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Kirsten von Elverfeldt

System Theory in Geomorphology

Challenges, Epistemological Consequences and Practical Implications

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System Theory in Geomorphology

Challenges, Epistemological Consequences and Practical Implications

Doctoral Thesis accepted by
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This book is a translation of the thesis in German "Systemtheorie in der Geomorphologie—Problemfelder, erkenntnistheoretische Konsequenzen und praktische Implikationen"

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The journey is the reward.

Parts of chapters 1, 3, 4 and 5 are based on or taken from the publications listed below

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Elverfeldt, Kirsten von & Glade, Thomas (2011): Systems theory in Geomorphology. A challenge. *Zeitschrift für Geomorphologie*, 55(3): 87–108.

Supervisor's Foreword

Investigations on system theory within geomorphology are still rare. However, there is a long history of working on "system theory" and "geomorphology" (e.g. Chorley 1962). Unfortunately, in the German speaking countries such as Austria, Germany and Switzerland, profound and systematic analysis on this topic are missing. This is in clear contrast to personal statements or contributions within discussion rounds where one often hears, that a "system-theory" thinking is very evident within geomorphology. Consequently there is seen no need for such studies.

This presented research shows the contrast. Indeed, the "thinking" in terms of "system theory" is often inherent in traditional geomorphic analysis. However, it is often not made explicit. And this makes the difference. One of the major underlying problems is that there is neither a common scientific ground for "system theory in geomorphology" nor a sound and founded reflection of the relevant theoretical concepts. As a consequence, there are no common definitions on relevant terms available.

Therefore, Kirsten von Elverfeldt digs in a very muddy, sticky and heavy ground. Despite the many difficulties starting with the general problem that there is no recent textbook available on system theory in geomorphology, Kirsten managed to start right from the scratch. Indeed, there are some publications available (e.g. Chorley (1962), Scheidegger (1992), Thorn and Welford (1992), Phillips (2011) and Dikau (2006)), however, it appeared to be necessary to explore the topic on "system-theory" scientifically. Embedded in international publications, Kirsten explored the current situation. The research investigates the different understandings and mirrors these by reviewing other important disciplines also working scientifically on "system-theory", such as sociology, physics, biology, and socio-ecology, to name the most important ones only. Based on this theoretical framework, various applications are investigated in detail. Practical implications and recommendations finalize this research study.

This research can be regarded as a significant contribution in the field of "geomorphic system theory", which indeed deserves widespread attention. Besides the advances in conceptual, technical and modelling fields of geomorphology, this research is—in my opinion—definitely on the leading edge in the field of "system theory". I am really looking forward to the response of the scientific community, internationally but also and in particular in the German speaking countries. I wish us all a new and innovative impulse to continue our scientific discussion in geomorphology, not only in a purely scientific theoretical debate, but also in real applications. The work of Kirsten von Elverfeldt might substantially contribute to it.

University of Vienna Prof. Dr. Thomas Glade

Preface

To write a preface is a difficult task. Prefaces are always a balancing act, as they offer insight into the author's personality. For this dissertation thesis, I have read many books, and from time to time the biggest pleasure was to read the prefaces and/or epilogues. Often, I even burst out laughing (or, quite the opposite, put the book aside). Subsequently, the author somehow resonated in the back of my mind, and thus reading the book was a better and, yes, more personal venture.

What was my motivation to write a dissertation, which deals in such depth and width with geomorphological system theory? Probably, the first academic roots for this are in Richard Dikau's working group in Bonn, where there was no way around dealing with theory. This tradition has also been continued by Thomas Glade in Vienna. However, I obviously neglected or forgot to look at the bigger picture—it was pretty comfortable in my world of geomorphology. Suddenly, however, I was pulled out of this comfortable little world by a seminar taught by Heike Egner: I got to know Niklas Luhmann's system approach. And—for whatever reason—I allowed myself to feel irritated and started to ask myself (and others!) uncomfortable questions. And as I subsequently discovered, at some stage I had obviously crossed a *point of no return*: I simply was not able to think as I had done before. This was the starting point of my dissertation and I began to delve into theories far beyond geomorphology. Despite the fact that, in the beginning, I had no notion at all of where this would lead me, I soon figured out that these theories always brought me back to geomorphology (despite some fierce self-doubts during that process). But even more so, and this is the most enriching and fascinating aspect, with each of these theories I have always learned something 'for life'. It was a pleasure.

For this thesis to be a success—as I hope—, I first and foremost owe thanks to my two mentors Thomas Glade and Heike Egner. In some sense, they have created a force field of holding and driving forces in the centre of which (or should I say: equilibrium of which?) this thesis came into existence. I owe thanks to you, Thomas, for giving me the freedom to pursue this thesis; I know that this has not always been easy. And I owe thanks to you, Heike, for bringing the joy of science back to me.

Of course, I also want to sincerely thank several other people, first of all the members of the working group ENGAGE at the department of geography and regional science of Vienna University. But particularly, I want to thank those friends, family members, and colleagues who took time for proofreading: Rainer Bell, Heike Egner, Brigitta von Elverfeldt, Christine Embleton-Hamann, Melanie Kappes, Margreth Keiler, Ronald Pöppl, Peter Weichhart and Eva Zelzer. My dear friend Oliver Löhmer always provided plenty of impulses with our physics discussions, and he also proved that physics can be a very humorous business. Walter Lang helped considerably with the figures. Karen Meehan was an enormous help for the translation of my thesis—thank you! My family and friends have supported, distracted, encouraged, and cheered me up in many ways. I am so happy that you are in my life! My deepest thanks, however, go to my son, who always reminded me that the essential things in life are somewhere else.

Contents

Chapter 1
(System-)Theoretical Thinking: A Challenge to Geomorphology?

I do think that there exists at least one philosophical problem which is of interest to all thinking humans. It is the problem of cosmology: The problem to understand the world—including ourselves and our knowledge as part of this world.

Karl Popper 1959

We encounter the term "system" literally everywhere, in everyday discussions about the newest communication systems just as in scientific discussions about the "system earth", the climate system, the social system, or questions regarding the political system (cf. [1, 2]). But where does system thinking come from, and even more so: Does "the" system thinking exist at all?

The contemporary system theoretical vocabulary such as "complexity", "thresholds", "self-organised-criticality" and "feedbacks" is of a relatively young age and is rooted in developments which have taken place since the 1940s and 1950s. Still, already Aristotle's widely cited sentence "the whole is more than the sum of its parts" is a prequel of an explicit system's thinking ([2, p. 19]). In general, the ancient Greeks considered a system to be an orderly set whole, whereas from the seventeenth century onwards within theology and philosophy system was rather seen as a set of theories. Since then, i.e. the baroque era, the word system quite explosively became a vogue word, thereby losing terminological strictness and unambiguousness [3]. This certain arbitrariness survived the following centuries, despite several attempts to counteract this development.

As diverse as the notion of system was understood through time, as continuous, on the other hand, is a discordance kept: The question, whether system thinking principally is organismic or mechanistic [3]. Systems, e.g. a state as a whole, the human body or the economy, from time to time have rather been understood as machine (e.g. as a watch) or as an organism. It was Immanuel Kant who in 1790 stressed an important difference:

> In a watch, one part is the tool for the movement of the other parts, but a wheel is never the acting cause for the creation of another; any part indeed exists for the other, but not through the other ([4, p. 280], translation by KvE).

This means that a watch (or a part of it) will never create another watch (or another part of it),

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> or even corrects itself if it got into disorder: all of which, however, we can expect from organised nature. Nature, "in fact, organises itself in a way self-preservation requires accordingly to the respective circumstances" ([4, p. 280f]).

In consequence, this does also mean that natural systems, according to Kant, are intentional, i.e. working towards self-preservation. Despite Kant's argument, the old antagonism between "mechanism" as synonym for a reductionist approach and "organism" as synonym for a holistic approach as foundation for explaining the world have persisted to the present. According to this understanding, geomorphological system theory is mechanistic, i.e. reductionist.

Hence, today's system theories have to be viewed in a broad historical context. Their younger roots are founded in developments which took place in the 1950s and which have to be largely attributed to the Austrian biologists Ludwig von Bertalanffy (1901–1972) and Paul Alfred Weiss (1898–1989) (cf. [5]). According to Bertalanffy's general systems theory, organisms should be regarded as open systems, which, for their metabolism, absorb mass and energy from their environment (cf. e.g. [6, 7]). Furthermore, Bertalanffy also suggests intentionality, as open systems as he understands them are striving for a steady state (Fließgleichgewicht). Although the general system theory was intended to be a description and explanation of living beings, Bertalanffy thought that his theory and its basic assumptions were universally applicable to all systems (cf. [8, 9]). Bertalanffy's approach was a revolution with the aim to unify the separated sciences. The centre of this revolution was interdisciplinarity ([10, p. 109]).

The claim to be generally applicable to all system might be, on the other hand, also the reason why the system theory has been split up in probably just as many concepts as there are disciplines. These concepts cannot be consolidated into one single theory, which stands against Ludwig von Bertalanffy's real intention. After all it has to be stated that Bertalanffy did not succeed in finding a formulation of universal principles which are applicable to all systems (cf. [10]).

Ludwig von Bertalanffy also considered his general systems theory to be an attempt to overcome the old antagonism between "mechanism" and "organism". Despite all his efforts to include holistic approaches, Bertalanffy's general systems theory is rooted in a mechanistic and causality-focussed thinking [3]. This mechanistic keynote also predominates newer (biological) system theories which, however, partly is intended as deliberate provocation and aversion of animistic/vitalistic tendencies[1] which often accompany the organismic view on systems (cf. [11–13]). In this case the equation of (living) systems with machines is quite deliberate and intends to focus on a network of processes which bring forth system elements. Mechanistic in this context means that only forces and principles are used which can be found in the physical world (cf. [14, pp. 180–183]).

System theoretical concepts which rely on those of Ludwig von Bertalanffy were introduced to geomorphology more than fifty years ago [15–19], even though the

[1] Animism or vitalism is characterized by the assumption that the multitude of living systems has to be attributed to a creative power, or that nature bears in itself a vital force.