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Spatial Data Infrastructuring: Praxis between Dilemmas*

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Abstract

The paper argues that SDI can best be understood in terms of praxis more than as technological artefact. Because of the many different and often conflicting views of reality, interests and other values between the many heterogeneous actors that are involved, SDI development causes inevitably paradoxes and dilemmas. The paper assumes that SDI is context specific but also has the generic properties for any networked assembly. The paper also assumes that understanding SDI comes predominantly from four perspectives; the public policy and governance discourse, and the information systems discourse as context-specific perspectives, and actor-networking and transdisciplinarity as generic perspectives. The paper concludes that SDI development must be based on creating and maintaining between the actors a shared view of the reality of the emerging SDI initiative. The paper suggests a prudent and reflexive approach in SDI development based on practical common sense and ethnographic methods.

Keywords: SDI, praxis, dilemmas, actor-network, transdisciplinarity, ethics

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1. INTRODUCTION

Spatial Data Infrastructure (SDI) is more than technical; it also embraces non-technical elements. And like any construct, it comes out of a development process. In this sense, SDI could also be regarded as a verb – ‘infrastructuring’. The paper highlights this process character of SDI. Its significance is the emphasis put on conditions for SDI development more than on final, blue-printed outcomes only. In this respect, the aim of the paper is to contribute to the contemporary SDI discourse and to balance its predominant focus on technological artefacts. Put more specifically, the aim of the paper is to show that the understanding of concrete SDI initiatives must also consider issues that are easily ignored by more traditional and positivist approaches; notably conflicts and dilemmas in the development process. The paper assumes that these concerns are not of purely academic interest. They may also challenge practitioners who are involved in the development of concrete SDI initiatives. Therefore, I intend to address ‘reflective practitioners’ in particular (Schön, 1983).

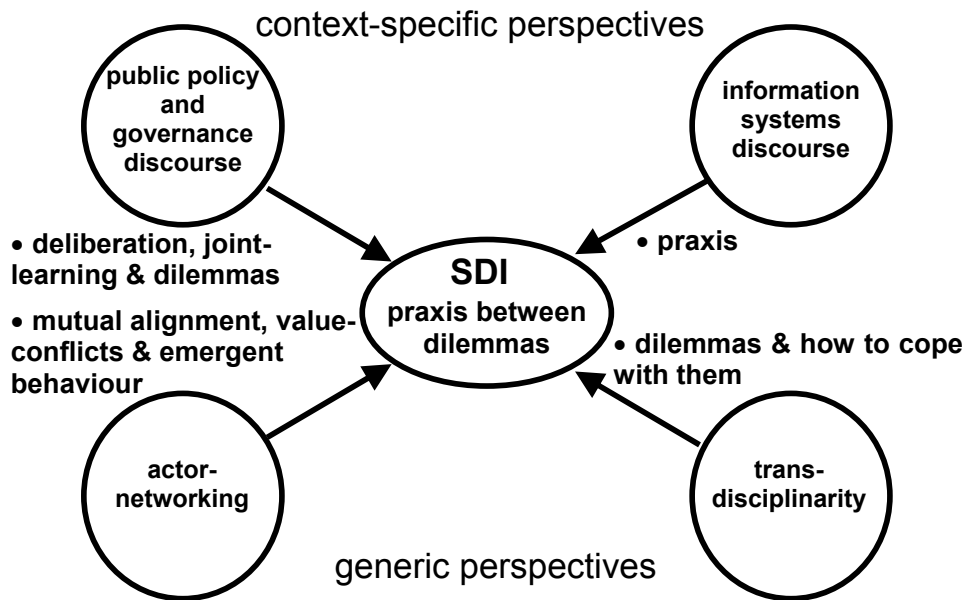
In brief, the paper considers SDI development as (1) assembling technical and non-technical elements for the exchange, distribution and sharing of spatial data, (2) in an ongoing process of negotiations and alignments between heterogeneous actors, and (3) embedded within a specific context. [Admittedly, other interpretations of the SDI concept are possible since no agreed definition exists in the literature (e.g. Cromptoets et al, 2008: 2).] The paper echoes and elaborates the observation by Masser that SDI development and implementation is very much a social process of learning by doing (2009: 219). Typical of this development process are the many multiples that are involved – including multiple actors, multiple concerns and interests, multiple points of view, and multiple challenges. This situation easily creates value-conflicts and even dilemmas. Therefore, the paper characterises SDI development as coping with dilemmas. Because this is essentially subject to value-rationality, coping with dilemmas will be referred to here as praxis. In this respect, the paper proposes to understand SDI in terms of praxis and dilemmas more than as artefact only.

The remainder of the paper first outlines this proposal in greater detail. Section 2 also elaborates the foundation of this claim. It posits as methodological postulate that understanding of complex systems comes from the outside in, more than from within. This allows the scope of the paper be limited to the definition of an appropriate SDI by its context and not requiring the evaluation of an existing, concrete SDI initiative. Four perspectives are suggested on SDI from the outside in; two are context-specific and two are generic for any networked assembly. Together they provide a multi-faceted framework for its understanding (as displayed in Figure 1). The context-specific perspectives are the public policy and governance discourse, and the information systems discourse because SDI typically develops from the interplay between public governance and (spatial)

information technology. The generic perspectives are actor-networking and transdisciplinarity. 'Discourse' is defined here as a language-based ensemble of ideas, concepts and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through practices (following Hajer, 2005: 300).

These perspectives are briefly discussed in the subsequent sections. Section 3 sketches the contemporary public policy and governance discourse. This discourse revolves around deliberation and joint-learning in societal decision making; often, as coping with dilemmas. The case of local-level flood-risk management is presented to illustrate how the context of public policy and governance could define appropriate SDI. In particular, the need for support in the exchange, distribution and sharing of spatial data in deliberation and joint-learning regarding localised matters. Section 4 relates the SDI concept to the discourse in the information systems field on whether artefacts are central to that field's identity or not. That discourse pays attention to the role of praxis. Section 5 briefly discusses SDI from the perspective of complex actor-networking. This perspective emphasises the role of mutual alignment between the different actors of their value-conflicts, as well as the emergent behaviour of the network. Section 6 further elaborates the nature of these value-conflicts from the perspective of transdisciplinarity. Many of these conflicts present dilemmas. The perspective suggests that coping with dilemmas requires the involved actors to 'think out of the box' and acknowledge their different realities, logics and rationalities. The concluding Section 7 summarizes the paper's main points and synthesises the different perspectives on SDI from the outside in. This synthesis suggests a prudent and reflexive approach in SDI development based on practical common sense and ethnographic methods.

Figure 1: Understanding SDI from the Outside In; Praxis between Dilemmas



2. UNDERSTANDING FROM OUTSIDE IN; SDI AS PRAXIS BETWEEN DILEMMAS

This section further elaborates the main tenet of the paper that SDI can best be understood in terms of praxis and dilemmas more than just as artefact. First, SDI typically develops from the interplay between public governance and spatial information technology involving a multitude of heterogeneous actors. Next, the SDI development process can be characterised as ongoing, never-ending mutual alignment between these actors of their competing and conflicting values. I refer to this behavioural process as praxis between dilemmas. Finally, this section elaborates the methodological postulate that understanding of SDI comes from the outside more than from within. The scope of this understanding is a context-specific definition of appropriate SDI.

2.1. SDI: Interplay between Public Governance and Spatial Information Technology

The paper views the SDI phenomenon as emerging from the interplay between public governance and spatial information technology. Developments in one domain influence developments in the other in intricate ways. Take, for example, planning and maintenance of social services and physical infrastructure. These tasks generally involve concerted actions by an ever-increasing number of societal actors at different levels of governance. As a consequence, a permanent effort is needed to improve the management of necessary spatial data; specifically their exchange, distribution and sharing. Such a situation would make a clear case for an SDI initiative. But new issues and concerns will emerge in the course of time for which no data has been considered yet. This example indicates on the one hand how contemporary governance may drive the development of SDI initiatives towards flexibility and adaptation. But on the other hand it points to the risk of inertia: once established, SDI can no longer easily adapt to changing societal demands. And that would simply constrain responsive governance. Another example is the ongoing European integration that has undoubtedly contributed to the development of SDI initiatives within and between the member states (notably through the INSPIRE programme). As a result, concrete SDI initiatives, adopting state-of-the-art technologies, standards, and models, serve as examples for developments elsewhere in Europe. A recent study (Craglia et al, 2009) shows the important role that regional (sub-national) SDIs in particular can play in coordinating and organising socio-economic development at the local level. This case illustrates how developments at one level of governance may stimulate developments at a different level through a chain of technological developments between these levels and involving multitudes of heterogeneous actors.

2.2. SDI in terms of Praxis and Dilemmas

The proposal to understand SDI in terms of praxis and dilemmas more than just as artefact must be viewed against this contextual backdrop of emergence and behavioural processes within and between public governance and spatial information technology. Before going into its details, the main elements of the proposal need to be described: praxis, dilemma and artefact. First, praxis is perceived here as social activity contingent on context-dependent value-rationality; on situational ethics (following Flyvbjerg, 2001: 4, 55-65, 134-136). Praxis in the development of SDI would then refer to those activities that have an impact on a concrete development process and are guided by the interests, beliefs and other values of interacting actors. This is not a trivial issue. Often, these values are mutually competing and conflicting – if not: mutually excluding. Next, dilemmas are ‘wicked’ value-conflicts in the sense that they cannot be

solved definitely and objectively (Rittel et al, 1973). Take for example the earlier mentioned need for flexibility in the development of SDI. This need can easily be in conflict with the equally important need for systematic and standardised handling of spatial data; the dilemma of standards. (The paper elaborates the notion of 'dilemma' in Section 6.) Finally, the term artefact here simply refers to the resulting SDI construct.

In brief, the proposal to understand SDI as praxis between dilemmas is based on the following arguments. They will be elaborated in the remainder of the paper.

- Understanding SDI reflects its role beyond the technical intricacies of the exchange, distribution and sharing of spatial data. I consider the role of SDI primarily as facilitating deliberation and joint-learning in public governance, more than being a vehicle for control and sustenance of central authority. Deliberation and learning are key elements in the contemporary public policy and governance discourse (as will be discussed in Section 3).
- The role of SDI to facilitate deliberation and joint-learning is a complex matter. Many actors are generally involved and bring their own, diverse, frequently changing and often mutually conflicting interests, beliefs and other values. Moreover, empirical evidence suggests that SDIs are foremost social networks of people and organisations (for instance Craglia et al, 2009: 10). And, last but not least, SDI develops in an ongoing, never-ending process. Hence, the development of SDI can best be seen as complex and ongoing actor-networking (as will be discussed in Section 5). These social activities will likely revolve around the dilemmas that emerge from the conflicting values of the actors involved.
- Therefore, SDI development will generally imply the resolution of such dilemmas. This is not a value-free process. The alignment of competing and conflicting values will likely affect the 'right to exist' of each of them. In this sense, the SDI development process has a clear ethical dimension and, hence, can be referred to as praxis between dilemmas.

2.3. Understanding SDI from the Outside In; Context-specific and Generic Perspectives

Now we turn to the question of what evidence supports the proposal to understand SDI in terms of praxis and dilemmas. This question, however, cannot be answered definitively and objectively. It will not be possible to prove in a scientifically positivist way that the focus on praxis and dilemmas is generally better for understanding SDI than the traditional focus on technological artefacts. It all depends on how the problem context of a specific SDI initiative regarding spatial data handling is perceived and defined. If, for example, the existing

problems in the exchange, distribution and sharing of spatial data are experienced as predominantly technical, the focus on technological artefacts will likely be seen as appropriate. But this qualification may not be justified when important non-technical issues were ignored in the problem definition. This suggests that the understanding of SDI depends on the interpretation and definition of its context. [Here, the paper follows the classic adage by Thomas (1928: 572): "If men define situations as real, they are real in their consequences".] Added to this are generic properties attributed to networked assemblies in general. In other words, the understanding of SDI comes from the outside in; more than from within. Put more specifically, its understanding comes from context-specific perspectives and from generic perspectives. In this respect, the paper clearly reflects an interpretive philosophy of science, which emphasises understanding and searching for meaning as distinct from law-based explanation (see also Flyvbjerg, 2001: 25-49; Geertz, 1973: 3-30). The next four sections elaborate the public policy and governance discourse, as well as the information systems discourse as context-specific perspectives, and actor-networking and transdisciplinarity as generic perspectives.

3. PUBLIC POLICY AND GOVERNANCE AS CONTEXT FOR SDI DEVELOPMENT; DELIBERATION AND JOINT-LEARNING

This section elaborates the perspective on SDI development from the contemporary public policy and governance discourse. First, it gives a brief and impressionistic summary of that discourse as far as it is relevant for the development of SDI. Broadly speaking, this discourse revolves around the need for deliberation and joint-learning in societal decision making. (Within the scope of the paper it is not possible to do any justice to the breadth of the discourse, conflicting views and the vast literature that reflects it.) Next, the case of local-level flood risk management is presented to illustrate the needed support in deliberation and joint-learning regarding localised matters in multi-level governance. The section concludes that an appropriate SDI would address this need; particularly through its contribution to the exchange, distribution and sharing of spatial data.

3.1. The Contemporary Public Policy and Governance Discourse

The contemporary public policy and governance discourse reflects a shift in vocabulary regarding societal decision making, portrayed by some as 'networked' deliberation and joint-learning (Hajer et al, 2003). The discourse follows on the rhetoric of the rise and decline of big government and welfare state over the past 80 years or so. Put in broad terms, big government was generally regarded till the mid-1960 as the beneficent instrument of an expanding economy and increasingly just society. But from then onwards, government was increasingly seen as a potential threat to individual freedom and as the enemy of economic

efficiency (Esman, 1988: 125-129). Along with this development, the public policy discourse has shifted from government to governance; societal decision making and governing beyond government. Modern governance is generally seen as multi-level and polycentric reallocation of authority from the central state. The governance concept thus contains both vertical and horizontal dimensions (Bache et al, 2004: 3). Allocation of authority over multiple jurisdictions would make governance more flexible than concentration in one jurisdiction. But it will also make it more complex – for instance in the form of transaction costs and trade-offs (Bardhan, 2002).

The complex nature of multi-level governance is already evident from its variety in structure and style. Regarding its structure, two contrasting types can be drawn from the literature, differing in their degree of hierarchy (Hooghe et al, 2003). In one type of multi-level governance, authority is allocated to general-purpose, nonintersecting, and durable jurisdictions with units at each level perfectly nested within those at the next higher level. The second type is less hierarchical. It is composed of task-specific, intersecting, and flexible jurisdictions. These two types clearly show that even though every hierarchy is a multi-level system, not every multi-level system is a hierarchy (Mayntz, 1999: 101). For instance, centres of authority at a lower level in the second type of multi-level governance enjoy independent powers. Such 'federalism' adds its own complications to multi-level governance; particularly with respect to wide-ranging infrastructures like SDI (see also Masser, 2009: 224).

The style of multi-level governance may vary together with its structure. One could expect that the more hierarchical its structure is, the more the emphasis will be on traditional approaches of command, control and enforcement. In less hierarchical structures the style of governance is that of continuous negotiation and bargaining among policy networks at different territorial tiers – supranational, national, regional and local (Hooghe et al, 2003: 234; Marks, 1993: 392; Snellen, 2002: 183), and the management or manipulation of information in networks (Van Kersbergen et al, 2004: 155). This type of governance inevitably faces contradictions and dilemmas. Examples of dilemmas in governance are (Jessop, 2003a: 101; 2003b: 9-11)

- cooperation versus competition. Commitment to cooperation and consensus can block the emergence of creative tensions that could promote learning (capacities) and thereby enhance adaptability;
- openness versus closure. Participants in governance arrangements face problems in remaining open to the environment while at the same time securing the closure needed for effective coordination among a limited number of partners; and
- governability versus flexibility. There is a needed capacity for guidance in a complex world through standardisation and operational rules. But this

must be balanced against the equally needed capacity to adapt to changed circumstances by recognition of complexity and to mobilise the 'requisite variety' (Ashby, 1956) of actors and resources.

Much of the complex nature of multi-level governance is also evident at its local tier. It is here where citizens, government, street-level bureaucracy and public services, market and business, and civil society directly meet and interact. Their interests, beliefs and other values are often diverse, competing and – potentially at least – conflicting. But at the same time, most local communities develop networks and institutional arrangements for building social capital and providing 'rules of the game'. Transaction costs of deliberation and joint-learning may therefore be relatively low at this level and the information problems that can contribute to central government failures may be less acute (Ostrom, 1990; 2007; Putnam, 1995; 2000; Scott, 1998).

To conclude, governance in its most articulated form can both be seen as a polycentric system and as societal practice of deliberation and joint-learning that involves a wide variety of heterogeneous actors in different geographical and administrative levels and jurisdictions. Moreover, the local tier clearly exposes the complex nature and dilemmas of multi-level governance. And, finally, different possible types of multi-level governance will likely have important implications for SDI development.

3.2. Local-Level Flood Risk Management in Naga City, The Philippines

This section argues that the local tier of governance accommodates many of the challenges that must be accounted for in the definition of an appropriate SDI; specifically in deliberation and joint-learning. For illustrative purpose reference is made to the case of local-level flood risk management in Naga City, The Philippines. [The rationale of this choice is that Naga City has been one of the locations of ITC's research project to develop a methodology for the application of geographic information technology in local-level risk management of natural disasters (Van Westen et al, 2005; see also Peters Guarín, 2008).]

Naga is a medium size city in Bicol Province of the Philippines. The city is located in the so-called 'typhoon belt' of the Philippines, and experiences two to five typhoons annually accompanied by extremely intense rainfall. Naga City serves as a major commercial, governmental, educational and cultural centre and hosts a private, catholic university. Still, its economy remains primarily agricultural. Administratively, the city is divided into 27 wards (barangays). Naga City has been widely recognised for its innovative leadership and governance. It has formed partnership with the private sector. It also institutionalised citizen participation in decision making. A recent initiative aims to bring information to

the people and to open a communication channel where average citizens are given voice (feedback) in the affairs of the city.

The annual recurrence of typhoons has created differentiated understanding of the flood threat between barangays and local government. Citizens within the affected barangays understand and perceive these threats in relation to their everyday life and how they cope with them. For example, management of various risks – like flooding, earth quakes, health hazards, and unemployment – are integrated into livelihood. At the city government, knowledge about flooding concentrates on disaster response measures more than on flood risk reduction. In addition, different risks are handled at city level separately through specialized departments and agencies. The implementation of effective measures by the city government to counteract the negative effects of flooding is still lacking. In general, urban development initiatives are not comprehensively planned. Moreover, such initiatives often benefit the interests of a few while aggravating the flood situation for the marginal groups. The research has also highlighted the importance of local knowledge and recommends that flood risk management based on local peoples' coping capacities needs to become a cross-cutting issue for the overall management and development of Naga City (Peters Guarín, 2008: 323-324). This requires deliberation and joint-learning between municipal and barangay officers, other community leaders and the local people themselves.

3.3. Defining An Appropriate SDI; to Facilitate Deliberation and Joint-Learning between Dilemmas

The Naga case illustrates the need for deliberation and joint-learning in governance when a multitude of heterogeneous actors is involved. These actors generally come from different, partly overlapping jurisdictions. And even though these actors may share the same flooding event, they are likely to perceive it differently. This heterogeneity will easily create value-conflicts and even dilemmas between the involved actors. The case study also shows that deliberation and joint-learning often involves localised matters and, hence, the exchange, distribution and sharing of spatial data of a wide variety of different kinds and qualities, including reports, maps, and local knowledge.

We may conclude this section as follows. The perspective from public policy and governance suggests that an appropriate SDI must address the need for deliberation and joint-learning between dilemmas. In particular, this will be through its contribution to the exchange, distribution and sharing of spatial data of different kinds and qualities.

4. INFORMATION SYSTEMS DISCOURSE; PRAXIS VIS-À-VIS ARTEFACTS

The understanding of SDI may also come from discourses about information systems development because SDI can be seen as special case of information infrastructure (De Man, 2007). Over the past fifteen years, intense debates within the information systems field were held about that field's identity and legitimacy. Some even speak of these debates in terms of "identity crisis" within the field (for instance Benbasat et al, 2003; Ciborra, 1998) or of "anxiety discourse" (King et al, 2004). Though it will again not be possible to do any justice to the full richness of these discourses within the limitations of the paper, some salient issues can be presented nevertheless. First, this section briefly addresses the divisive question whether or not the information technology (IT) artefact is central to the information systems field. Next, the focus will be on information infrastructures as transformational development of information systems into greater complexity. Here, the discourse includes an understanding – by some scholars – of information infrastructure development as evolving quasi-autonomously. Finally, the section concludes that these discourses emphasise the possible role of praxis in information infrastructure development. This is significant for the proposal to understand SDI in terms of praxis.

4.1. Are IT Artefacts The Core Subject Matter of the Information Systems Field?

A recurrent theme in the information systems discourse is about the role of the IT artefact. On the one side of the debate are those who claim that these artefacts ought to be the field's core subject matter but that the field has not sufficiently engaged them as such (for instance Benbasat et al, 2003; Orlikowski et al, 2001: 121). IT artefacts are not necessarily limited to technical constructs. Orlikowski and Iacono (2001: 131) understand them as those bundles of material and cultural properties packaged in some socially recognisable form such as hardware and/or software. More specifically, they consider IT artefacts as (1) not just given; (2) always imbedded in some time, place, discourse, and community; (3) usually made up of a multiplicity of often fragile and fragmentary, interconnected components; (4) neither fixed nor independent, but emerging from ongoing social and economic practices; and (5) not static or unchanging, but dynamic. Benbasat and Zmud (2003: 186) conceptualise the IT artefact as the application of IT to enable or support some task(s) embedded within a structure that itself is embedded within a context. Hevner, March and Park (2004: 77) take the broader perspective of design science and consider IT artefacts as *constructs* (vocabulary and symbols used to define problems and solutions), *models* (abstractions and representations of the problem domain), *methods* (algorithms and practices), and *instantiations* (implemented and prototype systems). These artefacts are concrete prescriptions that enable IT researchers and practitioners to understand and address the problems inherent in developing and successfully

implementing information systems within organisations. But these authors do not include people or elements of organisations in their definition of IT artefacts nor the processes by which such artefacts evolve over time (Hevner et al, 2004: 82, 83).

On the other side of the debate on the information systems field's central identity, are those who see the focus on IT artefacts as too narrow. For instance, Ciborra (1998: 5-9), worried that the field is too much focused on methods of the natural sciences and tends to forget the role of human choice behind the technical artefacts – “the fundamental role of the everyday life world of the agents, users, designers, managers, and the messiness and situatedness of their acting” (: 9). Similarly, DeSanctis (2003: 367, 373) argued that (research in) the information systems field must change focus on matters peripheral to the IT artefact for at least two reasons. First, IT artefacts have transformed from a technical back-office development role to a strategic business opportunity. Second, IT knowledge and creative use are pervasive and no longer the sole domain of specialists. Hence, the context of IT artefacts is increasingly knowledge-based and social.

This transformation of IT – whether real or anticipated – must have an impact on the information systems discourse. Ciborra (1998: 12-16) concluded therefore that another, less formal and structured language is required to capture the intricacies of everyday life, routines and operations surrounding the design and use of technology. Not surprisingly, some authors use the term ‘praxis-based’ to denote the field's centre (for instance Lyytinen et al, 2004).

4.2. Quasi-Autonomously Evolving Information Infrastructures

The emergence of the information infrastructure phenomenon signifies another transformational development of information systems into greater complexity. A defining characteristic of information infrastructures is that they are not only embedded into other structures, social arrangements and technologies, but built on an existing (installed) base. Infrastructure develops not from scratch but through extending and improving the installed base. It inherits strengths and limitations from that base (Ciborra et al, 1998; Star et al, 2006: 231). But any information infrastructure is itself the installed base for further development and therefore a powerful actor influencing its own future life; its extension and size as well as its form. In other words, information infrastructures – like any other infrastructure – have the tendency to evolve more or less autonomously over time. Moreover, information infrastructures may have ‘network externalities’; either positive or negative. Positive network externalities occur where all users benefit when a new user joins the network because of the ability to communicate with more actors. Conversely, network externalities may be negative when, for instance, not being “hooked up” makes it impossible to participate effectively

within a given community of work or societal life (Graham et al, 2001: 147; Monteiro et al, 1996: 333; Star et al, 1996: 124). Because of these network externalities, information infrastructure development would also be about “who wins and who loses” from it. Put in more general terms, information infrastructure development is contingent on context-dependent value-rationality. Following the discussion before (in Section 2.2), such actions can be referred to as ‘praxis’.

From an engineering and managerial perspective, the task of information infrastructure development is to design, build, and control it. However, the socio-technical and evolutionary dynamics of information infrastructure suggests that the practice of ‘cultivation’ is a wiser and sounder strategy for intervention. The concept of cultivation regards socio-technical systems as organisms with a life of their own and recognises the limits of instrumental-rational control of them (Ciborra et al, 1998: 312; Dahlbom et al, 1993: 128).

4.3. SDI Development as Praxis

The information systems discourses seem to move beyond the domain of idealized abstractions to the worlds of everyday life. This is reflected by the emergence of new vocabularies and meanings. In the case of information infrastructures it might take the form of ‘cultivating’ quasi-autonomous developments. Some scholars emphasise the role of praxis in this respect because it would balance instrumental rationality with value-rationality or (situational) ethics. These discourses are significant for understanding SDI when we see the latter as special kind of information infrastructure in general. Of course, they do not unequivocally support the proposal to consider SDI development as praxis. All they suggest is that such proposal is not (too) far fetched and could fit within contemporary discourses.

5. SDI AS ACTOR-NETWORKING; MUTUAL ALIGNMENT, VALUE-CONFLICTS AND EMERGENT BEHAVIOUR

Besides the context-specific perspectives of both the public policy and governance discourse and the information systems discourse for understanding SDI, there are also generic perspectives for any networked assembly. As mentioned before (Section 2.2), the paper views the development of an SDI as complex and ongoing actor-networking. This section elaborates that perspective thereby relying on two interrelated but distinct concepts or ideas in the literature; complexity and the so-called ‘actor-network theory’. These are briefly and impressionistically presented here in relation to SDI development. The section concludes that the perspective of actor-networking views SDI development as mutual alignment between the different actors of their competing and conflicting values, and as emergent, self-organising and evolving.

5.1. Complexity and SDI

From the discussion so far, one could easily agree that SDI – like any other networked infrastructure – is complex beyond just being technically complicated. But what is precisely meant by ‘complexity’ would probably be less clear. Partly, this is because the ‘discourse of complexity’ has not yet resulted in any clear, precise or generally agreed definition of the term; let alone a single unified theory of complexity (Martin et al, 2007; Mitleton-Kelly, 2003). Nevertheless, some fruitful concepts are offered for renewed seeing and re-thinking dynamic, networked systems. Merali and McKelvey (2006) even speak of paradigm shift in this respect. This sub-section briefly focuses on complex systems and emergent properties, complex behaviour and co-evolution, and built-in redundancy to maintain reliability of systems under uncertainty.

Complex systems are in the view of Mitleton-Kelly (2003) not designed in great detail. They are made up of interacting agents, whose interactions create emergent properties, structures, and patterns of behaviour. Hence, they are self-organising and evolving. Complexity is in the view of Barabási (2003: 12, 225; 2005: 70) as much rooted in the structure of networks as it is in the nature of the processes taking place on these networks. Because of the emergent properties, the emphasis of complex systems is on the interacting whole and on the non-reducibility of those whole entities to their component parts. Mol and Law (2002: 1) describe complexity succinctly as (1) if things relate to each other but do not add up, (2) if events occur but not within the processes of linear time, and (3) if phenomena share a space but cannot be mapped in terms of a single set of three-dimensional coordinates. This brief and admittedly sketchy and incomplete account of the characteristics of complexity may show already their relevance for the contemporary SDI discourse. They challenge for example the hierarchical SDI model, where higher-level infrastructures can be subdivided into lower-level ones and are made up of them (as for instance Rajabifard et al, 2003: 28-37); they may not add up.

Complex behaviour is not random but arises from interaction. These interactions are in the view of Barabási (2003: 65-78) the key to understand emergence and self-organisation in complex systems. Mitleton-Kelly considers the joint-creation of new order and coherence as one of the defining properties of complexity; driven by co-evolution and adaptation. In her view, co-evolution is a notion of empowerment as it suggests that all actions and decisions affect the system and its environment whereas adaptation is a notion of responding to. Co-evolution may lead to the creation of new order whereas adaptation maintains coherence. Additionally, emergence is the result of past choices made (the history), and subsequent evolution into new order may depend on that critical choice as well (Mitleton-Kelly, 2003: 27-34; see also Martin et al, 2007: 5, 6). Co-evolution,

adaptation and historicity are all three apparent in the required functionality of appropriate SDI supporting governance as discussed before (Section 3).

Under certain conditions complexity will increase the reliability of systems under uncertainty (Carlson et al, 2002). Built-in redundancy and overlap in particular, while adding to complexity, may provide an essential contribution to diminishing uncertainty and maximizing reliability (Landau, 1969; 1973; Ostrom, 2005: 284). But mainstream thinking in SDI development is more concerned with diminishing and avoiding redundancy. Although some duplication in spatial data handling may certainly be avoided (e.g. Cromptoets et al, 2004: 667-670; SDI-Association 2009), the point is that a positive view of redundancy and overlap is almost absent in the contemporary SDI discourse. This is significant for the arguments set forth in the paper; particularly those arguments about the functionality and appropriateness of SDI. It is hard to think of deliberation and joint-learning in public governance without some degree of redundancy. Specifically, information redundancy as sharing of information beyond the minimal amount required by each actor may increase trust between them. And trust, in turn, is critical to the effectiveness of societal problem solving (see also Madhavan et al, 1998; Putnam, 1995; 2000) and, hence, of governance.

5.2. SDI as Actor-Networking

SDI development can also be looked at from the perspective of the so-called 'actor-network theory' (ANT). It is then seen as an ongoing process of negotiating and aligning the various interests, beliefs and other values of interacting actors – both human and nonhuman, including spatial data. Despite the fact that ANT is by its very nature not a unified body of concepts and approaches, some general consensus can also be found in the literature. A characteristic property of actors is that they *do* something and make a difference. Specifically, they make other actors *do* things as well; for example they make them to cooperate. Not by force but by 'translation' between them (Latour, 2005: 107, 108, 154, 217). Translation refers to a phased process whereby the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited. It is a process, never a completed accomplishment (Callon, 1986: 196, 203; Woolgar, 1991). In other words, translation is ongoing negotiated alignment of actors into specific roles and the associated actions. Actor-networks are assembled and reassembled in these ongoing processes of interacting actors (Callon, 1985: 24, 28, 33; Latour, 2005: 169, 179). Translation signifies two aspects. First, actors have their own interests, beliefs and other values as premises for their actions. Second, value conflicts are negotiated by translation and within the multiple realities of the emerging actor-network. [Recall the classic adage by Thomas followed in this paper: "If men define situations as real, they are real in their consequences" (see also Section 2.3).]

Literature on ANT includes references to information technology (for instance Aanestad, 2002; 2003; Mähring et al, 2004; Monteiro et al, 1996; Walsham, 1997) and GIS (for instance Chrisman, 2005; Harvey, 2000; 2001). Martin (2000) applied ANT to study the implementation of four environmental GISs in Ecuador. His investigation produced useful insights into the effects and impacts of social interactions surrounding GIS technology and possible conditions for stability and sustainability in the development of GIS. In his analysis, Martin (2000: 721-725) situated the actors and their interactions around the GIS artefact – a closed black-box at the centre of the actor-network. De Man (2006: 338, 339) considers SDI itself as actor-networking. ANT would suggest that SDI as actor-network is embedded in a host actor-network (see also Mähring et al, 2004: 226-230). Public governance as context for SDI could then also be seen as (higher-order) actor-network.

5.3. SDI Development; Mutual Alignment, Value-Conflicts and Emergent Behaviour

From the perspective of complex actor-networking, focus is on the dynamics of SDI development. Two aspects are emphasised in particular. First, SDI is viewed in terms of interactions between the different actors – mutual alignment of their competing and conflicting values – more than as networked components and conditions only. Second, SDI is seen as complex; self-organising and evolving. This emergent behaviour of SDI would continuously and irreversibly bring about new situations, structures, relationships, or even new entities.

6. TRANSDISCIPLINARY FRAMING OF SDI DEVELOPMENT; COPING WITH DILEMMAS

Another generic perspective for understanding SDI focusses on paradoxes and dilemmas in its development. The perspective of transdisciplinarity suggests that coping with dilemmas requires what can be called 'thinking out of the box'. This section first indicates the kind of dilemmas that can be encountered in SDI development. Next, the notion of transdisciplinarity is briefly discussed as it appears in the literature. Finally, the section concludes that the perspective of transdisciplinarity views SDI development as creating and maintaining a shared view of the reality of the emerging SDI.

6.1. Dilemmas in SDI Development: Conflicting Views of Reality

SDI development faces inevitably paradoxes and dilemmas caused by the multitude of different and often conflicting interests, beliefs and other values. In general, many paradoxes of large scale, dispersed technologies arise from the tension between local, customised, intimate and flexible use on the one hand and the need for standards and continuity on the other (Star et al, 1996: 111, 112). Whereas paradoxes are situations in which two contradictory or even mutually

exclusive alternatives are both desired, dilemmas are the need to choose between them. Dilemmas for SDI, stretching across different governance levels, include:

- dilemma of standards; the need for systematic and standardised data handling versus the need for flexibility in capturing relevant data (Hanseth et al, 1996; Rajabifard et al, 2006: 738);
- dilemma of network externalities (briefly discussed in Section 4.2). The dilemma is that any concrete infrastructure will have differentiated accessibility effects for (potential) users – some actors may gain access and benefit from it, while others may be excluded;
- dilemma of the ‘modernity-ideal’ (related to the previous dilemma). Some actors gain new communication facilities through the initiative, while others may lose their existing, traditional ones. An example is the possible loss of indigenous and traditional knowledge;
- dilemma of network growth. On the one hand, positive network externalities propel their growth. On the other hand, with a growing network one may expect forces towards collapse as well (Graham et al, 2001: 22-30, 90-136). For example, a growing network like SDI, may become increasingly difficult to manage and to sustain centrally;
- dilemma of ‘governing the commons’. If SDI is to support ‘the common good’, the question is how to navigate between (1) needed central authority and some form of central control over the infrastructure, and (2) equally needed support through delegation of authority and responsibility. This dilemma may be dealt with, for example, by polycentric arrangements, self-organisation, or co-production between different actors in the SDI development process (see for ‘governing the commons’: Ostrom, 1990; 1999; 2000).

Dilemmas are thorny problems. Rittel and Webber (1973: 160) characterise them as ‘wicked’ in the sense that they cannot be solved definitely and objectively. At best they are only resolved – over and over again. A major reason for such situation is probably that many of the underlying value-conflicts are caused by different and often conflicting views of reality. [Similar to ‘world-view’; the picture people have of the way things actually are, their concept of nature, of self, of society; their most comprehensive ideas of order (Geertz, 1957: 421).] And because a particular view of reality brings about its own subjective logic and rationality as premises for decisions and actions, conflicting views of reality result in conflicting logics and rationalities. Hence, these conflicts are very difficult to resolve. An obvious example is the bureaucratic ‘reality’ of most governments based on standardisation and efficiency, whereas the ‘reality’ of citizens hinges on uniqueness and nuances (see also “seeing like a state” versus “mētis” – knowledge embedded in local experience; Scott, 1998). Conflicting views of

reality are also underlying the “two cultures” (Snow, 1965) or the “science wars” (Sokal, 1996a; 1996b) between the natural and social sciences disciplines.

6.2. Transdisciplinarity and Coping with Dilemmas

When SDI development is seen as coping with dilemmas, it would then mean: coping with different, often mutually excluding perceptions of reality. The idea of ‘transdisciplinarity’ in the literature offers some help in finding a way out of such either/or dichotomies (for instance Hirsch Hadorn et al, 2006; Klein, 2004; Klein et al, 2001; Max-Neef, 2005; Nicolescu, 2002; 2007; Pohl et al, 2008; Tress et al, 2003). But, like complexity and ANT, transdisciplinarity is also not a unified body of concepts and approaches. Nevertheless, some general consensus can be found here as well.

Transdisciplinarity is generally placed at the juxtaposition between science and society. It addresses the need for integrated knowledge from a variety of different perspectives in societal problem solving regarding complex societal concerns (Hirsch Hadorn et al, 2006: 122; Klein et al, 2001). The knowledge that is required may exceed the sum of disciplinary knowledge in a fundamental way. Transdisciplinarity concerns what is *between* the disciplines, *across* the different disciplines, and *beyond* all disciplines (Nicolescu, 2002: 44). Some authors see transdisciplinarity primarily as (action) research beyond disciplinarity and involving stakeholders who are not academics (for instance Pohl et al, 2008; Winder, 2003: 75). This does not mean that those stakeholders are member of the research team. The point is that their involvement is not confined to the reality of the various scientific disciplines (for example as the filling out of pre-formulated questionnaires and the responding to opinion surveys) but that their ‘realities’, logics and rationalities are fully taken into account.

Transdisciplinarity, in the view of Nicolescu (2002: 15-29), acknowledges multiple levels of reality. Being a theoretical physicist, he frequently refers to the example of quantum physics with a different level of reality than that of classical physics and with different logics and governing laws accordingly. Put generally, transdisciplinarity accepts that a phenomenon can relate to different levels of reality each having its own laws, logics and rationalities. This may generate conflicts between those levels. The Naga case clearly illustrates this point (Section 3.2). Although the city government and its local communities share the same flooding events, they are perceived differently. As argued earlier, this is mainly because of the different realities of these actors; the bureaucratic reality versus the reality of citizens. In some instances these conflicts may even take the form of contradictions; what is possible or desired at one level is impossible or undesirable at another.

Transdisciplinarity not only assumes that contradictions occur at specific levels of reality as mutually excluding opposites, it also assumes that they can be reconciled at a different level of reality (the 'axiom of the included middle'; Nicolescu, 2002: 28) Though, this may create new contradictions. Intuitively, transdisciplinarity is 'thinking out of the box' – specifically, out of the disciplinary box. The emergence of 'public governance' is an obvious example (Section 3). Deliberation and joint-learning between government and its citizenry – the hallmark of public governance – creates a shared level of reality that enables resolving many of the incompatibilities and dilemmas occurring between them. Put generally, the capacity of resolving dilemmas makes a shared reality more than the sum of its constituent realities.

To conclude, transdisciplinarity can be seen as situated negotiation to understand diverse – often contradictory – views of societal problems and to engage in mutual learning and integration. This requires a culture of openness and of cooperation; a culture of questioning and accepting the responses as temporary; a culture of dialogue and mutual learning (Hirsch Hadorn et al, 2006: 120, 121; Klein et al, 2001: 4; Nicolescu, 2002: 121).

6.3. Transdisciplinary SDI Development; 'Thinking out of the box'

The perspective of transdisciplinarity puts emphasis on dilemmas in SDI development. These dilemmas emerge because of mutually incompatible views of reality between the various actors within the realm of governance; notably between government bureaucracies and their citizens. Transdisciplinarity suggests a way of coping with dilemmas in SDI development by jointly creating and maintaining a shared view of the reality of the emerging SDI. This would require an attitude of 'thinking out of the box' of individual, taken-for-granted views of reality.

7. SUMMARY, CONCLUSION AND OUTLOOK

The main tenet of the paper is that SDI can best be understood in terms of praxis and dilemmas more than just as artefact (construct). Support for this claim is sought following the assumption (as methodological postulate) that the understanding of complex systems comes predominantly from the outside in. Four perspectives on SDI were elaborated in the previous sections to this end; the public policy and governance discourse, and the information systems discourse as context-specific perspectives, and actor-networking and transdisciplinarity as generic perspectives. The major aspects for SDI development from these perspectives are summarised in Table 1.

Together, these perspectives emphasise the process character of SDI. They suggest that SDI emerges out of interactions between heterogeneous actors with

different interests, beliefs and other values. Often, these values are mutually competing and conflicting; or even mutually excluding. In this respect, SDI development can be regarded as coping with dilemmas (Section 2.2 and Section 6). And because these development activities are contingent on context-dependent value-rationality, SDI development can also be regarded as praxis (Section 2.2).

Table1: Context-specific and Generic Perspectives on SDI

Perspectives on SDI	Major aspects for SDI development
<i>context-specific perspectives</i>	
public policy and governance discourse	<ul style="list-style-type: none"> • support for deliberation and joint-learning in public policy and governance between dilemmas • partly overlapping jurisdictions • exchange, distribution and sharing of spatial data of different kinds and qualities
information systems discourse	<ul style="list-style-type: none"> • information infrastructure development as praxis • new vocabularies; e.g. 'cultivation' of quasi-autonomous infrastructures
<i>generic perspectives</i>	
actor-networking	<ul style="list-style-type: none"> • mutual alignment between different actors of their competing and conflicting values • complex; self-organising and evolving • emergent behaviour
trans-disciplinarity	<ul style="list-style-type: none"> • dilemmas (either/or problems) • jointly creating and maintaining a shared view of the reality of the emerging SDI • 'thinking out of the box' of taken-for-granted perspectives

To conclude, these perspectives together indeed suggest that SDI can best be understood as praxis between dilemmas more than just as artefact. In coping with dilemmas in SDI development, a strategy of creating and maintaining jointly a shared view of the reality of the emerging initiative is suggested. The focus on praxis and dilemmas in SDI development is significant because it considers a wider variety of issues than when the focus is on artefacts only. For example, the nuances and fringes of the infrastructure may easily be overlooked or simply ignored when a technocratic and positivist approach is followed assuming SDI development as law-like patterned. This does not mean that the approach set forth here necessarily substitutes and replaces those traditional ones; it may simply add to what already exists.

Ethnographic methods can help to focus attention on nuances and fringes as well as on the practical concreteness of SDI. These methods also help in surfacing silenced voices, coping with disparate meanings, understanding the gap between words and deeds, and in understanding changes in the social orderings that may be brought about by the SDI initiative (see also Star, 1999: 383; 2002: 107). Ethnography often challenges what is “taken for granted” and provides researchers with the opportunity to get close to “where the action is” (Myers, 1999: 5-6; for such action research, see for instance Kock, 2003). Narratives can grasp the complexity of SDIs through the stories told by the actors who were (and are) involved in the development of concrete SDI initiatives (see also Hedman et al, 2005). Praxis-focused SDI action research is a behavioural and social field of scientific inquiry, and could significantly benefit from the idea of a “social science that matters” (as proposed by Flyvbjerg, 2001: 56-62) – prudent and practical common sense. Flyvbjerg offers some guidelines for such inquiry, including: focussing on values, placing power at the core of the analysis, getting close to reality, emphasizing little things, studying cases and contexts, asking “how?” and doing narratives, and dialoguing with a polyphony of voices (Flyvbjerg, 2001: 129-140). The question of how praxis-focused SDI research may enter the curricula of (post) graduate studies needs (yet) to be dealt with.

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