Coughlan and Coghlan, 2011).

Action learning has been identified also as a more effective learning process in small-medium enterprises (SMEs) (Choueke and Armstrong, 1998), and as a means to successfully developing SMEs (Clarke et al., 2006). A major consideration for action learning lies in the balance between action and learning (Cho and Egan, 2010). The core of action learning lies in the combination of both the learning, and the solving of the problem. Action learning provides the basis for critical inquiry as it generates insights into how learning is realized. This approach has been shown to turn ineffective networks into effective ones by developing a richer collaborative relationship between partners and has been successfully utilised to support pan-European networks (Coughlan & Coghlan, 2011).

The project began with a kick-off event. This event embodies action learning and provided a focus for the first steps in the formation of the cluster and an opportunity to explore early indications of the potential for storming, norming and performing. During the kick-off event, presentations from the Principal Investigators of the project were scheduled. A senior expert was invited as a guest speaker from European Innovation Partnership (EIP) on Water. A networking session was scheduled following the presentations where each participant was instructed to select two other persons from the crowd to form a group and discuss several items which were presented as discussion prompts. The questions used as discussion prompts are shown in Table 2.

Table 2: Discussion Prompts

Subject	Prompts
Motivation	What is my motivation to participate in this project?

	Who am I? Representing an organization, a household, a user? What is my area of expertise?
Learning	What would I like to learn from my participation? With whom might I collaborate/interact?
Contribution	To which theme (Engineering, Environment, or Climate Change?) can I contribute? With whom might I collaborate/interact?
Expected Outcomes	What do I expect from the partners & project team? What end results would I like to bring back to my organization or household?

The group discussion carried on for approximately 15 minutes, during which the project team members moved around the room to observe, listen and join in the discussion as observers where it suited their interests. The team members were instructed to listen actively and take notes of the discussion. This was done with the intention of identifying the participants to their specific interests in the project for future organization of workshops and activities.

In the afternoon of the kick-off event, a 10-minute presentation by two project partners, Welsh Water (WW) and National Trust Wales (NTW) was delivered. Each was to host a demonstration site to exhibit one of the technologies developed in the project. However, this demonstration in prospect was to focus also on the organisational challenges involved in integrating and implementing the technology into their operating systems. The presentations contained information regarding the two enterprises and the plans for the demonstration sites. This was followed by a breakout session involving all participants. Three groups were pre-formed by the project team by carefully selecting and placing individuals in small- group interaction with WW, and two groups with NTW. In the breakout session, the three groups were hosted by one representative of WW, and two from NTW as group leaders. During the small group sessions, practitioners and end-users from 23 organizations questioned demonstration site design and access choices. The project team members placed themselves strategically into the three groups according to project theme responsibility and interests and to prompt, observe and note the questioning. The participants of each group posed various questions regarding the roles and involvement of the demonstrators in the project, in addition to technical and feasibility questions and concerns. It was also witnessed that various suggestions were provided by the participants to the demonstrators during this session. Project team members took notes accordingly.

At the end of the event, all participants were given a one-page questionnaire to record specific details about each of them in terms of personal and organizational motivation, contribution, interest, and expectations.

Emerging Insights

In a cluster and network, there is a need to capture the motives and expectations of the participants in order to understand their potential to introduce and implement new technologies. The networking sessions provided useful and usable data on the needs of the participating organizations and barriers to collaboration. The small group activities and questioning resulted in learning for participants and for project team members and inform the further design of a program of collaborative actions.

Networking

The networking session created a forum for the project team members to listen and to understand the motivations of the participants and the enterprises they represented regarding the project ambition. In doing so, the team members who represent various work packages of the project were able to distinguish and evaluate the level of involvement and the contribution the enterprises may bring into the project. This could be seen in the example of a specific developer enterprise working across wind, solar and hydro power technology services present at the kick-off event creating the opportunity for the Hydropower Energy Recovery team members to explore or collaborate with a new partner.

The demonstrators, for their parts, established new contacts and gained knowledge regarding various technology and services which are available in the market. Similarly, the participants took the opportunity of the networking session to discuss and market their technology and services regarding the water-energy nexus. They, not only had the opportunity to learn about the Dŵr Uisce project and meet the demonstrators, but also established new contacts within the network for collaborations amongst themselves. In this way, they began to shape the climate within which the cluster might develop norms and perform.

Breakout Session

The demonstrators exploited the opportunity to inform the participants of their enterprises in addition to the details and progress of the demo sites. The discussion and queries in the breakout sessions were directed to specific technology and methods applicable to each of the demo facility. Additionally, the participants explicitly understood the roles they could play to contribute, or not, to the demo sites according to their offerings and expertise. The discussion and queries were inquisitive in nature, where participants offered ideas and suggestions on technologies and methods which could be applied to further enhance the efficiency water and energy use.

Participants also gained deeper understanding of the role and involvement of demonstrators in the Dŵr Uisce project, therefore creating the possibility to evaluate and consider the capabilities of the enterprises they represent to become a demonstrator. The project team members acted as facilitators, listeners and observers during the breakout session, where they had the opportunity to catch and evaluate ideas or suggestions which may then be used in their respective work packages.

Questionnaire

Participants and demonstrators expressed their motivations, objectives, interests and contribution to the project in written form using the questionnaire. The learning through this tool was more for the project team members where the data could be used to plan and create workshops and short courses for the relevant participants, and at relevant demo sites.

As an example, one enterprise expressed the interest to benchmark the water and energy efficiency when asked about the ideas he/she would like to bring or share. Based on the input, this enterprise could be connected to the benchmarking of the energy efficiency measures to collaborate in a benchmarking activity through organizing a short course in benchmarking as a project event for the next quarter.

Discussion

In this study, we address the question of how to apply knowledge integration strategies in a smart specialization cluster made up of a large network of organizations. Based on the emerging insights described in the previous section, the data was analyzed according to the integration strategies adopted from Becker & Zirpoli (2003) and Griffin & Hauser (1996) for all three knowledge sharing activities; networking, breakout session, and questionnaire. Table 3 summarizes the strategies in evidence in the project.

Table 3 – Knowledge integration strategies and mechanisms in the Dŵr Uisce project (adapted from Becker & Zirpoli, 2003 and Griffin & Hauser, 1996)

Strategy	**Classic examples of operationalization in a product development context**	**Evidence in the Dŵr Uisce project**
Organization Structures	Multifunctional teams, concurrent engineering, coordinating groups, matrix organization, cross-functional project teams	Multifunctional representatives from stakeholder organizations, research coordinating group
Substitute Knowledge by Access to Knowledge	Gatekeepers; new managerial roles such as platform or program managers	Research team as gatekeepers; demonstrators playing new managerial roles to provide access to sites and the opportunity to contribute to knowledge
Competency to Fill in the Knowledge Gap	New examples identified to create capacity to fill in knowledge gaps	Demonstrator organizations identified to create capacity to fill in knowledge gaps
Decomposition	Integration by standardized interfaces allows for decomposition of complex designs or tasks	Integration by different modes of interaction during the kick-off (and in prospect) allows for decomposition of complex tasks of design and implementation of new technologies
Physical and Virtual Artifacts	Use of artifacts to elaborate, develop, test, and industrialize concepts that will later be exploited by product managers	Prospective use of demonstrator sites as artifacts to elaborate, develop, test, and industrialize concepts that will later be exploited by participants on their sites
Co-location	Relocation of personnel and physical facilities, personnel movement	Bringing together of the participants with the promise of co-location of personnel at the physical facilities of the demonstrator organizations

Further, the integration strategies also identify with the knowledge sharing activities. In the networking session, the participants chose two members to share and exchange information, motivation, expectations and potential contribution. The outcome varied depending on individual participant's connections, relationships and areas of expertise. For example, groups were made of those from the water industry, the energy sector, manufacturers, and service providers based on mutual connections, existing relationships, and/or area of expertise. This approach mirrors the 'co-location' strategy for knowledge integration.

The breakout session was designed to inform through dissemination of knowledge regarding the demonstration sites, the functions and applications of new technologies and the contribution to environmental sustainability in terms of energy savings. The knowledge dissemination by the demonstrators could be described as the 'decomposition' strategy, where the complex functions and applications were decomposed in relation to the project and its objectives.

The impact of the effectiveness of these strategies is evident in the insights and associated learning from the actions summarized in Table 4 below.

Table 4: Key stakeholder learning

Key stakeholders / Actions taken	Project team	Demonstrator Enterprises	Participants
Networking	Understood the motivations, objectives and background of participants	Opportunity to mingle and discuss with participants the details of the demo sites	Shared motivations and objectives with others
Breakout	Learnt about the demo sites	Opportunity to present the demo sites, share knowledge, raise concerns, understand participants expectations	Understood the involvement of the demonstrators, gain knowledge about the demo sites
Questionnaire	Evidence of motivations, objectives, and contribution of participants	-	Expectations regarding general intentions for the project, and feedback on the kick-off event to the project team

It is not automatic that a network will form and become a learning network. Intervention is required. That intervention must begin somewhere, and an event can set the scene for subsequent knowledge integration. In that sense, knowledge integration is a process and not an event. It extends beyond the kick-off event. However, if the kick-off event is ineffective in generating stakeholder learning, the prospect for further knowledge integration will be limited.

Conclusion

In a smart specialization cluster, there is evidence of the application of a selection of knowledge integration strategies to disseminate and deploy knowledge efficiently. This study contributes to our understanding of how integration strategies vary according to factors such as the design of the activities where action learning takes place, the stage of formation of the learning cluster, and the substantive action content. These insights have implications for management with responsibilities for the long-term sustainability of water supply, treatment and end-use.

References

Becker, M. C. & Zirpoli, F. (2003), "Organizing new product development: knowledge hollowing-out and knowledge integration–the FIAT Auto case", *International Journal of Operations & Production Management*, 23**,** 9**,** 1033-1061.

Bodin, Ö. & Crona, B. I. (2009), "The role of social networks in natural resource governance: What relational patterns make a difference?", *Global Environmental Change*, 19**,** 3**,** 366-374.

Brown, B. J., Hanson, M. E., Liverman, D. M. & Merideth, R. W. (1987), "Global sustainability: toward definition", *Environmental Management*, 11**,** 6**,** 713-719.

Cho, Y. & Egan, T. M. (2010), "The state of the art of action learning research", *Advances in Developing Human Resources*, 12**,** 2**,** 163-180.

Choueke, R. & Armstrong, R. (1998), "The learning organisation in small and medium-sized enterprises: A destination or a journey?", *International Journal of Entrepreneurial Behavior & Research,* 4**,** 2**,** 129-140.

Clarke, J., Thorpe, R., Anderson, L. & Gold, J. (2006), "It's all action, it's all learning: action learning in SMEs", *Journal of European Industrial Training,* 30**,** 6**,** 441-455.

Coughlan, P. & Coghlan, D. (2011), *Collaborative strategic improvement through network action learning: The path to sustainability,* Edward Elgar Publishing.

Dunlap, R. E. & Jorgenson, A. K. (2012), "Environmental problems", *The Wiley-Blackwell Encyclopedia of Globalization*.

Ferreira, S., Hamilton, K. & Vincent, J. R. (2008), "Comprehensive wealth and future consumption: accounting for population growth", *The World Bank Economic Review,* 22**,** 2**,** 233-248.

Fischer, M. A., Waugh, L. M. & Axworthy, A. (1998), "IT support of single project, multi-project and industry-wide integration", *Computers in Industry,* 35**,** 1**,** 31-45.

Foray, D. & Goenaga, X. (2013), "The goals of smart specialisation", *Luxembourg: Publications Office of the European Union*.

Griffin, A. & Hauser, J. R. (1996), "Integrating R&D and marketing: a review and analysis of the literature", *Journal of Product Innovation Management,* 13**,** 3**,** 191-215.

Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N. & Noble, I. (2013), "Policy: Sustainable development goals for people and planet", *Nature,* 495**,** 7441**,** 305.

Hart, S. L. (1997), "Beyond greening: strategies for a sustainable world", *Harvard Business Review,* 75**,** 1**,** 66-77.

Hoel, M. & Kverndokk, S. (1996), "Depletion of fossil fuels and the impacts of global warming", *Resource and Energy Economics,* 18**,** 2**,** 115-136.

Hussey, K. & Pittock, J. (2012), "The energy–water nexus: Managing the links between energy and water for a sustainable future", *Ecology and Society,* 17**,** 1.

Lambooy, T. (2011), "Corporate social responsibility: sustainable water use", *Journal of Cleaner Production,* 19**,** 8**,** 852-866.

Leonard-Barton, D. (1990), "A dual methodology for case studies: Synergistic use of a longitudinal single site with replicated multiple sites", *Organization Science,* 1**,** 3**,** 248-266.

Meredith, J. (1998), "Building operations management theory through case and field research", *Journal of Operations Management,* 16**,** 4**,** 441-454.

Nautiyal, H., Singal, S. & Sharma, A. (2011), "Small hydropower for sustainable energy development in India", *Renewable and Sustainable Energy Reviews,* 15**,** 4**,** 2021-2027.

Newig, J., Günther, D. & Pahl-Wostl, C. (2010), "Synapses in the network: learning in governance networks in the context of environmental management", *Ecology and Society,* 15**,** 4.

Ramos, H., Mello, M. & De, P. (2010), "Clean power in water supply systems as a sustainable solution: from planning to practical implementation", *Water Science and Technology: Water Supply,* 10**,** 1**,** 39-49.

Tortoriello, M. & Krackhardt, D. (2010), "Activating cross-boundary knowledge: The role of Simmelian ties in the generation of innovations", *Academy of Management Journal,* 53**,** 1**,** 167-181.

Verburg, R. M. & Andriessen, E. J. (2011), "A typology of knowledge sharing networks in practice", *Knowledge and Process Management,* 18**,** 1**,** 34-44.

Williams, B. K. (2011), "Adaptive management of natural resources—framework and issues", *Journal of Environmental Management,* 92**,** 5**,** 1346-1353.

Voss, C., Tsikriktsis, N. & Frohlich, M. (2002), "Case research in operations management", *International Journal of Operations & Production Management,* 22**,** 2**,** 195-219.

Vörösmarty, C. J., Green, P., Salisbury, J. & Lammers, R. B. (2000), "Global water resources: vulnerability from climate change and population growth", *Science,* 289**,** 5477**,** 284-288.

Yüksel, I. (2010), "Hydropower for sustainable water and energy development", *Renewable and Sustainable Energy Reviews,* 14**,** 1**,** 462-469.