IGS-SENCE CONFERENCE

RESILIENT SOCIETIES - GOVERNING RISK AND VULNERABILITY

FOR WATER, ENERGY AND CLIMATE CHANGE

19 - 21 OCTOBER 2011
UNIVERSITY OF TWENTE
ENSCHEDE, THE NETHERLANDS

Integrating functions for a sustainable urban system. Crossing boundaries between domains.

Saskia van Broekhoven
Erasmus University Rotterdam
Public Administration
Burg. Oudlaan 50 Rotterdam The Netherlands
+31 (0)10-4082138, vanbroekhoven@fsw.eur.nl

Anne Lorène Vernay
Delft University of Technology
Technology Policy and Management, section Technology Dynamics and Sustainable Development
Jaffalaan 5 Delft The Netherlands
+31 (0)15 27 81653, a.b.h.vernay@tudelft.nl

Abstract:
Many climate adaptation and mitigation measures integrate different social and technical functions with each other in order to optimise resource use and efficiency. The concepts of multifunctional land use and systems integration are two examples of such integration of functions. Decision making and implementation of such measures often takes place in interactions between different actors and organisations which each come from different domains, such as housing, energy infrastructure, welfare and work, environment and nature, water safety, sanitation. Innovative solutions integrating functions often cross boundaries between these previously separated domains. The resulting domain-domain interactions could both constraint or enable the integration of function. Stemming from the observation that scholars studying multifunctional land use and systems integration pay little attention to the influence of domain-domain interactions, this paper aims to show that analysing how boundaries are crossed between different domains will bring new insights and understanding regarding the challenges faced by these projects. Moreover, we argue that a focus on domain-domain interaction can lead to new ideas about how these projects could be further supported and stimulated. Building on literature about boundary spanning, the paper analyses how boundaries between domains may be crossed and suggest a research agenda for studying the integration of functions.

Keywords: Integration of functions, multifunctional land use, systems integration, domain-domain interaction, boundary spanning

1. Introduction

In the last decade, there has been increasing awareness about the need to respond to climate change. Cities have a key role to play in climate change; being both responsible for greenhouse gas emissions and vulnerable to a changing climate. Spatial planning is often identified as one of the key means in approaching these challenges (Bulkeley 2006). Many cities have now set up ambitious targets to mitigate climate change by reducing their CO2 emissions. Moreover, the need for cities to adapt to the consequences of climate change is increasingly recognized. Such adaptation involves making urban space more resilient to a changing climate and reducing vulnerability. To realize adaptation and mitigation ambitions measures can be taken that relate to a single function such as housing, water safety or travel, and which aim to increase the performance for that function in terms of reduced greenhouse gas emissions or vulnerability or improved renewable energy production or resilience. Some examples are reducing emissions by improving the insulation of houses, or by fostering the introduction of renewable energy technologies (e.g. PV), or reducing vulnerability and increasing resilience by heightening dikes or increasing water retention areas. Many mitigation and adaptation measures however do not optimize one function, but integrate different social and technical functions with each other in order to optimise resource use and efficiency. Examples of this are using household waste to produce heat which can be used to supply dwelling with district heating, designing broad multifunctional dikes which can be used for other functions as housing and recreation, or realising multifunctional urban squares which are used for recreation but serve as water retention areas in times of high precipitation.
In this article we look at the integration of function in mitigation and adaptation measures. We focus on two types of integration of functions which both aim at (amongst other things) responding to climate change, namely multifunctional land use and systems integration. Multifunctional land use relates to the integration of ecological, social and economic benefits by integration of different land use functions. It is increasingly seen as a solution to accommodate land use claims of adaptation measures by integrating with already existing land uses or other land uses. Systems integration relates to the integration of different technical functions in order to close or optimise energy and material cycles and decrease the environmental burden of existing technological systems.

We are specifically interested in the observation that many innovative examples of such integrative measures have been developed, but their implementation faces many difficulties (O'Farrell & Anderson 2010). Barriers to the implementation found in the literature on MLU and SI relate (amongst others) to financing, regulations, or cooperation between actors with each their own interests and perceptions (Priemus, Nijkamp & Dieleman 2000; Heijden 2005; Fry 2001; Hemmes 2009; Mirata 2004). Projects typically involve a variety of actors coming from both the private, public and societal sector, different policy departments, as well as from different levels of government. Often each of these actors possesses part of the necessary means to establish legitimate and effective solutions. Yet, they all have their own interests, values and procedures, which are

frequently contradictive (van Buuren et al. 2010). However in the current literature only little attention has been paid how decision making and implementation of such projects takes place in interactions between different actors and organisations which each come from different domains, such as water safety, infrastructure, housing, wastewater treatment, energy production et cetera. We argue functions cannot be seen separate from these institutional domains. This makes integration of functions is neither just a matter of technological feasibility, spatial planning or design, gaining public support, changing regulation, finding financial means, nor just negotiation and cooperation between actors. Innovative solutions integrating functions often require thing to be done in new ways, crossing boundaries between previously separated domains. The resulting domain-domain interactions could both constraint or enable the integration of function.
With this paper, we aim to show that analysing how boundaries are crossed between different domains will bring new insights and understanding of the lack of implementation of these projects. Moreover, it could bring new insights on how these projects could be further supported and stimulated.

The remaining parts of this article we be organized as follows. We will first introduce both MLU and SI and provide an overview of the challenges and strategies to overcome challenges have been identified in the both fields of literature We will then discuss whether and how these challenges relate to the interaction of domains. In order to strengthen our argument that domain-domain interaction can explain some crucial challenges, we will review the challenges that are faced by project involving actors from multiple domains. Furthermore, making use of the literature on boundary-spanning we will provide some first insights on how such boundaries may be crossed. Applying these insights to MLU and SI, we will suggest research questions that, when answered, could create additional understanding of the challenges faced by these project and possible strategies to overcome them.

2. Integration of functions in Multifunctional Land Use and Systems Integration. An overview of current approaches.

In this section we analyse challenges to the integration of functions in climate change measures as well as strategies to overcome them, focussing on two integrative concepts, multifunctional land use (MLU) and systems integration (SI). Our aim is to provide insights whether and how such challenges and strategies found in the current literature are related to the interaction between different domains.
Beyond crossing boundaries between different domains, MLU and SI share several similarities, making them suitable for comparison. Bringing the literature on these two concepts together can provide insights what challenges are faced in integrating functions. First of all both focus specifically on the integration of functions. Multifunctional land use specifically focuses on integration of land uses relating to different benefits and functions within a certain area, while systems integration focuses on the integration of socio-technological systems. Both concepts aim at responding to climate change (amongst others, e.g. more general sustainability goals). Multifunctional land use mainly

relates to adaptation, whereas systems integration mainly relates to mitigation. Further more they both involve similar actors; typically these may be municipalities, as well as higher levels of government, residents, companies, and societal actors such as NGOs. Lastly both these concepts are mostly implemented on a local level, in concrete projects which aim to integrate several functions.

2.1. Multifunctional Land Use

2.1.1. What is Multifunctional Land Use?

The concept of Multifunctional Land Use (MLU) refers to the combining of economic, environmental and social benefits through the integration of various land use functions, by a diverse set of actors and within a spatially and temporally set context (Katharina Helming & Hubert Wiggering 2003). Lagendijk & Wisserhof (1999)) categorized four dimensions of MLU:

- Intensification of land use (more efficient use of land);
- Interweaving of land use (use of the same land for different functions);
- Use of different depths (use of underground and/or above ground levels);
- Uses of land in time-frames (using the same land for different functions in certain time frames).

One of the strong points of the concept is its ability to inspire people to come new and innovative ideas on how functions and benefits can be combined and how a certain area can be used. Multifunctionality can be seen as the outcome of innovation process developing strategies that combine private interests such as profits, property rights, competiveness, production and consumption, with public goods and values such as natural resources, ecological services, water safety and availability, retaining cultural heritage, equality (Wolf & Primmer 2006).

2.1.2. Why and how integrate functions in MLU

The concept of multifunctional land use is studied from a variety of disciplinary backgrounds. Most of the literature derives from the fields of spatial planning, landscape studies, agricultural studies. These fields study MLU in different ways, and moreover relate to different reasons of why to integrate land use functions in the first place. In this article we focus on the integration of functions in urban systems, we will therefore not go in depth about MLU in agriculture.

The literature from spatial planning provides insights in the historical development of MLU. (Priemus et al. 2004) state in pre-industrial times most land was used for multiple functions. Only with the coming of industrialization functions as housing, work, and leisure became separated, both in space (housing and working) as in time (working hours), for health or economic reasons. More recently, the concept of functionalism in spatial planning has influenced a separation of the four main land uses (housing, working, recreation and transport) in many European an US cities, enforced by zoning codes

(Louw & Bruinsma 2006). Monofunctional use of land now has become the normal state of affairs. However with the concepts of mixed and multifunctional land use there has been a shift towards an integration of land uses in spatial planning literature in the last decades (ibid). Main drivers for MLU in the spatial planning literature are increased land use claims and 'scarcity of space', revitalizing and diversifying urban areas as well as reducing transportation needs.
Another driver for MLU is formed by sustainability concerns. With a growing world population and growing consumption standards the various demands on land for socio-economic functions as food production, industry and housing and keep increasing, together with our footprint on landscapes. Sustainability concerns acts as a driver for MLU in two ways. Firstly with an increased focus on the environment and sustainability in society the land claims for nature, recreation, and water are increasingly recognised. This adds to already existing and growing land use demands, and thus to land use pressures. Secondly MLU is seen as a tool to develop sustainable landscapes, through combining functions within the available ecological limits of a certain area. In the landscape literature sustainability aspects are seen as main driver for MLU. Various tools are developed to assess the sustainability of integrating functions (Helming et al. 2011). Tools are also developed to assess landscape elements and enable the valuation of land use functions (de Groot et al. 2010; de Groot 2006), to facilitate the development of integrated landscapes. Stakeholder involvement in valuation of land use functions is stressed in the literature (Helming & Wiggering 2003; O'Farrell & Anderson 2010). Furthermore, the relation of nature and culture within landscapes is researched. In several studies in the landscape literature attention is called towards a holistic and transdisciplinary approach to multifunctional landscapes (Naveh & Lieberman 1993; Naveh 2001; Tress & Tress 2001; Fry 2001; O'Farrell & Anderson 2010).
Climate adaptation adds another driver in integrating land use functions, as adaptation measures put forward another land use claim, e.g. for water retention, flood protection, and protection or ecosystem services. Especially in densely populated urban areas such land demands can lead to challenges and controversies for land use and planning. Increasingly a solution is sought in integrating climate adaptation measures with already existing land uses or with other land use demands. An example of such integration is the development of water retention areas within the city of Rotterdam, where a solution to the limitedly available space within the existing city structure is found in integrating retention strategies with neighbourhood redevelopment and recreational facilities by creating multifunctional city squares that can function as water retention areas at times of heavy rainfall.

2.1.3. Challenges to integration of functions

Several authors note the compartmentalized governmental system can act as a barrier, as departments are arranged by functions as spatial planning, housing, environment, water safety et cetera, which are crossed by multifunctional projects (van Ark 2006; van Buuren et al. 2010; Priemus, Nijkamp & Dieleman 2000).
The last aspect, rules and regulations made for a monofunctional use, pose jurisdictional barriers, e.g. development plans relating to different zoning codes and environmental

permits that regulate emissions allowed when certain functions are involved (Heijden 2005; Louw & Bruinsma 2006; Priemus, Nijkamp & Dieleman 2000).
As projects integration land uses are often of an innovative character, a lack of knowledge on design and technological possibilities, as well as on what is possible within the existing rules and regulations can pose a barrier (Priemus, Nijkamp & Dieleman 2000). O'Farrell & Anderson (2010) relate the lacking implementation to a lack of implementation tools integrating economic, environmental and social aspects, as well as a science-policy gap. The integration of functions means actors coming from different disciplines, as well as from both science and practice need to work together to define solutions, leading to epistemological barriers (Fry 2001; O'Farrell and Anderson 2010; Tress and Tress 2001).
Furthermore barriers can be of a financial nature, integrative measures may be more costly than non-integrative measures (Priemus et al 2000). Next to this possible cost reductions compared to single function projects (so per function) are difficult to identify due to the intermingling of costs and benefits. Different sources of financing often involved in integrative projects make possible cost reduction even less transparent (ibid). Furthermore integrative projects might be (perceived as) more risky, due to the innovative character of many of these measures as well as to the variety of stakeholders involved (Louw and Bruinsma 2006). Lastly the coordination and alignment between many actors involved, coming from different sectors and organisations as well as different governmental levels, may provide challenges (Priemus et al 2000).

2.1.4. Strategies/tools for realising integration

Several strategies for a better implementation of MLU are recommended in the literature. To overcome the gap between disciplines as well as science and policy a solution could be sought in collaboration and exchange of ideas between various stakeholders, using a transdisciplinary approach (Naveh & Lieberman 1993; Naveh 2001; Tress & Tress 2001; Fry 2001; O'Farrell & Anderson 2010). O'Farrell en Anderson (2010) suggest using so-called learning organisations, which are transdisciplinary as well as use adaptive management in order to deal with uncertainties and adapt to emerging knowledge and information.
Several scholars argue possibilities to integrate functions should be determined regionally, as different areas will produce different combinations of functions, and their value is determined by regional stakeholders (McCarthy 2005; Wiggering et al. 2003). Moreover they argue MLU projects should be governed by the most local level of government (subsidiary principle), as only there the right regional approach can be taken.
Another strategy suggested is putting values of different functions involved in MLU in monetary terms, e.g. valuing ecosystems services, using market incentives to stimulate multifunctionality (de Groot 2006).
The participation of stakeholders is stressed by several authors, both in identifying (future) land use demands, valuing functions, and negotiating possible combinations of functions (McCarthy 2005; Wiggering et al 2003; O'Farrell and Anderson 2010).
Furthermore the need to understand how agenda setting takes place on what is a desirable land use, power relations, who gets benefits and who has to adapt to changes in land use,

are increasingly recognised, and tools as network analysis, community mapping and political analysis are suggested (O'Farrell and Anderson 2010).

2.2. Systems Integration

2.2.1. What is systems integration?

The word "integrate" comes from the Latin word "integer" which meant whole or wholeness. Integration is thus a reference to the restoration of wholeness, it is "the act of combing into an integral whole" (princeton). The term integration has become something of a buzzword. It is used by disciplines ranging from health care to marketing, ICT, semantics, planning, policy, energy, resource management and so on.
In this research we focus on integrations options that imply the combination of socio-technological systems with each other. Socio-technical systems combine technologies and organizations, actors and institutions, nature and values in a seamless web (Hughes 1983). They provide us with electricity, transport, waste and wastewater management, heat, drinking water, ICT, health care, etc. These socio-technical systems can be integrated with each over in order to use them more efficiently or to decrease their environmental impacts. We will from now on refer to this type of integration as systems integration. From the following introduction, it will become clear that systems integration can take place at various scales: in a region, an industrial cluster, a city, a district, etc.

Since its creation, the field of industrial ecology has been promoting the introduction of systems integration type of solutions. By taking a systemic view, it advocates that existing systems of production and consumption should be integrated to each other in order to create synergy, re-use waste and optimize the environmental performance of industrial regions, cities, and production and consumption systems (Lifset & Boons 2011). The field has been mainly concerned with industrial practices and is promoting systems integration via concept such as industrial symbiosis. As defines by (Chertow 2000). (Chertow 2000), "industrial symbiosis engages traditionally separate entities in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products". There is also a growing interest to apply similar perspective to the development of Agropark (a.k.a Greenport) where food production and industrial activities realise symbiotic exchange (Baas 2008; Smeets 2010). Finally, with concepts such as urban symbiosis, industrial ecology scholars are also paying some attention to exchanges that can take place in urban regions, a scale more comparable to that of multi-functional land use (Van Berkel et al. 2009). Examples of such practices include the now increasingly common waste to energy plants (integrating district heating; electricity and waste management) or the valorization of organic waste through anaerobic digestion in order to produce biogas and or compost (integrating wastewater treatment with transport and agriculture) (Van Berkel et al. 2009).
These ideas of developing synergetic exchange and closing cycles have also been embraced by scholars in urban planning (see for instance (van Timmeren 2006; Van Den Dobbelsteen et al. 2007; Stremke et al. 2011). Practitioners are also showing interest in these ideas and district such as Bedzed in England, Caofeidian in China, Hammarby

Sjöstad in Sweden, Zira island in Azerbaijan, are developed based on this notion of closed urban cycles. Finally, the Swedish consultancy firm Sweco is, for instance, using these ideas as a key selling point for their expertise (SWECO n.d.).

Systems integration involves very diverse types of actors and the specific types of organisations involved will depend on the type and the scale of integration that is being attempted. Generally speaking, this could be public and private companies from wide ranging type of sectors, local, regional and/or national authorities, consultancy firm, and local inhabitant / community.

2.2.2. Systems integration, why

As already suggested in the previous section, improving environmental performance is the core driving force of systems integration. It can both help reducing the pressure put on natural resources and lead to more environmentally friendly waste management practices. For firms, valorising waste streams or using fewer resources can also be a way to gain competitive advantage by decreasing operational costs.

2.2.3. What are the challenges to systems integration

Scholars, especially from the field of industrial ecology have identified a number of barriers and challenges to systems integration. First, possible option for integration are not always be obvious (Chertow 2000; Mirata 2004) and tools are needed to be able to identify these options. Moreover, these integration options may present challenges in their design (Jong de 2004). Beyond technical feasibility, there may be economic barriers to systems integration as it may require high levels of investment and could be costly to operate (Mirata 2004).
Moreover, Regulatory structures may also generate barriers to systems integration (Boons & Baas 1997; Mirata 2004). Likewise, existing research and development policy is usually fragmented, living little space for integrative solutions (Hemmes 2009).
Furthermore, systems integration crosses the boundaries of individual companies or organisations. These organisations may have difficulty trusting and collaborating with each other (Mirata 2004; Gibbs & Deutz 2007). This also presents challenges in terms coordination (Boons & Baas 1997). Finally, systems integration options are dependent on the institutional setting shaping the various actors involved and require institutional innovation in management practices (Piasecki 1992).

2.2.4. Strategies/ tools for realising systems integration

Industrial ecology scholars have developed a number of tools to help in the realisation of systems integration. They mainly focus on ways to un-cover possibilities for integration by mapping material and energy flow (e.g. materials mapping, or mass or energy flow analysis) or by seeking to match the input and the output of different industrial processes

(input-output matching) (Chertow 2000). These tools may also provide useful insights to develop scenarios for future possibilities for systems integration (Korhonen et al. 2004).
Moreover, because systems integration requires the interaction of heterogeneous actors, some scholars have also highlighted the importance of using tools to facilitate these interactions by fostering networking and stimulating stakeholder participation (e.g. focus group discussion or community visioning workshops) (Schlarb 2001).
Some scholars have also applied tools from other disciplines to systems integration. For instance, (Batten 2009) suggested that tools stemming from complexity theory (agent based modelling and participatory modelling) could be used to identify the element that could be integrated and build trust and foster cooperation among actors involved in the attempt at systems integration. Similarly, (Patil et al. 2006) proposed using dynamic actor network analysis (DANA) to identify the perspective and perception of various stakeholders and highlight situations where goals may be conflicting between different actors. They argue that this tool can help managing the various stakeholders involved.

2.4. Challenges and strategies in the two fields

Table 1 provides an overview of challenges and strategies identified in both fields. Below we explore further how the identified challenges do or do not relate to our argument that integration of functions is to a large extent about crossing boundaries between domains.
Before we continue we need to establish an understanding of what we see as domains. We understand domains as fragmented and functionally specialised units, arising from a compartmentalised governance context where tasks are largely divided by function (e.g. housing, energy infrastructure, welfare and work, environment and nature, water safety, sanitation). Different tasks lead to different interests and different rationales that characterise the domains. Domains may include both public and private actors, as well as different policy levels. However boundaries between domains may also be divided between such actors. Furthermore single organisations may be part of different domains, e.g. different departments of a municipality that focus on different functions. Furthermore we need to define what boundaries between such domains are. Defining boundaries is notoriously difficult; boundaries between domains are no exception. Being social constructs, different actors may perceive such boundaries differently (Lamont & Molnár 2002). Boundaries are not fixed but on the contrary can change over time, be re-evaluated and restructured. However they can also become more institutionalised, posing barriers to the crossing of boundaries (ibid). Building upon Kerosuo's (Kerosuo 2006) definition of boundary, we can state that social domains establish "distinctions and differences between and within active systems that are created and agreed on by groups and individual actors over a long period of time while they are involved in those activities".

Strongly related to our argument the crossing of boundaries between domains can cause challenges in integrative projects is the observation by some MLU literature that challenges can arise from the involvement different governmental departments and organisations in MLU, who are structured by a largely functional division into policy domains (e.g. housing, infrastructure, welfare and work, environment and nature, water), closely relates. In the literature on SI no comparable argument is made. Authors

recognise challenges rise from crossing boundaries between organisations, but this is not related to a crossing of boundaries between different domains.

In most of the challenges identified in the reviewed literature on both MLU and SI, the crossing of boundaries between different domains is not directly addressed. Off course challenges may be related to many other aspects than merely domain-domain interaction. Financial challenges as increased costs and higher risk of investment pose barriers with or without domain interaction. Furthermore difficulties in division of costs, as well as in collaboration between different actors can be attributed to the fact that a variety of actors is often involved in projects integrating functions. Difficulties in collaboration between the variety of private and public actors involved may rise regardless of what domains they come from. Furthermore technological or design challenges and a noted lack of knowledge is related to the innovativeness of integrative projects.

Nevertheless several of the identified challenges can be related to the interaction of domains. Indeed, the authors that identify the compartmentalised governance context as a challenge to integration of functions already relate some of the other challenges, such as jurisdictional and financial challenges, to the compartmentalised context (van Ark 2006; Priemus, Nijkamp & Dieleman 2000). Below we explore further those challenges that do relate to our argument that integration of functions is to a large extent about crossing boundaries between domains.

Jurisdictional barriers are one of the expressions of the compartmentalisation as the development of rules and regulation by policy domains usually focuses on single functions. For example environmental legislation may pose barriers to integration, e.g. a product labelled as waste may not be allowed to be utilised as a resource for another function, or emission regulation can pose barriers to the development of several functions in close proximity ((Priemus, Nijkamp & Dieleman 2000; Mirata 2004). Furthermore spatial rules and refulation can provide challenges, as areal plans are often developed without consideration of integrative measures (Priemus et al 2000). Such plans can be adjusted; however this is often a lengthy procedure. Moreover, more than the jurisdiction in itself, the interpretation of what is possible can act as a restriction. Furthermore a lack of familiarity with or clarity of possibilities in existing rules or for adjustment of such rules may pose challenges (ibid).

Regarding financial barriers, challenges that can be related to domain boundaries are mostly about division of costs and benefits, and the fit of possible new divisions with current task descriptions. When multiple functions are integrated discussions may rise over who pays what part of the integrated project, and who gains what benefits. When for instance a dike is combined with the development of parking and business areas, it might be discussed whether the water board should also gain the financial benefits from this, and whether then they should participate in the initial investment.

Challenges formed by lack of knowledge might easily be solved by knowledge development. However more fundamental are epistemological differences between actors. Actors can have largely different perceptions on what the issues and problems are as well as on suitable solutions, and consequently what kind of knowledge is needed. Clearly differences in perceptions and interests, and - more in general - cooperation across a variety of different actors can create challenges regardless of whether these

actors come from different domains. We argue however that the fact that in integrative project actors and organisations come from different domains can increase the difficulty in interaction as such domains relate to completely different disciplines, interests, logics of reasoning and rules. A water board that has responsibility over providing water safety reasons in very different ways from a spatial planning department aiming to provide a good areal plan for regional development. Similarly a wastewater treatment company producing biogas differs large in its reasoning from a company operating and maintaining a gas network where that biogas could be injected.

	Multifunctional Land Use	**Systems integration**
Why integrate functions	- Adaptation - Scarcity of space - Sustainability goals - Regional development	- Mitigation - Sustainability goals - Closing material and energy cycles
Challenges to integration of functions	- Epistemological, interaction disciplines and science-policy - Compartmentalised governance system - Jurisdictional - Financial - Cooperation actors - Knowledge	- Technological or design barriers - Financial - Regulatory structures - Cooperating across organisational boundaries, trust, collaboration and coordination - Institutional setting shape behaviour actors
Strategies to develop integration of functions	- Transdisciplinairy approach, collaboration between disciplines and various stakeholders - Regional approach, mapping functions, values and combinations locally - Use market incentive by valuing functions (discussed) - Facilitate stakeholder participation - Power relations and agenda setting	- Uncovering possibilities for integration by mapping material and energy flows - Tools to facilitate networking and stakeholder participation - Understanding perspectives and perceptions stakeholders (network analysis) - Modelling complex structures of elements to integrate and behaviour of actors, to facilitate cooperation

Table 1 Challenges and strategies for integration of function in multifunctional land use and systems integration

Noticeably the proposed or used strategies do not match directly to the identified challenges. The jurisdictional challenges are not addressed by any of the strategies. Financial challenges are addressed by the use of market incentives with valuation of function in MLU, however increasing market incentive does not solve how costs and benefits should be divided between stakeholders. Moreover the challenges and strategies seem somewhat interconnected, for instance a transdisciplinary approach may facilitate cooperation between actors but epistemological challenges will become more prominently visible in using this strategy. Most of the strategies are aimed at increasing stakeholder participation, facilitating networking and developing understanding of different perspectives. But how does bringing together different actors then lead to overcoming differences between actors?

We argue the integrations of functions is not just a matter of changing regulation, finding financial means, developing knowledge on technological feasibility or design, gaining public support, nor just negotiation and cooperation between actors. Many challenges can be attributed to the underlying institutional structures where functions cannot be seen separate from the domains to which they belong, and of which boundaries are hard to cross.
Though in the current literature in both fields challenges arising from the institutional context in which such integrative ideas need to be realised are noted, there is currently not much focus on how the crossing of boundaries between domains leads to challenges and possibilities for integration, and how integrative projects can be realised within this context. Building upon the discussions initiated here, we will, in the next section, describe more in-depth what the challenges to crossing boundaries between different domains are.

3. Integrating functions: identifying the challenges in domain-domain interaction

Complementing the challenges identified in the previous section, in this section we draw on literature from scholars interested in understanding decision-making processes in collaborative projects that bring together actors from different disciplines. By doing so, we can better identify what makes projects requiring across domains so difficult to realise. Joint processes and collaboration pose attractive ideas with clear possibilities for mutual benefits for the different actors involved. However it is increasingly recognised in the literature collaborative projects can be very lengthy and difficult process (Bryson et al. 2006; Huxham & Vangen 2004). Huxham (1996) uses the concepts of collaborative advantage and collaborative inertia with the first relating to the potential for synergy from working collaboratively and the last relating to the reality of lengthy and difficult processes and often disappointing results.
Six categories of challenges are identified: differing interest and strategies, epistemological factors, institutional logics, routines and practices, power, and embedding the developed ideas within the existing structures. In the following paragraphs, we will introduce each of them.

Different interests and strategic games

The integration of functions itself is not a goal. It is a means, an instrument to reach a certain goal. This could be realizing sustainability goals, efficient use of land, finding of additional financing, and many other aspects. These will often differ amongst the actors involved in integrative projects, especially as different domains are focussed towards different tasks. A water board that has as primary task and responsibility water safety will have different interests than a department of spatial planning of the local municipality that is focussed on regional area planning. A most obvious challenge is negotiating between different interests.

To realise these different interest actors involved in projects may act strategically. The policy process is in this regard often seen as a series of policy games, played by the different actors involved, in which actors strategically try to influence the framing of the problem, its solutions and its procedures to benefit their own interest (Scharpf 1997). Complicating the picture such policy games can be played in different places simultaneously, with the events in one game influencing actions in another game (Klijn et al. 2000). This implies that the challenges and possibilities in projects integrating functions are shaped not just by different interests and strategies of actors in relation to the project at hand, but also by events in other games in which actors are involved.

Different institutional logics

Opportunities actors regard as possible and actions they undertake are not only shaped by consequence oriented strategic acting, but are also shaped by how appropriate such actions are within the institutional context an actor is part of as well as in the specific situation at hand (March & Olsen 1989). Behind different interest and strategies often lie different values, beliefs, rules and norms. We make use of the concept of institutional logics to explore how such aspects may play a role in the context of domain interaction. Institutional logic explain how these aspects lead organisations to perceive reality and act in certain ways (Friedland & Alford 1991; Thornton & Ocasio 1999). Thornton & Ocasio (1999) define institutional logics as 'the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality.' Logics focus the attention of decision makers and actors on certain issues, possibilities, outcomes, and sources of power that fit with their dominant logic, and thereby influence organisational behaviour (ibid) In projects where actors from multiple domains are involved, building on shared understanding, frames, trust, leadership and legitimacy become more complex as actors are likely to represent different institutional logics (Bryson et al. 2006). Furthermore, competing logics can arise when actions, norms, processes seen as relevant from one institutional logic are not seen as valid or even legitimate from another logics vantage point (Thornton en Ocasio 1999).

Such differences in logics are perhaps most clearly visible between actors coming from the public or private domain. (Klijn & Teisman 2003) show how differences in values between public and private actors can lead to very different strategies, with public actor's strategies aiming at control of projects and minimizing financial risks and private actors' strategies aiming at a certainty of market share and profit and seizing opportunities. (Child & Faulkner 1998) relate to cultural fit between organisations, stating barriers to

cooperation can arise when different cultures merge by interaction between organisations. Organisations with similar motivations and methods are more likely to have a cultural fit.

Different perspectives, epistemological factors

As many project integrating function are of an innovative nature, the development of knowledge is often an important issue. We therefore elaborate on how development of knowledge, and different ways of knowing, can act as a challenge. In the previous section we have found lack of knowledge may act as a barrier. However knowledge is not a neutral concept. Different perspectives about the nature of the problem, its causes and its effects, possible solutions and the knowledge and research available or needed can cause conflicts between actors involved in such projects (van Bueren et al. 2003). Various experts and stakeholders often depart from different rationalities and use different ways of knowing, set different priorities, and approach the problem in their own typical ways (van Buuren et al. 2010; Ratcheva 2009; Fry 2001). The difficulties in knowledge exchange amongst different actors can pose major barriers to establishing a collective outcome (van Bueren et al. 2003) argue often solutions are sought in new knowledge, but more research cannot solve the differences in perception that lie underneath. Such epistemological differences can result in 'dialogues of the deaf' where actors talk to each other but not with each other (Termeer 1993 in (van Bueren et al. 2003)).

Power

Differences in power between different domains and actors involved in them can complicate the cooperation process. Huxham & Vangen (2004) identify power imbalances between different actors in a collaborative process can lead to mistrust, making effective cooperation difficult.

Routines and practices

Theories on practice put forward a related perspective to the concept of institutional logics, though focussing more on how – next to different values, norms and rules - cognitive-symbolic aspects shape the actions, strategies and decisions of actors (Reckwitz 2002). Practice theory brings the attention to aspects of routines and action, seeing decisions, solutions and strategies not so much as formulated but as arrived upon by acting to the situation at hand and based on background knowledge, routines, set beliefs and meanings (Hajer & Wagenaar 2003). These aspects are themselves embedded within practices. Hajer and Wagenaar see practices as interconnecting "[…] intuitions, understandings, commitments, and action into a meaningful, self-evident way of going about things in a particular domain" (2003, p35). Such practices are produced and reproduced by actors who themselves draw upon sets of rules and resources which are connected to situated practices.

Such a perspective can provide insights on how existing practices shape decisions, solutions and strategies of actors. Projects integrating functions don't only cross boundaries between domains, but may also cross different established practices within these domains. Actors might be cooperative or uncooperative in collaborative processes focusing on a certain issues, because their practice orients them towards certain options.

Embedding the developed ideas within the existing structures and practices

A last challenge relates more to the relation between the project as it is developed and the existing ways of working within the domains involved, though it arises from the interaction of the different domains.
The integration of function often involves the development of new ideas, new designs and technologies, but also new ways of working and new task divisions, needed to make the realization of the integrative project possible. As different organisations coming from different domains become involved in developing such projects, their different logics and practices are confronted with each other in a process of collective action. (Lounsbury 2007) identified that as different institutionally based logics meet in collective action processes, many ambiguities may rise and actors come to struggle to define which practices are appropriate. When such different logics come to blend in order to develop the desired collective action, new logics are created and new practices can emerge. In order to explain innovations, practice theory distinguishes between more stable practices which are routinely reproduced by knowledgeable practitioners and follow predictable trajectories, and new practices which are more unstable and who reproduce the elements they are made up from in different manners than before (Geels 2011). We can apply this perspective to the development of new solutions in integrative projects. As actors representing different organisations on the level of projects interact and their logics come to meet a more unstable situation can occur. Actors may start blending different logics and develop new strategies and ideas in order to realize the integrative project and overcome challenges. New practices may develop reproducing the element they are made up from in new manners. However on the level of the domains existing practices can be expected to be reproduced in predictable manners by actors not involved in the project, and new ideas and strategies might meet opposition from the way things were arranged within or between the domains. How then, do these new and existing practices interact? Following this reasoning we can expect actors who cross boundaries between domains in their involvement in these projects can face difficulties when coming back in their own organisation and routine of practices.

Supporting this line of reasoning, existing research finds existing practices can have a strong influence on complex governance processes where cooperation or integration is an aim. For example by domain demarcation that act as barriers to interaction between actors, as well as inhibit actors to make new links as this does not fit with the way of working of their own domain (Klijn & Teisman 2003; van Bueren et al. 2003). Klijn en Teisman (2003) find integrated and combined investment programs pose attractive ideas, but are often turned into loosely coupled project. Processes and contracts that do not significantly differ from the existing value patterns of the organizations involved and require the least amount of adaptation on the part of these organizations are usually used. Moreover, actors are often too preoccupied with their own issues and procedures to act as partners.

Given the herculean list of challenges faced by project crossing boundaries, one may wonder how then can boundaries between different domains be overcome? This paper does not claim to bring answers to this question. Instead, the following section will, drawing upon literature of boundary-spanning, provide preliminary insights regarding how this question could be addressed.

4. Integrating functions: Spanning boundaries

We have argued decision making and implementation of projects integrating functions takes place in interactions between different actors and organisations which each come from different domains, such as water safety, infrastructure, housing, wastewater treatment, energy production et cetera. How then are boundaries between such different domains crossed? To answer this question, we will make use of boundary spanning literature. Boundary spanning is a concept that has been used to refer to activities that are performed by actors outside the boundaries of their organisation in the external environment (Leifer & Delbecq 1978). Research on boundary-spanning started to receive a lot of attention since the 70's and focused mainly on boundary-spanning at the level of a given organization. Scholars looked at for instance specific boundary-spanning activities such as sales or marketing (e.g. Johnson & Lysonski 1983); analysed the influence of boundary-spanning activities on firms' performance (e.g. Aldrich & Herker 1977); studied boundary-spanning taking place internally between different departments within an organisation(Katz & Tushman 1979; Balogun et al. 2005); and explored the role of boundary-spanning in knowledge creation and innovation processes (Rosenkopf & Nerkar 2001).
Boundary-spanning is understood as a two way process , with on the one hand information coming from the environment to the organization and on the other hand information going from the organization to the environment (Friedman & Podolny 1992). Actors who span the boundaries of their organisations, so-called boundary-spanners (Tushman 1977), must thus not only be able to have access to knowledge present in their environment but they must also have enough influence within their own organization to ensure that this new knowledge can come to use (Swan & Newell 1998). To that Noble & Jones (2006) added that boundary spanners do not have to be stable entities but that their characteristic and identity may change over time. Furthermore, Steward et al. (2008) showed that when innovations require intense interactions with actors from separate networks (or in our case domains) the boundary-spanner can play a crucial role in contributing to the successful implementation of the innovation. Boundary-spanners may thus also play an essential role in projects of MLU and SI.

For actors taking part in projects of MLU or SI, this means that they will have to cross the boundaries of their own organisation and become boundary-spanners. These boundary-spanners will play an essential role in these projects and to ensure the projects are realised, they must be able to first open up to their environment and develop integrated ideas and second have sufficient influence in their home organisation to communicate these integrated ideas back to their organisations and gain sufficient support for them. We see this as an dynamic and continuous process, with boundary spanners acting as a link between on the one hand the interests, logics, rules and practices of their organisations and the larger domains they are embedded in, and on the other hand the project level where the different interests, logics, rules and practices of different organisation and their domains meet, and possible integrative solutions are developed. In this process of exchange between an organisation and its environment, Friedman and Podolny (1992) differentiate between so-called gatekeepers and representatives. A gatekeeper receives information from the environment and passes it on to his/her

organization while a representative receives information from his/her environment and passes it on to the environment.

However, in the present paper, we are not only interested in understanding how boundaries are crossed between or within organisations but also and most importantly how boundaries are crossed between separate domains. The concept of boundary spanning has been applied to such context before, where boundaries are crossed not just between organisations but between domains. (Warner et al. 2010) for instance applied a similar standpoint to the study of integrated water resource management where boundaries are crossed between domains such as water safety, agriculture and spatial planning. Building on the fact that boundary spanning is a two-way process, this means that an organization spanning the boundary of its domain should be able to access information from its environment. However, in order to make the new information come to use within the larger domain the boundary spanner should also be able to communicate the information back to the larger domain, and have enough influence to gain support for the new integrative idea. . Furthermore, the integrative solution might require changes in the larger domain in order to be realised, such as changes in regulation. Take for example a wastewater treatment company interested supporting the installations of kitchen waste disposers (small artefact that can be used to grind kitchen waste so that the organic waste is disposed of in the sewage). This may be forbidden by a regulation limiting the amount of organic waste present in the wastewater requiring the regulation within the domain to be changed before the innovation cam be introduced. The wastewater treatment company thus needs to convince other actors in the domain to gain support for such change.

Interestingly, such MLU and SI projects then do not only need that one organization spans the boundary of its domain. Multiple organizations will have to span the boundaries of multiple domains. Furthermore such process needs to be synchronized, with boundary spanning taking place simultaneously. Similarly, integrative projects might even require changes to be made regarding the relations between multiple domains, (e.g. changes in task divisions). However, not all organizations may directly be interested and willing to participate in integrated projects. In section 3, we highlighted the challenges that are faced by projects bringing together actors from different domains. To that, it is important to add that these challenges or barriers may be expressed differently or in varying degrees within different domains. For example, for one domain the project may require important changes in routines while for another regulatory aspects may be more problematic. Likewise a project might at the same time be of high priority for one domain, and hardly interesting for another that may thus not willing to invest much in it.

To enable boundary spanning across such different domain boundary spanning activities may thus need to be stimulated. A so-called boundary object may play a facilitating role in such a process. A boundary object could be a vision, masterplan, technical design, patent, etc. It is shared by actors coming from different social worlds (or in our case domains). Each actor give the boundary object its own, specific meaning without the object losing its essence (Star & Griesemer 1989). A boundary object can trigger organisations to reconsider their boundaries (Warner et al. 2010).

Nevertheless, even though a boundary object can help creating bridges between actors coming from different domains and stimulate boundary crossing activities, it may not be sufficient in itself to ensure the realisation of boundary crossing activities (Guston 2001).

Some more active form of coordination may be needed to facilitate or stimulate these simultaneous boundary-crossing activities. Some scholars have suggested that this could be done by so-called boundary organisations (Guston 2001). The term is usually used by scholars who are investigating way to create a bridge between the world of science and the world of politics (Guston 2001). However, this concept could also be applied to organisations that are creating bridges between different domains. Boundary organisations "involve the participation of actors from both sides of the boundary, as well as professionals who serve a mediating role in the co-production of knowledge that can be used by multiple audiences" (Guston 2001). A boundary organization is then different from a boundary-spanner in that it actively tries to stimulate boundary crossing activities of different organisations, by creating an environment for different organisation to come together. When dealing with projects of MLU or SI, a boundary organisation should create a bridge between organisations coming from separate domains. In order to fulfil such a role it must become accepted by of all the involved organisations. Moreover, as stated previously, it must be able to address the variety of barriers that may arise within each involved domains. In addition, it may not be known on forehand which domains need to align for the integrated project to be realized. The importance of certain domain may be uncovered as the project develops. A boundary-organization will have to be flexible to the demands emerging within the integrated project.
In the following section, we will discuss more thoroughly what the information presented here means for future research for scholars interested in MLU and SI.

5. Discussion and conclusion

In this paper we have analysed the integration of functions from the perspective of domain-domain interaction. Focussing on the concepts of multifunctional land use and systems integration we have reviewed what challenges and strategies to stimulate integration of functions have been identified. Although in the current literature the crossing of boundaries between different domains is rarely referred to, we argue challenges can in part be explained by the underlying institutional context where functions cannot be seen separate from domains. Decision making and implementation of measures integrating functions often takes place in interactions between different actors and organisations which each come from different domains, such as housing, energy infrastructure, welfare and work, environment and nature, water safety, sanitation. Innovative solutions integrating functions often cross boundaries between these previously separated domains. The resulting domain-domain interactions could both constraint or enable the integration of function.
In order to better identify what makes projects requiring across domains so difficult to realise we identified several challenges which may rise in domain-domain interaction: differing interest and strategies, epistemological factors, institutional logics, routines and practices, power, and embedding the developed ideas within the existing structures. All these challenges lead one to wonder how boundaries between different domains can be overcome. Drawing upon literature about boundary-spanning, we have provided preliminary insights regarding how this question could be addressed.

We argue focussing on how boundaries between different domains are crossed in projects such as MLU and SI could bring new insights to the challenges that are faced by these projects. Similarly, it could also lead to the development of new strategies to deal with these challenges. In this section we derive several questions from our analysis, drawing a research agenda for further research on projects that integrate functions. The proposed questions can be structured in two main lines: What is needed to cross boundaries given the amount of challenges identified and how can it be stimulated? How do innovative solutions developed on the level of projects become more largely diffused and institutionalised within the domains? In the following sections we further elaborate on these questions.

<u>What is needed to cross boundaries given the amount of challenges identified and how can it be stimulated?</u>

We have identified that boundary spanning in MLU and SI projects does not involve just boundary spanning of single organisations, but in fact of several organisation embedded in different domains. These different organisations all need to work across their boundaries and be willing to allow or facilitate the realisation of integrative projects. Moreover, this needs to be done simultaneously. The question then is: *How can boundaries between various organisations embedded in different domains be crossed? And how can the boundary-spanning activities of the different domains involved be synchronised?*

The literature on boundary spanning suggests that boundary spanning can be facilitated by boundary spanners, boundary object and boundary organisations. This leads to several questions about how these could help to facilitate boundary spanning in practice, and what is needed to make them work optimally: Do all organisations need a boundary spanner in order facilitate the process of simultaneous boundary spanning?; Are boundary objects used, and what kind of boundary object?; Are larger organisations present that can act as a boundary organisation? What types of organization can facilitate boundary-crossing activities not only within a single domain but in multiple domains? How do such organisations come to be accepted in this role by involved actors? Should they be independent organisations or can they be related to one of the organisations in the process?

Furthermore one can ask how boundary spanning takes place during the process of the project. Do boundaries need to be constantly crossed? Or are they at times also utilised again by organisations involved to focus on their own interests? As each of the domains consist of their own logics, interests, perceptions, routines and practices a constant process of interaction between own and joint interest takes place. Boundary spanners in their role of bringing information to and from the environment can be seen as facilitators of this process. How does this process take place? *Are there patterns of integration and separation between the different organisations and domains they are embedded in?*

Furthermore, often different actors within organisation are responsible for different project phases. The design phase often involves different actors and skills than implementation or maintenance phases. These actors however may not have been involved in previous boundary spanning activities. Does the process of boundary spanning start again then with every phase? *How does the boundary spanning develop*

during the process of the project, during the phases of design, implementation and maintenance?

How do innovative solutions developed on the level of projects become more largely diffused and institutionalised within the domains?

We have identified that there is an interesting relation between the innovative practices being developed within projects, and the existing practices on the level of domains which can be expected to be reproduced in predictable manners by actors not involved in the project. Innovative ideas and strategies might thus meet opposition from the way things were arranged within or between the domains. How then, do these new and existing practices interact? *How do boundary spanners gain sufficient support by their organisations during the development of integrative projects? And do such projects lead to onetime exceptions on the existing rules and ways of working system, or changes become further institutionalised in the domains? How do new practices become routinized themselves?*

Projects integrating functions will of course not be the only projects interaction between domains. Often interaction between domains already takes place, for instance between the water domain and nature development. *How then do new practices developed to realise integration affect the existing relations between domains?*

To conclude these articles we would like to put forward some additional points for discussion. First, the questions derived previously are all based on theoretical facts and concept. Off course it would be very informing to ask how whether the actors themselves are explicitly aware their differences and whether they actually perceive them as problematic.

Moreover we might ask what should happen to the boundaries between different domains. The focus in this article on challenges put forward by boundaries between domains may lead us to the conclusion that boundaries should be overcome or removed as much as possible. However, boundaries have a use. They enable us to make sense of the world, and reduce the complexities and amount of information to manageable proportions. Using boundaries we can focus on specific issues at hand, not needing to go into the complexity of everything. Being useful social constructs boundaries are used largely to order society. Even when boundaries between domains might be successfully removed they will reappear elsewhere as they have a use to keep things manageable and overseeable. The question then is *how negative effects of boundaries can be overcome while positive ones are kept, looking from the viewpoint of integrating functions.*

We would like to end this paper with a last suggestion not related to the interaction of different domains, but rather directed to the two concepts analysed, multifunctional land use and systems integration. Though in this paper we have not done a full comparison between the two concepts and their related literature and scholars, we have found several differences but also many similarities between the two fields. However scholars working on these two concepts appear to have little interaction. A *more in-depth comparison of the literature on the two concepts could provide valuable insights for learning from each other.*

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