Developing Philosophical Foundations of System Dynamics with Buddhist Philosophy

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Abstract

This study explores conceptual similarities between System Dynamics and Buddhist philosophy to investigate how the latter can contribute to the development of philosophical foundations of System Dynamics. First, it identifies and reflects on the main concepts underlying the philosophy of System Dynamics. Second, it presents the fundamental concepts of Buddhist philosophy. Third, it analyses how the main concepts of System Dynamics are represented and interpreted in Buddhist philosophy. In doing so, the study grounds itself in the existing findings about conceptual similarities between systems domains and Buddhism and makes a comprehensive up-to-date review of the major publications on the topic. It also presents novel insights not yet discussed in the literature. For example, the discovered consilience of the epistemological stance of System Dynamics and Buddhist philosophy. Finally, the study makes suggestions on how the identified consonant concepts of Buddhist philosophy can be integrated into System Dynamics to improve its theory and modelling practice.

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1. Introduction

An increasing number of scholars argue that there exist similarities between the ideas of systems domains[1] and Buddhism. Macy (1991) states that both Buddhism and General Systems Theory (GST) adopt a holistic perspective and consider causality as intrinsically mutual, with feedback. In her other publication, Macy (1979) suggests that since Buddhist ethics are grounded in its views on causality which are consonant with the ones of systems theory, Buddhist ethics can become the basis for the further development of systems ethics. Varela et al. (2016) suggest that modern science should integrate contemplative practices and the approach for studying cognition from Buddhism. Senge et al. (2008) integrate ideas from systems thinking and Buddhism, arguing that while the former makes a significant leap by departing from the common reductionistic approach to science, it still lacks ethical and spiritual dimensions as well as practical methods for their application which can be provided by Buddhism based on its similarity with systems thinking. Shen & Midgley (2007) explore "the similarities between [Humanistic] Buddhist philosophy and various systems perspectives" (p.168) to "spark debate" (p.167) about the topic in the systems sciences community. Generally, it is suggested that there is a need for further investigation of similarities between systems domains and Buddhism as such can be beneficial for both theoretical development of systems domains as well as their practical application (Bajracharya, 2010; Kim, 2010; Macy, 1979; Shen & Midgley, 2007). At the same time, yet there has been not a single attempt made to systematically relate and compare System Dynamics (SD) and Buddhism to discover if the two have conceptual similarities. However, why is making such comparison necessary or relevant?

SD is a theory and method for studying behaviour of complex systems (Forrester, 1968). SD originated as an application of ideas from feedback control theory about management of engineered systems to organizational management (Richardson, 2011; Sterman 2018). In this way, organizations are viewed in SD as complex human-based systems and, thus, to effectively manage organizations, their problems are approached in a systemic way and studied as systems (Forrester, 1968). At the same time, SD can be used to study dynamics of any system - organizational consulting has just historically been its major application area (Sterman, 2018). In practice, system dynamicists employ modelling and simulation as the main tools for gaining understanding about why a certain problem occurs, or another word, why the problematic system behaves the way it does (Forrester, 1968). In turn, models and insights gained during the modelling process help to find effective solutions aimed at shifting the problematic system's behaviour towards a more desirable direction (Sterman, 2000).

[1] *"Systems domains" is the term introduced in this work to denote scientific theories, methods and approaches which adopt the concept of a system as their central premise, the main object of investigation and modus of thinking to study phenomena from reality. For the present study, the term primarily implies four specific domains: System Dynamics, Systems Thinking, General Systems Theory and Cybernetics.*

Thereby, it is possible to distinguish *two sides of SD*. The first is the theoretical framework and thinking perspective which "revolve around" the notion of a dynamic system and form the philosophical foundation of SD as a theory of systems behaviour. SD is based on a set of paradigmatic assumptions and concepts such as feedback loop and systems structure which form and substantiate the rationale for the specific kind of explanation of real phenomena proposed by SD. I will call this side *the dynamic systems paradigm* of SD. The second part – *simulation and modelling* – is the specific way of how the theoretical premises of SD are implemented into a practical method for studying behaviour of systems. In this way, the second and practical part of SD is based on its philosophical foundation - the dynamic systems paradigm. Hence, every user of SD adopts (even if implicitly) its paradigmatic assumptions, thinking perspective and the related set of concepts. Thus, the dynamic systems paradigm is the main component of SD and defines it both as a theory and as a practical method.

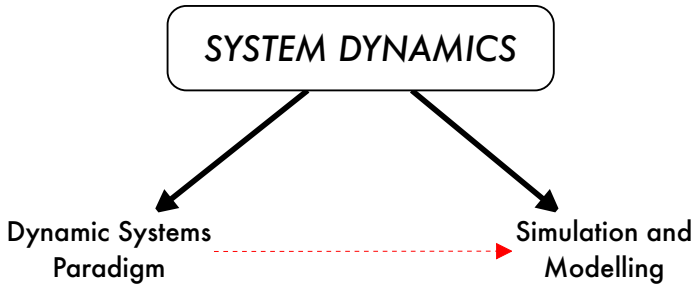


Figure 1. Two Sides of System Dynamics

Therefore, if there exist conceptual similarities between the premises of SD and Buddhism, the latter, being one of the oldest and most extensively developed philosophical traditions in the world (Piatigorsky, 2007; Siderits, 2016) could potentially contribute to the further development of philosophical foundations of SD. In this way, ideas from Buddhism could be integrated with the ones of SD based on their intellectual commonalty. *Buddhism as philosophy* appears of the main interest for such comparison rather than its other dimensions – Buddhism as religion and as practice (Siderits, 2016). But what exactly can be improved or needs to be improved in the "philosophy of SD"? The points below will elaborate on that question.

- By studying phenomena as systems, SD forces the assumption that such *can be studied as systems*. That imposes that "things" in reality are systems or at least have systemic properties. Otherwise, there would have been no point in studying anything as a system. Surely, every scientific domain is built on paradigmatic assumptions which cannot be proven and ultimately remain beliefs (Bertalanffy, 1968; Sterman, 2000). However, it appears that SD takes this assumption somewhat for granted, not attempting to justify why a system is a good metaphor to study something. In fact, thinking in systems is substantiated, but as being a superior alternative (in relation to some issues) to the reductionist "thinking in parts" (Forrester, 1968; Meadows, 2008; Senge, 1994; Sterman, 2000), and

not why it is good by itself. Thereby, there is a need for justification of why a system is an appropriate framework to study phenomena from reality.

- The second point is related to the first. There appears to exist *a dilemma in the understanding of the concept of a system* in SD. This dilemma can be represented through the following question: is a system in SD an ontological statement about reality or an epistemological tool to study reality? The common approach to SD suggests that only the latter (Forrester, 1968; Moxnes, personal communication, 25.03.2019; Sterman, 2000). At the same time, we can often find references in SD literature to systems as "real systems". As I will demonstrate later, the resolution of this dilemma has important implications for the SD approach to modelling and model validation.

- SD originated as a problem-driven discipline (Forrester, 1968; Sterman, 2000). Historically, it has not only been predominantly applied in, but also positioned as a method for corporate management and public policy-making (Sterman, 2018). Such direction of application arguably results in the emphasis on pragmatism which has its downside. Specifically, it appears that the worthiness of efforts within the field is measured mainly against the possible utility of their outcomes. In this way, everything that falls beyond pragmatism and doesn't promise practical value is regarded as irrelevant. That includes abstract theoretical development and any philosophical inferences. Arguably, what follows is that some premises of SD remain under-elaborated as in the dilemma presented above. Therefore, comparing the concepts of SD with the ones of Buddhist philosophy can help to reveal weak points in SD and to "cover them up" by adopting the consonant concepts from Buddhist philosophy. Now that' what I call utilitarian/pragmatic thinking: let's fix it

- *Systems ethics* is another example of the idea existing within SD which is not developed to its full potential. While Meadows (2008) outlines what can be viewed as the foundation of systems ethics, Khisty (2006) and Senge et al. (2008) argue that the ethical dimension remains under-elaborated in systems thinking and suggest that Buddhist ethics can be used for its further development.

- Macy (1976) suggests that ideas from systems theory and Buddhism can be used for mutual interpretation and elaboration based on their consonance. In this way, if conceptual similarities between SD and Buddhist philosophy would be established, the latter can provide an alternative perspective and way of communication about the concepts of SD. Such can help to look at the "same things" from a different angle, broaden their understanding and possibly assist in their teaching. The suggestion is supported by Kim (2010) who proposes that teaching SD by using consonant premises of Buddhism to students familiar with the latter simplifies their learning process.

- Lastly, comparing SD and Buddhist philosophy will further integrate the ideas of Buddhism into science in general and systems domains in specific, the importance of which had been emphasized by multiple scholars (Macy, 1991; Senge et al., 2008; Varela, 2016).

Given the above, **the objective** of this study is **to explore how the main concepts of System Dynamics are represented and interpreted in Buddhist philosophy in order to contribute to the further development of the philosophical foundations of System Dynamics**. To fulfil this objective, the study proposes the following main and sub-research questions.

Main research question: How are the main concepts of System Dynamics represented and interpreted in Buddhist Philosophy?

Sub-question 1: What are the main concepts of Buddhist Philosophy?

Sub-question 2: What are the main concepts of System Dynamics?

To answer the main research question, a review of literature on SD, Buddhist philosophy and comparison of other systems domains with Buddhism will be made. First, the canonical SD literature will be analysed to identify and define the main concepts of SD. Second, the literature on Buddhist philosophy will be reviewed to identify its main concepts for their subsequent comparison with SD. Finally, by synthesizing the findings about the main concepts of SD and Buddhist philosophy, and using the insights from the existing comparisons of Buddhism with other systems domains as indicators of potential connection points between SD and Buddhist philosophy, the study will conclude about how the main concepts of SD are represented and interpreted in Buddhist philosophy. The established connection points will be then used to suggest ways for integration of the consonant concepts of Buddhist philosophy into SD, taking into account the points for improvement discussed above.

The report has the following structure. First, the methodological approach adopted in the research will be discussed, including the relevant ethical matters. Next, Buddhist philosophy and its main concepts will be introduced. Then, the identified main concepts of SD will be presented and defined. Next, the identified conceptual similarities between SD and Buddhist philosophy will be discussed along with the suggestions on the integration of the consonant Buddhist concepts into SD. The concluding chapter will summarize and discuss the key findings and contributions of the research, consider its limitations and present recommendations for future research on the topic. Finally, the list of the used literature will be presented, followed by the appendices.

2. Methods

This chapter describes and substantiates the methodological approach adopted in this study. The present research is purely *conceptual* in the sense that it does not include any empirical data gathering and analysis. The latter is not necessary to explore similarities, or as called by Stinson (2018) - "conceptual and paradigmatic compatibility" (p. 6) between SD and Buddhist philosophy. The sources of information used in this research are academic literature about SD, Buddhist philosophy as well as publications in which systems domains are compared with Buddhism. Given that, the primary method used in this research is *literature review*. "A research literature review is a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners" (Fink, 2014, p. 3). Literature review is commonly used for conducting analysis of theoretical foundations of scientific domains for their subsequent comparison and/or synthesis (Bleijenbergh, personal communication, 07.06.2019; Fink, 2014). Hence, the method is appropriate here since the present research entails identifying and defining the main concepts of SD (*research sub-question 1*) and Buddhist philosophy (*research sub-question 2)* to subsequently explore how the main concepts of SD are represented in Buddhist philosophy, conclude whether there exist conceptual similarities, and, if yes - synthesize and integrate the consonant Buddhist premises into SD (*main research question*).

The present research is *exploratory*. Exploratory studies are appropriate when "researcher examines a new interest or when the subject of study itself is relatively new" (Babbie, 2010, p.92). Additionally, exploratory studies are commonly made to test worthiness and feasibility of the future targeted in-depth research on a specific topic as well as to lay foundations for such (Babbie, 2010). This work is the first academic attempt to systematically and comprehensively relate SD and Buddhist philosophy. In this way, the breadth of discussion appears more important than its depth since by comparing more concepts, even potentially in the expense of losing details, more connection points can be established which is important given the objective and the pioneering character of the study. An "exploratory ambition" also appears more feasible in the face of the limited time available for the accomplishment of this Master Thesis. Thereby, this work will lay the foundation for the further more in-depth work on the integration of SD with Buddhist philosophy and does not claim to cover all the enormous complexity of the topic.

Fink (2014) suggests the following *steps for conducting literature reviews*: 1) defining research questions; 2) establishing where and how the information sources will be sought; 3) selecting keywords and search phrases for literature search in online databases; 4) evaluating the discovered literature on its relevance and quality; 5) conducting the literature review; 6) summarising and synthesizing the literature review results. Thereby, I will now describe how these steps were performed in the present

study and explicitly describe the rationale behind every choice which was made following the suggestions of Bleijenbergh (personal communication, 07.06.2019) and Fink (2014) about reporting of literature review studies.

2.1. Literature Search and Selection

The following section describes the process and rationale behind the literature search as well as the criteria of literature selection used in this study. There were three types of literature which had to be found based on the defined research questions: 1) *SD literature*; 2) *Buddhist philosophy literature*, and 3) *literature on the comparison of systems domains and Buddhism*.

To identify the main concepts of SD, four canonical SD textbooks were chosen: Forrester (1968), Meadows (2008), Senge (1994) and Sterman (2000). These textbooks were chosen under the guidance of the first and second supervisors of this study and experts in SD – Akkermans (personal communication, 22.03.2019) and Moxnes (personal communication, 25.03.2019). Arguably, the four works substantially cover all the main concepts of SD throughout its historical development: the original ideas of Forrester (1968) who describes the basic concepts of the domain from an engineering perspective; the comprehensive and probably most commonly used textbook in SD education - Sterman (2000) - with the author's focus on application of SD in business; Meadows (2008), who frames SD into a broader and arguably less than in the two aforesaid publications simulation-based perspective of systems thinking; the modern application of SD and systems thinking into corporate management and leadership field made by Senge (1994) which contains a noticeable "taste" of oriental philosophy and Buddhism, the influence of which had been confirmed by the author himself (GlobalLeadership.TV, n.d.). Additionally, in several occasions, other publications were used to elaborate on some of the identified main concepts of SD. Specifically, Richardson (2011), Sterman (2018) and Vennix (2001) were used respectively to further elaborate on the endogenous view, the epistemological stance of SD as well as the SD model-building process. Next, Olaya (2009) was used to infer about the philosophical foundations and background of SD, the reflection on which is partially missing in the four main authors. Lastly, the article by Pruyt & Kwakkel (2007) was used as an additional source on the dimension of ethics in SD. The detailed description of the process of search and selection of these five "additional articles" is presented in *Appendix A*.

To identify and define the main concepts of Buddhist philosophy, the following three textbooks were chosen: Piatigorsky (2007), Prebish & Keown (2010) and Siderits (2016). The present study doesn't concentrate on a specific school of Buddhism, but rather considers Buddhist philosophy in general. Therefore, the criteria for choosing textbooks on Buddhist philosophy were the following. First, the textbooks should discuss the main concepts of Buddhism as philosophy, and not as religion or practice, while not taking the stance of any of its traditions. That implies that the textbooks must encompass and

reflect on the ideas of the main Buddhist traditions: early Buddhism, Mahayana and Theravada (Prebish & Keown, 2010). Second, the textbooks should include original Buddhist sutras (texts) and not only their Western interpretations to ensure that the claims about Buddhist philosophy made in this thesis are grounded in the original sources (Akkermans, personal communication, 22.03.2019). Third, the textbooks should be credible and academically acknowledged (Fink, 2014). Piatigorsky (2007) and Siderits (2016) adhere to all of the aforementioned criteria. Alexander Piatigorsky was a well-known philosopher and a professor of Buddhism and oriental philosophy at the University of London (Alexanderpiatigorsky.com, n.d.). Piatigorsky (2007) was a deliberate choice - I consider him as an extremely interesting philosopher and a distinguished expert in Buddhism from the familiarity with whom my interest in Buddhism started. According to Bleijenbergh (personal communication, 07.06.2019), personal interest in an academic author is a valid justification for the literature choice. Siderits (2016) was discovered on June 9, 2019, via Google Scholar and was the most cited publication among the 56 search results with "Buddhism as philosophy" keyword present in the title. Finally, while Prebish & Keown (2010) do not focus on Buddhism as philosophy, but Buddhism in general, the authors clearly describe the main concepts of all major schools of Buddhism and provide references to the original texts. Additionally, the publication is used as the main textbook in the "Buddhism" course given at Radboud University which I had taken in preparation for the present thesis. Lastly, in addition to the three main sources, Harvey (2010) and Shulman (2007) were used to elaborate on the difference in interpretation of the dependent origination axiom in early and later Buddhism. Both publications were suggested by Prebish & Keown (2010) relative to the topic of dependent origination.

Finally, this study builds upon the existing literature in which various systems domains were compared with Buddhism. SD largely shares the same conceptual base with other systems domains, for example with GST, Systems Thinking and Cybernetics (Bertalanffy, 1968; Ison, 2008; Richardson, 1999). Hence, *the existing findings can be used at least as starting reference points or indications* which can suggest the possible connections between SD and Buddhist philosophy. Thereby, if a previously discovered consilience between for example certain concepts of GST and Buddhism was used in this study, to transfer the claim about their similarity, the concepts were re-analysed from the SD perspective. Overall, 14 publications on the comparison of systems domains and Buddhism were identified and reviewed in this study. The process of their selection, as well as summaries of their contents are provided in *Appendix A*. In brief, the literature was searched mainly on March 7, 2019, using Google Scholar and Researchgate databases. The following keywords were used in the search: "Buddhism systems theory", "Buddhism system dynamics", "Buddhism systems thinking" and "Buddhism systems philosophy". Half of the discovered literature compared Buddhism with systems theory rooted in GST. Hence, to have the ability to justify conceptual similarities between SD and GST

to subsequently transfer the insights from the existing comparisons, the literature review also included the canonical textbook of the founder of GST - Bertalanffy (1968).

2.2. Literature Review

First, SD literature was reviewed. Initially, 50 concepts were identified as the main concepts of SD. *Appendix B* contains *Table 3* which provides a description of these concepts and substantiates their "main-ness" in the following way: 1) indicates whether each of the four aforesaid authors mentions and/or defines these concepts (yes/no), and 2) if yes, provides literate quote(s) to prove that the reference to these concepts was made by the author. Next, these 50 concepts were grouped into 13 categories to simplify their understanding and further comparison with Buddhist philosophy. These categories and the concepts which they contain are presented in *Appendix C*. The initial concepts and categories list was reviewed with the two main and one informal advisor of this thesis (Akkermans, personal communication, 22.03.2019; Bleijenbergh, personal communication, 07.06.2019; Moxnes, personal communication, 25.03.2019). In the result of the review, the decision was made to remove some concepts which do not constitute the essence of the dynamic systems paradigm of SD and are rather related to its practical simulation modelling part. The revised and final list of *36 concepts under 11 categories* is presented in *Appendix D*.

Next, the literature on Buddhist philosophy was reviewed. Since the focus of this research is not on Buddhist philosophy per se, but rather on its conceptual similarity with SD, the criteria for identifying and later presenting in the respective chapter its main concepts were the following: 1) to cover the most fundamental concepts underlying Buddhist philosophy: Samsara and Nirvana, karma, the middle way, the Four Noble Truths and dependent origination (Piatigorsky, 2007; Prebish & Keown, 2010); 2) to cover all concepts of Buddhist philosophy which are discussed in the subsequent comparison with SD, and 3) to ensure that the Buddhist concepts which had been previously compared with the concepts of other systems domains are explained (such are indicated in the summaries of the existing comparison studies in *Appendix A*). Additionally, since Buddhist philosophy encompasses several traditions, any contradictions or differences in philosophical viewpoints existing between them relative to the discussed concepts were included in their presentation. Furthermore, to prove the validity of my interpretation of the discussed concepts of Buddhist philosophy as well as to make sure that I did not exclude any of its fundamental premises, the respective chapter of this report was reviewed and confirmed with an expert in Buddhism (Velde, personal communication, 17.07.2019).

2.3. Summary and Synthesis of the Reviewed Literature

Finally, the identified main concepts of Buddhist philosophy were analysed in terms of their conceptual similarity with the main concepts of SD. First, the potential connection points between SD and

Buddhist philosophy were outlined. I already had several ideas about such prior to the formal start of this study. Besides, this study used the insights from the existing comparisons of systems domains and Buddhism as clues about "where" and how the SD concepts could be represented in Buddhist philosophy. Other novel insights about possible connection points not yet represented in the existing comparisons emerged during the process of literature review and analysis.

Next, to conclude whether a certain SD concept is represented in Buddhist philosophy, the understanding of that concept in SD was compared with the understanding of the suggested counter-part concept or group of concepts in Buddhist philosophy. In this way, by comparing how the analysed concept is interpreted in SD and Buddhist philosophy, the conclusion was made about whether the interpretations are consonant or not. Wherever possible, I substantiated my reasoning with the findings of the existing comparison studies. A few times my conclusions differed from the ones of other authors. In such cases, I explicitly discussed the observed contradictions and made references to the analysed Buddhist philosophy literature to prove my argumentations.

Having demonstrated how a certain SD concept is represented and interpreted in Buddhist philosophy, I made suggestions about how based on the discovered consilience the insights from Buddhist philosophy can be incorporated into SD, considering the points for improvement discussed in the *Introduction*. While in some cases the suggestions were derived from the ones in the analogous studies, others remain the product of my own "creativity" and ideas' synthesis. In this way, I acknowledge that the proposed suggestions are not definitive statements about how things should be, but rather illustrations of possibilities and directions for what can be done to improve the theory and practice of SD.

2.4. Research Ethics

Finally, I will consider the matters of research ethics relative to this thesis work. First, this study does not involve empirical data gathering or analysis, working with people or organizations and handling of any personal or sensitive data. Additionally, no critical or potentially offending claims about Buddhism or any other scientific domain discussed here were made. Therefore, the only dimension of research ethics relevant to this study is the integrity of the conduct of the research itself (Denscombe, 2012). In this way, I tried to set and follow high research standards in this study, thoroughly and deeply analyse the used literature, honestly and transparently report the findings, and creatively, but at the same time critically approach the insights I gained as well as how they can be used in SD.

3. Buddhist Philosophy

This chapter introduces the main concepts of Buddhist philosophy according to Piatigorsky (2007), Prebish & Keown (2010) and Siderits (2016) and answers *the research sub-question 1*.

3.1. Buddhism as Philosophy

I will start with clarifying what is understood in this work as Buddhist philosophy. Since Buddhism is often associated with religion, philosophy and practice (Siderits, 2016) it is important to distinguish these dimensions of Buddhism here. First, why Buddhism can be viewed *as a religion*? Regardless of doctrinal differences, what all religions share is "that they each try to articulate some vision of the ideal state for humans" (Siderits, 2016, p. 6). Such vision usually denotes dissatisfaction in the normal, mundane condition of humans' living and suggests that the ideal lies in attaining salvation, escaping from this discontent condition (Siderits, 2016). The salvation aspect of religions is called *soteriological* (Siderits, 2016). In this way, Buddhism can be viewed as a religion since its main goal is soteriological – to provide people with the teaching which describes the path for liberation from the state suffering and attainment of Nirvana – the ideal state of being in Buddhism (Prebish & Keown, 2010).

Next, why Buddhism can be viewed *as a practice*? Buddhism has never been an abstract body of knowledge. Ideas in Buddhism are not means on their own, they are referring to something which the Buddhist follower should experience and understand through active contemplation on his mind. That is, through the practice of meditation (Varela et al., 2016). But, probably the most important attribute which highlights the "practical orientation" of Buddhism is that the attainment of Nirvana is not a matter of faith, but rather of the continuous training of the mind. Only the person with a meditatively trained mind has the ability to investigate and understand the true nature of reality and oneself, and through this – attain Nirvana (Piatigorsky, 2007; Siderits, 2016). In this way, for Buddhism, ideas without active reflection and direct experience of their meaning remain empty words which have no connection with what they are designating (Piatigorsky, 2007). Additionally, a great deal of Buddhist literature is related to the everyday living rules and prescriptions for monks and laymen which in simple terms suggest how one should live and with which attitude (Prebish & Keown, 2010). At the same time, the "codes of conduct" of Buddhism are embedded and substantiated by its philosophical reasoning (Piatigorsky, 2007). Thereby, ideas and their practice are inseparable in Buddhism, and thus Buddhism is often viewed as a practice.

Finally, having set Buddhism as a religion and as a practice aside from Buddhism *as philosophy*, the last will be now discussed. First, what is philosophy? Philosophy attempts to answer the most fundamental questions relative to the object of its investigation using "analysis and argumentation in systematic and reflective ways" (Siderits, 2016, p. 5). Siderits (2016) suggests that philosophical

inquiry can be divided into three parts: *ethics*, *metaphysics* and *epistemology*. Ethics is concerned with how things ought to be. That is, how people should live, what is good and what is bad. Metaphysics is concerned with the basic questions about reality: what things are, how they come to be, what does it mean to be or to become, what is causality, space and time. Lastly, epistemology is the theory of knowledge and is about what it means to know something, is there true knowledge and how to acquire knowledge. Thus, Buddhism can be viewed as philosophy since its teachings attempt to answer all of the aforementioned fundamental questions about reality (Siderits, 2016). Moreover, not only to answer but to substantiate and to logically reason the answers. In fact, the reflective and critical approach to knowledge and explanation is what makes the Buddhist inquiry philosophical rather than only religious and dogmatic (Siderits, 2016). *The main method* of the Buddhist philosophical inquiry is meditation on the body, mind and its objects (Piatigorsky, 2007). To clarify, meditation is not a prayer, but rather an active cognitive process involving mind training and contemplation (Prebish & Keown, 2010). Finally, *the main object* of Buddhist philosophy is the mind with all its objects – thinkable (mental) phenomena (Piatigorsky, 2007). Thus, Buddhist philosophy as it is defined in this thesis is the body of knowledge related to the matters of ethics, metaphysics and epistemology existing under the broad umbrella of Buddhism with its three main traditions (early Buddhism, Theravada and Mahayana).

Next, I will make a short historical overview of the origins of Buddhism. Tracing the historical development of Buddhism can shed light on some of its premises and give an idea about why Buddhism has become what it has become.

3.2. Historical Background

3.2.1. Aryans and Vedas

Buddhism appeared in the territory of Northern India in approximately VI century BCE (Prebish & Keown, 2010). The cultural, religious and philosophical background in which Buddhism was born is related to the Indo-Aryan people who came to this land in approximately 1200 BCE (Piatigorsky, 2007; Prebish & Keown, 2010). Piatigorsky (2013) describes Aryans as warriors and materially poor people with no developed cities, but with a vast tradition of religious texts and rituals called *Vedas*. The Vedic culture had a multiplicity of gods and initially, its rituals were made to connect with these gods, take control of their powers in an ecstatic trance and through this achieve better harvest, rains, prosperity and other rather worldly goals (Piatigorsky, 2013; Prebish & Keown, 2010).

As time went on, some people started questioning the rightness of ecstatic rituals (Velde, personal communication, 11.03.2019). Rituals started becoming more internalized and turning into personal meditation (Prebish & Keown, 2010). The ordinary state of living was no longer perceived as satisfactory, but rather as an illusion which keeps one trapped in the ever-repeating cycles of births and

deaths, making him transmigrate from one lifeform to another (Velde, personal communication, 11.03.2019). Here we see the origination of the ideas of *rebirth* and *karma* which were later adopted by Buddhism (Prebish & Keown, 2010). The "spiritual quest" shifted towards the attainment of freedom from the phenomenal world with its constant rounds of births and deaths. "It was by meditation… the practitioner gained knowledge in a flash of realization; he perceived directly the unchanging reality that underlay the shifting panorama of experience, and his knowledge freed him forever from the terrible round of death" (Prebish & Keown, 2010, p.7). Thereby, the main inheritances of Buddhism from the Vedic culture are: 1) the division on the *normal* ordinary state of being and the aspired *liberated state* (Samsara and Nirvana) which should be attained through realization; 2) meditation as the mean for achieving realization; 3) karma and rebirth (Prebish & Keown, 2010).

3.2.2. Ascetics and Yoga

Another culture which started emerging approximately one century before the origination of Buddhism and impacted on it dramatically was *the ascetics culture* (Prebish & Keown, 2010). Historically, asceticism as a trend existed in many places in the World and was characteristic for the followers of different religions, but never in such great prominence as in India in those times (Piatigorsky, 2007). By a certain moment, the forests to which ascetics commonly retreated from their societies became so crowded that the desired seclusion got problematic which led to the origination of big ascetics' communes (Piatigorsky, 2013). These people were leaving their homes, families, society and the "normal" life with its constant peace/war, rituals, kettle, land, politics – things not interesting or worth thinking about for the Indo-Aryan ascetics (Piatigorsky, 2007). In this way, all teachings and philosophical ideas developed by these ascetic communes were "*anti-social*" in the sense that social aspects of life were not a matter of interest for them at all, as they were for example in Greek philosophy (Piatigorsky, 2013; Prebish & Keown, 2010).

Ascetics were also seeking liberation from the phenomenal world with its endless cycles of deaths and rebirths (Prebish & Keown, 2010). Commonly, the solution to that quest was sought in *transcendence* - withdrawal from all sensory input, mortification of the flesh, and immobilization of the body and mind (Prebish & Keown, 2010). The senses and the imperative of the natural needs of the body were viewed as something impure, trapping one in the ego-boundary, attaching to the phenomenal world and hindering from the attainment of liberation (Piatigorsky, 2013; Prebish & Keown, 2010). To achieve transcendence, ascetics developed and used the practices of *yoga* (Piatigorsky, 2013). Yogic practices involved connecting oneself with the body and its sensations, removing intentionality and generally obtaining control over oneself, senses and reactions to them (Prebish & Keown, 2010). By means of yoga, ascetics were trying to reach a supreme in comparison with the normal not yogically trained state of mind, and by this achieve realization (Prebish & Keown, 2010).

Buddhism was born in and from the ascetics' movement (Prebish & Keown, 2010). The Buddha himself was a wanderer-ascetic practising self-mortification. However, Buddhism departed from harsh austerities. Extreme mortification of flesh was proclaimed by the Buddha as vulgar and useless for the achievement of liberation from Samsara (Piatigorsky, 2007). Overall, Buddhism adopted the following traits from the ascetics' culture: 1) the "anti-social" inclination of thinking (in early Buddhism); 2) the practice of leaving society and relatively mild austerities; 3) yogic meditative practices; 4) the distinction on the *normal* and *transcendental, yogically trained* states of mind (Piatigorsky, 2007; Prebish & Keown, 2010).

3.2.3. The Historical Buddha

Siddhartha Gautama Sakyamuni is the person who is referred to as the historical *Buddha* (Prebish & Keown, 2010). In Sanskrit, "Buddha" means the "one who has awakened" (Prebish & Keown, 2010). Siddhartha Gautama was not a god, but an ordinary person of extraordinary and highly altruistic qualities who reached enlightenment and founded the teaching of Buddhism. *Time is cyclical* in Buddhism and Siddhartha Gautama is the Buddha who existed in our historical reality, while there had been and will be more Buddhas in other historical realities (Siderits, 2016). However, in this work, when using the word "the Buddha", I will be referring to Siddhartha Gautama Buddha.

Siddhartha Gautama is believed to have been born in a royal family in approximately VI century BCE (Prebish & Keown, 2010). His lineage provided him with material comfort and a promising bright future as a warrior or a political leader. However, at a certain point, Siddhartha realized that ultimately the condition of all living beings is characterized by *suffering*. Whatever one does, even life of full indulgence will eventually end up in sickness, ageing and dying. Having become dissatisfied with the normal living and its ultimate condition of suffering, Siddhartha left home at the age of 29 to become an ascetic in the forests in search for Nirvana – "a state beyond birth and death – a mystical goal which many of his contemporaries also sought under various names and descriptions" (Prebish & Keown, 2010, p.31). The story tells that Siddhartha Gautama reached enlightenment six years after while meditating under the tree of Bodhi, thereby attaining Nirvana in life and becoming the Buddha to teach other people the path for liberation from suffering (Siderits, 2016). Before reaching enlightenment, Siddhartha, in the time-honoured fashion, tried out both the classical yoga training and the path of harsh austerities (Prebish & Keown, 2010). However, the existing solutions offered only a temporary bliss and didn't solve the fundamental problem of the human's predicament – suffering. Thus, Siddhartha Gautama, having incorporated some insights from the practices he mastered, conceived his own solution which led him towards the enlightenment (Prebish & Keown, 2010).

In the next part, I will present and discuss the main concepts of Buddhist philosophy.

3.3. The Main Concepts of Buddhist philosophy

3.3.1. Samsara and Nirvana

Both the ascetics' movement and later Buddhism adopted the Vedic idea that all being simultaneously exists in *two modes*: 1) the normal mode – *Samsara* (Sanskrit – flowing on, conjuncture of flows into one) – "the world" of constant change, dynamics, cycles of arising and cessation, diversity, movement, and 2) the transcendental mode – *Nirvana* (Sanskrit – blowing out) – "the world" of liberation, cessation of Samsara with its cycles of births and deaths (Piatigorsky 2007, Prebish & Keown, 2010). Being the world of constant flux, everything is *impermanent* in Samsara (Piatigorsky, 2007). Samsara is also the world of *dependent origination* - nothing arises in Samsara out of own agency or will (Siderits, 2016). That implies that nothing in Samsara has an independent existence, individual being or a true selfness. All that conditionally arises, born in Samsara, is subject to eventual ageing and dying since all what it is dependent on is also dependent and impermanent (Piatigorsky, 2007). Thereby, Samsara is characterized by *suffering* and whatever one does, there is no escape from suffering in Samsara (Siderits, 2016). The idea of Samsara is also related to the concepts of rebirth and karma – the present birth or every living being is determined by the karma which one had accumulated during the past lives. Hence, it is the *karma*, good or bad, which conditions, and gives impulse to the new rebirth (Prebish & Keown, 2010; Siderits, 2016).

In turn, Nirvana is the state of cessation of suffering, non-accumulation of new and nulling of the existing karma (Prebish & Keown, 2010). Thus, Nirvana is the only state in which one escapes rebirths and suffering. However, attaining Nirvana does not imply disappearance from physical reality and escaping death. Siddhartha Gautama attained the state of Nirvana and continued physically existing in the world. However, he stopped accumulating karma and was not reborn after his death (Prebish & Keown, 2010).

According to early Buddhist philosophy, both Samsara and Nirvana simultaneously exist in everything but never intersect (Piatigorsky, 2007). However, the world or the state of Samsara cannot comprehend either Nirvana or even itself. At the same time, the state of Nirvana can comprehend Samsara and most importantly –itself. This is the reason for the tremendous complexity of reaching the state of Nirvana. Being in Samsara, one gets trapped since he cannot fully realize the state of own being. That can be done only from Nirvana. Here we find the paradoxical idea that the *knowledge of Nirvana* implies *attainment of the state of Nirvana* (Piatigorsky, 2007). However, it is only possible to comprehend Nirvana from Nirvana itself (i.e. being in the state of Nirvana). This premise also introduces another important Buddhist concept – *ignorance* (Piatigorsky, 2007). Ignorance in the sense of inability of comprehending, realizing oneself and one's state. Being in Samsara, one is ignorant. That is, unable to realize one's state and the fact of one's ignorance. Hence, it is also ignorance which leads one to get

entrapped in Samsara. In this way, the Buddha for his students was like an observer from Nirvana who was helping them to realize themselves in Samsara. Here, we also find an example of the common distinction in Buddhism between the *normal* and *transcendental* states of mind - only the yogically trained and *transformed* mind can observe and comprehend oneself (Piatigorsky, 2007).

3.3.2. Karma

Karma (Sanskrit – action) is one of the central concepts in Buddhism (Prebish & Keown, 2010). It is closely related to the idea of rebirth and Buddhist ethics. Buddhists believe in the *cyclical nature of "things"* – living beings are continuously born, die and get reborn in Samsara (Prebish & Keown, 2010). In this respect, karma is the mechanism which determines: 1) *the fact* of the happening of rebirths, and 2) *the quality* of the subsequent rebirths (Piatigorsky, 2007). Karma can be good and bad. By accumulating good karma, the living being will be born in one of the next lives in better conditions. Bad karma will realize itself in worsening one's living conditions. Interestingly, good karma cannot compensate bad karma – every karmic potency will realize itself separately. Living conditions affected by karma are not only things like getting born in a peaceful time, healthy, talented or wealthy, but also what one will be reborn as – a human, an animal, an insect or even a ghost. In Buddhism, there are six realms in which one can be reborn depending on the accumulated karma (Prebish & Keown, 2010). Being born as a human is considered as the best possible option because of the good balance between intelligence, available pleasures, and the exposure to suffering (Piatigorsky, 2007).

Next, how is karma produced? Good karma is produced by one's good deeds and bad karma – by the bad deeds. But, it is not the deed itself which determines the polarity of karma, but rather *the intent*, the thought which stood behind the deed (Piatigorsky, 2007). Another word, inner *motivation* is the ultimate determinant of the polarity of karma. For example: without a thought of murder - there is no "murder", or without a thought of stealing - there is no "stealing". For Buddhist philosophy, no act by itself has any meaning intrinsically (Piatigorsky, 2007).

Thereby, the idea of karma has *two dimensions*: ethical and metaphysical (Prebish & Keown, 2010). Ethically, karma is the substantiation of why one needs to act in one way, not another, and have certain moral principles. Metaphysically, karma is the natural order, "one function of the universal law of causation known as dependent origination" (Prebish & Keown, 2010, p. 17). In the sense of the latter, karma is the *cause* of rebirths and the quality of rebirths is the *effect*.

Lastly, the goal in Buddhism is not to accumulate good karma (Piatigorsky, 2007). Both good and bad karma contain potency which will realize itself and cause the next rebirth in Samsara. However, some intentions and actions are *karmically neutral*, neither good nor bad. Consequently, they do not produce any karma. In this way, the truly enlightened person does not do either karmically good or bad deeds (Prebish & Keown, 2010). For example, all Buddha's thoughts and actions after he reached Nirvana in

life were karmically neutral. Why? Because his mind was transformed in such a way, that it did not think in terms of "good/bad", or any other dualistic categories. His mind took *the middle way* position (Piatigorsky, 2007). Here, we come to arguably the main concept of Buddhist philosophy – the idea of the "*middle way*" and the "*Noble Eightfold Path*".

3.3.3. The Middle Way and the Noble Eightfold Path

The Buddha stated the idea of the middle way in the beginning of his first sermon which marked the origination of the teaching of Buddhism (Piatigorsky, 2007). Below is the fragment of this sermon.

> *"Bhikkhus, these two extremes should not be followed by one gone forth (into the homeless life). What two? That which is this pursuit of sensual happiness in sense pleasures, which is low, vulgar, the way of the ordinary person, ignoble, not connected to the goal; and that which is this pursuit of self-mortification, which is painful, ignoble, not connected to the goal. Bhikkhus, without veering towards either of these two extremes, the One Attuned to Reality has awakened to the middle way, which gives rise to vision, which gives rise to knowledge, which leads to peace, to higher knowledge, to full awakening, to Nirvana.*
>
> *And what, bhikkhus, is that middle way awakened to by the One Attuned to Reality which gives rise to vision, which gives rise to knowledge, which leads to peace, to higher knowledge, to full awakening, to Nirvana? It is just this Noble Eightfold Path, that is to say, right view, right resolve, right speech, right action, right livelihood, right effort, right mindfulness, right meditation. This, bhikkhus, is that middle way awakened to by the One Attuned to Reality, which gives rise to vision, which gives rise to knowledge, which leads to peace, to higher knowledge, to full awakening, to Nirvana" (Dhammacakkappavattana Sutta, n.d.).*

Addressing to 5 ascetics which later became the Buddha's first disciples, he started speaking about *extremes*: 1) the extreme of living life of indulgence and devotion to sensual pleasures, and 2) the extreme of harsh austerity and mortification of flesh. Both extremes are "vulgar" (the term often used in Buddhism to denote something common, simple or automatic - i.e. "normal") in the sense that the normal human's mind naturally leans towards thinking in extremes (Piatigorsky, 2007). Additionally, both lifestyles blur, delude the mind and do not result in salvation from Samsara. Avoiding leaning towards extremes means adhering to the *middle way* which should lead the practitioner to the true knowledge and ultimately – Nirvana (Piatigorsky, 2007). But, what is this middle way and how can one set oneself on it? The answer is given: the middle way is the *Eightfold Noble Path* which "consists of eight factors divided into the three categories of *Morality*, *Meditation*, and *Wisdom*" (Prebish & Keown, 2010, p.51). Morality is the foundation of the Path and involves self-discipline in one's speech, actions and livelihood. Meditation is concerned with training one's mind to be calm, concentrated and aware of one's body, feelings, thoughts and mental states. Lastly, Wisdom is related to the ability to see the nature of reality as it is as well as understanding how the enlightenment can be reached. Thereby, to comprehend and achieve the middle way position, one needs to practice the right Morality, right Meditation and right Wisdom. At the same time, the three factors should not be viewed as a series of stages or rungs on the ladder, but rather as a continuous process in which all three are intertwined

and developed simultaneously (Prebish & Keown, 2010). Nevertheless, as mentioned by Dalai Lama 14th & Hopkins (2003), it is the ethical basis of the right Morality which the beginner is usually recommended to train oneself in first.

Thereby, the middle way is both a goal of *self-transformation* and a method, a process for achieving this self-transformation (Piatigorsky, 2007). Piatigorsky (2007) suggests that we can distinguish two "levels" of the middle way:

- "Basic" avoidance of leaning towards extremes in ones living and judgements. That means to constantly adjust oneself to find the "golden middle" in everything in life, for example: not eating too much, but also not eating too little; not getting dependent on pleasures, but also not avoiding them completely; not judging that someone or something is only good or bad, but seeing both sides in everything. This aspect of the middle way is closely related to the right Morality factor of the Path.
- Complete removal of any *dualism* from thinking by *transforming* one's mind in such a way, that it will no longer operate in the dualistic mode. This level of the middle will be elaborated further.

According to Piatigorsky (2007), the Buddhist middle way idea has serious implications on the Buddhist theory of knowledge. It states that the normal mind naturally thinks or tends to think in dualistic terms. Another word, dualism in the sense of *thinking based on extremes* is the way how the mind works and structures knowledge. Therefore, most human's knowledge is built on extremes like "good/bad", "yes/no", "inner/outer", "being/non-being", "happy/unhappy" etc. Moreover, Piatigorsky (2013) argues that even languages and cultures are based on such dualistic structures and hence reinforce thinking in extremes. Thereby, the middle way represents such a transformed way of thinking, which provides the position of observation of reality in which not only thinking in extremes, but also the need for such thinking is completely ceased (Piatigorsky, 2007). This does not mean though that instead of being simply "good/bad" or "black/white", everything should become neutral or grey, that is the point between the two extremes. Neutrality is only an intermediate step for achieving the middle way. The "real" middle way position eliminates the existence of extremes and therefore the middle point between the extremes would not exist either. From the above follows that in Buddhist philosophy the middle way is a method for the neutralization of the natural tendency of the mind to think in extremes (Piatigorsky, 2007).

However, why is thinking in extremes bad? Here, we come to the psychological dimension of Buddhist philosophy. It suggests that the primary dualism of every individual being is the dualism between the "I" (one's self or ego) and "the rest" - everything which is experienced as being outside of one's "I" (Piatigorsky, 2007). Unlike for example Descartes with his "I think therefore I am", Buddhist philosophy does not accept the concept of "I" as an a priori category. In fact, Buddhist philosophy

denies the existence of a separate individual self (this point will be elaborated later). What a person experiences as his "I" is the derivative of the *five aggregates of individual existence*: 1) *material form*; 2) *feelings and sensations*; 3) *perceptions*; 4) *mental formations*, and 5) *consciousness* (Prebish & Keown, 2010). Material form is the physical substance of the body. Feelings and sensations are bodily reactions to stimulus. Perceptions represent the perception of bodily sensations and feelings as well as the ability for abstract thinking. Mental formations represent a complex term which designates the totality of individual reactions and thoughts which emerge in response to any experience. Lastly, consciousness is something that initiates and enables all other four aggregates. An individual who is naturally "provided with" these five aggregates, starts associating oneself with them and their objects (Piatigorsky, 2007). In this way, such form his life experience as well as the sense of individual self ("I"). At the same time, Buddhist philosophy suggests that the nature of these five aggregates with their feelings, desires, sensations, moods, mind states, is that they all operate in the dualistic mode, for example: "satisfied/non-satisfied", "happy/unhappy", "loving/hating" etc. (Piatigorsky, 2007). Thereby, by associating oneself with these naturally given aggregates, an individual gets attached to them and starts craving for the satisfaction of the desires and impulses they carry in themselves. As we shall see below, the craving then becomes the major cause of suffering and the person's entrapment in Samsara. Consequently, taking the middle way position means breaking the chains of craving by disassociating oneself from the five aggregates of individual existence and the experience of the individual self they create (Piatigorsky, 2007).

3.3.4. The Four Noble Truths

During his awakening, the Buddha is said to have apprehended the *Four Noble Truths* – another fundamental aspect of the "Dharma" – the teaching of the Buddha (Siderits, 2016). The Four Noble Truths were also described in the first sermon, after the introduction of the middle way idea.

> *"Monks, it is through not understanding, through not penetrating the Four Noble Truths that this long course of birth and death has been passed through and undergone by me as well as by you. What are these four? They are the noble truth of suffering; the noble truth of the origin of suffering; the noble truth of the cessation of suffering; and the noble truth of the way to cessation of suffering. But now, monks, that these have been realized and penetrated, cut off is the craving for existence, destroyed is that which leads to renewed becoming, and there is no more re-becoming (D.ii.90)" (Prebish & Keown, 2010, p. 60).*

So, the Four Noble Truths are: "1) life [all] is suffering; 2) suffering is caused by craving; 3) suffering can have an end; 4) there is a path which leads to the end of suffering" (Prebish & Keown, 2010, p.43).

The First Noble Truth describes the *condition* of being: all is suffering. Suffering in Buddhism is a universal feature characteristic for all living beings against which they are powerless (Prebish & Keown, 2010). Suffering has biological aspects: ageing, sickness and dying are inevitable. Grief, sadness, despair, losing what is loved or not getting the desired is also suffering. The constant change

and impermanence of everything in Samsara are suffering. However, suffering does not only imply inevitable negative experiences in life. Suffering is a fact, an objective truth (Piatigorsky, 2007). However, the objectivity of any fact in Buddhist philosophy is the objectivity of the consciousness of this fact. That is, outside of the mind any fact would not remain a fact in the literate sense. In this way, a "fact" in Buddhist philosophy is a mental category rather than something which exists independently from human's cognition (Piatigorsky, 2007). Thereby, suffering is the fact of the mind and of all that is perceived and thought of within it. Hence, "all is suffering" means that all that is perceived, cognized or understood is suffering (Piatigorsky, 2007). Hence, consciousness and cognition themselves are suffering (Piatigorsky, 2007). Therefore, suffering is induced through the five aggregates of individual being discussed above.

The Second Noble Truth explains the *cause* of the arising of suffering. Suffering is caused by *craving* (Prebish & Keown, 2010). Specifically, craving for sensual pleasures, for the satisfaction of one's needs and desires. Additionally, craving for existence – the ultimate will to live, and also craving for non-existence – the will for complete passiveness, release of all tensions. But what causes craving? As discussed, the five aggregates of individual being which one associates with as one's self operate in the dualistic mode of reacting in terms of "good/bad" and thus push the individual to crave. However, the Buddhist notion of craving doesn't imply only craving for good or bad experiences or satisfaction of needs. Rather, the key point is in the *craving for the experience* itself - the primary intent, the impulse to experience (Piatigorsky, 2007). The eye is craving to see, the ear is craving to hear, the nose is craving to smell. Another example: a loving person is dependent not only on his beloved one but on the fact of experiencing love itself. In this way, the dependence of the mind on sensual, emotional and other objects as well as the primary impulse of the five aggregates to experience them frame and condition the operation of the mind and psychic. Thereby, the Second Noble Truth, besides the soteriological meaning, also represents a *psychological theory* of the most basic level of functioning of the human's psychic and mind (Piatigorsky, 2007).

The Third Noble Truth states that the arising of suffering *can be ceased* by totally removing craving.

The Fourth Noble Truth tells that there is a path, *a method* which can help one to cease craving and the arising of suffering. This method is the middle way – the Eightfold Noble Path discussed in the section above. And, since suffering is in the first place the property of the mind, the Path for the cessation of suffering is ultimately aimed at the transformation of the mind (Piatigorsky, 2007).

In this way, the Four Noble Truths represent not only the Buddhist idea about suffering but also a theory on the origins of the functioning of human's mind, thinking and psychic. The Four Truths also introduce the specific logic of thinking: there exists suffering (condition) – suffering arises out of craving (cause) – removal of the cause of suffering ceases its arising (Prebish & Keown, 2010). This

logic implies that the concept of *causality* is central for Buddhist philosophy and, thus, will be discussed below.

3.3.5. Dependent Origination and Buddhist View on Causality

The Buddhist view on causality is represented by the axiom of *dependent origination*. Its basic premise is that "all phenomena arise in dependence on causes and conditions, and as a consequence lack intrinsic being of their own" (Prebish & Keown, 2010, p.48). The axiom has two significant implications: 1) there is no God or any absolute transcendental being or power since such imply independent existence; 2) nothing has selfness, and, importantly – there is no such thing as an individual separate self ("I") (Siderits, 2016). In this way, the five aggregates of individual existence, as well as their mental derivatives are also dependent on their origination, and, thus cannot constitute the individual "I". Thus, the body is not "I", the senses are not "I", the perceptions are not "I" and so on (Siderits, 2016). Generally, dependent origination can be represented using the following logical form: "A→B (when condition A exists, effect B arises), or its negation -A→-B (when condition A does not exist, effect B does not arise)" (Prebish & Keown, 2010, p.48).

The dependent origination axiom is commonly illustrated as a "series of twelve stages or [causal] links showing how the problem of suffering and entrapment in Samsara arises…" (Prebish & Keown, 2010, p.48). These twelve causal links are: 1) Ignorance → 2) Compositional factors → 3) Consciousness → 4) Name and form → 5) Six sense spheres → 6) Contact → 7) Feelings → 8) Craving → 9) Grasping → 10) Becoming → 11) Birth → 12) Old age and death (Prebish & Keown, 2010).

Thereby, I have described the basic premises of dependent origination. However, the axiom has two interpretations in Buddhist philosophy: 1) ontological, and 2) as a theory of the mind and psychic (Harvey, 2010; Shulman, 2007).

The *ontological interpretation* represents a rather literate understanding of the premises of dependent origination. Here, dependent origination is the universal principle based on which all "things" in reality come to be – out of dependence on something else (Harvey, 2010). In such a view, the world can be represented as a network of interrelated causes and effects (Harvey, 2010). Therefore, causality then "becomes" plural and mutual, with feedback loops, rather than singular or unidirectional. In fact, distinguishing between a cause and an effect, in this case, is impossible since a cause would be simultaneously also an effect. Next, since all "things" have no individual essence, everything then exists in the state of *becoming or arising*, rather than being. In this way, the "ontological dependent origination" suggests that every phenomenon should be viewed as *a process*, rather than as a substance (Prebish & Keown, 2010). Additionally, such an interpretation of dependent origination introduces the idea of "*oneness*" (Siderits, 2016). That is, since the arising of everything is mutually dependent, there is everything in "one" - in every individual "thing" there is every other "thing".

The interpretation of dependent origination as *the mind and psychic theory* does not contradict to the ontological one. However, it does not extrapolate dependent origination into the physical realm and considers the mental realm only. Here, the main idea is that all mental phenomena – feelings, mind states, objects, attitudes, thoughts and whatsoever – are dependent in their origination and lack any individual essence (Shulman, 2007). In turn, that implies that such also lack any intrinsic properties or meaning. Additionally, the arising of all mental phenomena "starts with" *ignorance* - the first factor of dependent origination (Piatigorsky, 2007). Here, ignorance means not only the inability of realizing one's state, as it was defined above but something more fundamental - the "initial state of all phenomenal existence" (Piatigorsky, 2007, p. 39). Every mental phenomenon which arises is *a priori not self-reflected* and arises out of ignorance of the fact of one's arising in the state of suffering (Piatigorsky, 2007). Thus, the initial impulse of arising "carries" suffering in itself and "passes it on" to what arises conditioned by this impulse: senses, mind, consciousness, craving, karmic accumulation and the subsequent rebirth.

As discussed, dependent origination is characteristic for the world of Samsara only. Furthermore, derived from dependent origination, Samsara is characterized by three features: no-self, impermanence and suffering (Prebish & Keown, 2010).

3.3.6. No-self, Impermanence and Suffering

Since everything in Samsara arises not out of own will or potency, but out of a cause - the arising of something else - everything is Samsara has *no self*. That is, lacking an intrinsic independent individual existence (Prebish & Keown, 2010). As already discussed, this premise is especially important for the idea of the absence of the individual self ("I").

Next, derived from the property of no-self, Samsara is characterized by *impermanence*. Since everything is dependent in its arising on something else, nothing is then permanent and will cease to exist once the condition or cause which led to its arising will cease (Prebish & Keown, 2010). Thus, Samsara is a world of constant change and dynamics.

Lastly, because everything is impermanent in Samsara, the craving can never be fulfilled and any satisfactory state of being is only temporary. Hence, all being is characterized by *suffering* – nothing is forever in Samsara and there is no escape from the ultimate suffering in Samsara (Prebish & Keown, 2010).

3.3.7. Abhidharma: Theory of dharmas

Abdhidhama is an aggregation of scholastic reworks and elaborations of the early Buddhist teachings, the major part of which represent *the theory of dharmas* (Piatigorsky, 2007). The term "Dharma" (with the capital D) was already used above in the sense of the teaching of the Buddha. Here, "dharma" has

another meaning. The dharma theory is related to the Buddhist theory of the mind and the nature of experiential phenomenal reality.

First, what is *a dharma*? The term is usually used as it is, without translation, since it does not have an analogue in English. A dharma is the smallest momentary unit out of which the whole experience of reality is comprised of (Piatigorsky, 2007). Every mental phenomenon is a dharma: every object of senses, thought, idea, experience, emotion, concept, perception etc. Suffering and karma are also dharmas. Even nothingness is also a dharma. To put it differently, dharmas are something through what the mind operates. In this way, the experiential reality is comprised of millions of separately arising and ceasing smallest mental phenomena (dharmas) which our mind aggregates and transforms into a continuous flow of life experience (Siderits, 2016).

Thereby, Buddhist philosophy suggests that what we experience as the whole continuous reality is, in fact, an aggregation of momentary dharmas. These dharmas are produced by the five aggregates of individual existence: body, senses, perceptions, mind and consciousness (Siderits, 2016). Dharmas arise and cease instantly. As we can understand from the previous discussions, dharmas arise dependently, conditioned by other dhramas and ultimately the mind itself. Hence, it is the dharmas which lack individual existence. Moreover, the arising of one dharma, instantly leads to the arising of multiple other dharmas. This can be compared with associations when the emergence of one thought brings a network of associations with it. It is suggested that the reason why people don't "see" dharmas is that the normal human's psychic strives to build a continuous and full perception of reality (Piatigorsky, 2007). Hence, only a yogically trained mind can capture the arising and ceasing of individual dharmas.

Thereby, Abhidharma represents a unique psychological theory which argues that the mind makes up reality from the smallest thinkable elements (Piatigorsky, 2007). All these elements arise conditionally, in dependence on the subject and his properties of cognition. Thus, all dharmas (mental phenomena) are characterized by the no-self and impermanence characteristics, and all dharmas entail suffering.

3.3.8. Emptiness

Emptiness is the core concept of Mahayana – the major strain of Buddhism which originated in India in II BCE and after spread to multiple East Asian countries (Prebish & Keown, 2010). Emptiness is derived from the axiom of dependent origination. Since all dharmas are dependent in their origination – the nature of them is emptiness (Prebish & Keown, 2010). That is, all dharmas are empty from individual being, essence or independent existence. However, emptiness does not imply that mental phenomena or the objects which they represent do not exist at all. Rather, emptiness is an epistemological tool used to illustrate *the relative nature of all mental phenomena* and the whole experience of reality (Piatigorsky, 2013). It suggests that all objects of experiential reality just appear

to us in some way - conditioned by how our mind works and structures reality. Hence, by themselves, mental phenomena have no essentiality, intrinsic properties or existence of their own. Epistemologically, that implies that *all knowledge is relative* and that no knowledge can exist separately or independently from the subject of that knowledge (Piatigorsky, 2013).

3.3.9. Meditation and Inseparability of Knowledge and Knower

Thereby, Buddhist philosophy acknowledges that *what* we know depends on *how* we get to know it and vice versa. Another word, the actual knowledge cannot be separated from the properties of cognition of the knower himself. For example, the middle way principle discussed above suggests that human's mind naturally tends to think in dualistic terms. In this way, such property of cognition shapes human's languages, cultures and worldviews, which according to Piatigorsky (2013) are largely based on and cannot avoid dualism. At the same time, what we know can also change how our cognition works (Piatigorsky, 2013). Consequently, meditation practices play an important role in Buddhism not only as a means to directly experience the premises of Buddhism but also for the understanding of how one's mind works to subsequently transform it. There exist two major types of Buddhist meditations: 1) *the practice of calm (Samatha)*, and 2) mindful observation - *the practice of insight (Vipassana)* (Prebish & Keown, 2010).

The practice of calm is often considered as a prerequisite for the practice of mindful observation. The main goal of the practice is to withdraw oneself completely from any sensory input and reactions to eliminate any distraction for further contemplation practices (Prebish & Keown, 2010). Here, the practitioner attempts to eliminate one's passions as well as emotional and judgmental responses to any stimuli (Piatigorsky, 2007). This process also involves training a neutral, indifferent attitude towards things like one's body, food, relationships, sex etc. Additionally, the practices of calm also involve training the ability to control and concentrate one's mind.

Unlike Samatha, *the practice of insight* involves observation of sensory input as well as analysis and contemplation on one's mind and its objects (Prebish & Keown, 2010). However, by the already calmed and controllable mind. Here, the aim is to gain insight into one's own thinking as well as to reflect on certain Buddhist premises. The important role here plays the ability to continuously objectivize any object in one's mind (Piatigorsky, 2007). That is, to be able to contemplate on a purposefully separated object, be it one's thought or any idea, while staying continuously concentrated on it, but also completely detached from any attitude towards it.

Another distinctive type of Buddhist meditation is the *techniques of spontaneity* (Prebish & Keown, 2010). Here, the practitioner attempts to observe one's mind and the passing thoughts while not reacting to them and not letting them pull the mind. By doing so, the meditator learns to keep one's mind in the natural flow, keeping it free from all effort or intention. Another aim of these techniques

is to learn how to remove the structures of meanings and automatic reactions which one has established during life in order to eliminate the projection of oneself and the existing knowledge on the life experience occurring in the present moment so as to perceive it more purely (Varela, 1983).

3.3.10. Buddhist Ethics

As noted by Piatigorsky (2013), *Buddhist ethics* are substantiated by the Buddhist philosophical views. Often, being ethical, at least for early Buddhism, has pragmatic purposes. First, Buddhist ethics and morality are grounded in the law of karma (Prebish & Keown, 2010). Acting well has positive consequences for future rebirths and acting badly – negative. Thereby, there is a pragmatic reason to act morally – to attain a better state of living in the future rebirths. However, as noted already, it is not the act itself which defines the polarity of the produced karma, but rather the *intention and motivation* lying behind the act. Hence, the dimension of motivation plays a central role in the Buddhist definition of morality. Thus, Buddhist practitioners are encouraged to always reflect on and know the essence of their intentions before making any actions (Prebish & Keown, 2010).

Buddhist ethics can be distinguished into two groups: 1) *laymen ethics*, and 2) *monastic ethics* (Prebish & Keown, 2010). Buddhist laymen ethics are to a great extent similar to the general religious and "common sense" moral rules. They are commonly represented by the following five precepts: 1) don't kill; 2) don't steal; 3) don't sexually misconduct; 4) don't lie and twaddle, and 5) don't take intoxicants. Not doing to others what one would not want them to do with him is also an acknowledged moral notion (Prebish & Keown, 2010). Next, one should avoid acting out of the three main "impurities" of the mind: *greed*, *hatred* and *delusion* (Piatigorsky, 2007). These three impurities are viewed as natural for a normal human's mind and represent one extreme form of reactions of the five aggregates of individual existence (Piatigorsky, 2007). Thereby, one should develop in oneself their positive counterparts – *generosity or unselfishness*, *benevolence* and *wisdom*. Lastly, *non-violence* towards all sentient beings is another important virtue in Buddhist ethics (Piatigorsky, 2013). The monastic ethics, in addition to the aforementioned points, include a large set of rules and guidelines ranging from how one needs to wear robes, take food and sleep, to the responsibilities in living in the monastic community (Prebish & Keown, 2010).

No-self is also an important concept for Buddhist ethics (Piatigorsky, 2013). The no-self principle relativities the attitude towards everything implying that nothing can be simply good or bad. Piatigorsky (2013) argues that Buddhism was the first philosophy which *decentralised the figure of the human being*. Humans are only one type of consciousness, one state of mind, while there are others, higher and lower level states, for example, animals. In this way, unlike in many other teachings, the emphasis in Buddhism is not put on the salvation of the man, but rather of all sentient beings (Piatigorsky, 2013). Another implication of the no-self principle is that it removes the primary dualism

of the individual self ("I") and "the rest" and hence substantiates the aspiration for the avoidance of selfishness (Prebish & Keown, 2010).

As I noted in the very beginning, Buddhism, at least in its early stages, was rather an anti-social teaching – the social aspects of human's life were not considered as important and the focus was on the individual salvation from Samsara. However, this feature somewhat changed from the origination of Mahayana Buddhism which proclaimed *compassion* to all sentient beings as the main virtue and trait one should develop (Prebish & Keown, 2010). Mahayana Buddhism suggests that since all living beings are in the same condition of suffering in Samsara, the goal of every practitioner should shift from attaining personal enlightenment to helping other living beings in achieving this goal (Prebish & Keown, 2010).

Furthermore, modern Buddhism, especially after blending with Western culture, has largely become socially active. The strain which emerged from that blend is called the *socially engaged Buddhism* (Prebish & Keown, 2010). The main topics of socially engaged Buddhism are human rights and ecology. Generally, it is built on the two premises: compassion in the sense of altruism and non-selfishness, and dependent origination in its literate interpretation as the axiom about the intrinsic interconnectedness and interdependence of everything and everyone (Prebish & Keown, 2010).

4. The Main Concepts of System Dynamics

This chapter presents and defines the main identified concepts of SD according to Forrester (1968), Meadows (2008), Senge (1994) and Sterman (2000). By doing so, the chapter answers *the research sub-question 2*. Please note, that since most of the material in this section is an aggregation and summary of the four aforementioned publications, references will be provided only for the statements which are: 1) direct quotes; 2) mentioned not by all four authors; 3) contradicting between the authors, and 4) made not by one of the four main authors. Thus, the statements which contain no reference are the ones which are based on and supported by all four main authors.

The following sections of this chapter are structured according to the categories into which the main SD concepts identified in this study were grouped. Please see *Appendix B* for the justification of why a certain concept was identified as the "main". *Appendix C* contains the initial categorization of concepts, and *Appendix D* – the final one used in the sections below.

4.1. Characteristics of "Normal" Human Thinking

All four main authors start their narration by discussing what will be called here as *characteristics of "normal" human's thinking*. By doing so, they illustrate the *need for an alternative way of thinking* which they later introduce and propose - System Dynamics and/or Systems Thinking. Thereby, the normal way of thinking, in the sense of how people ordinarily and naturally tend to think and make decisions is opposed to the holistic thinking in systems. So, people commonly think in one way (non-systemically), but problems emerge out of such thinking. Specifically, the problems of management, governance or broadly - decision-making - in spheres like business, environment conservation and public policy-making. Even the well-intended policies just don't work out well and turn out to be ineffective often due to the occurrence of some unintended "side-effects" which jeopardize all efforts. However, not only the "big decision-makers" suffer from the normal thinking. Similar policy failures also happen in daily life on the level of individual decision-making. But why do policies fail? Because problems are intrinsically complex, interrelated and systemic, especially in modern times, while the person with normal thinking does not or cannot treat them as such. What are then the characteristics of this normal human thinking? First, the tendency to think *reductionistically*. That is, to reduce the problem to a small number of causes and study their relationship with the effect (problem) separately. Another word, people tend to *think in parts* rather than *in wholes*. Second, the *linear* approach to problems (problem A needs solution B) and *failure in recognition of feedback processes* (solution B will feed back and redefine the problem). Third, natural *cognitive limitations* and *bounded rationality* which lead to substantial simplification in the understanding of everything, selective perception and usage of automatized habits. Fourth, *event-oriented judging* about reality and problems, rather than recognizing them as being *continuous processes*. Fifth, limited time perception: *failure in*

understanding dynamics, *short-term perspective* and *negligence of time delays* between causes and effects. Sixth, the tendency for *exogenous*, rather than endogenous reasoning. In general, the normal thinking is not suited to deal with complex systems, while for SD almost everything which humans need to deal with is a system, or has systemic properties. Lastly, the most specific for SD limitation of the normal thinking is the inability of "mental modelling and simulation" – the brain cannot construct and understand models of complex systems (Forrester, 1968). Hence, computer modelling is required.

Lastly, it is worth mentioning that in Meadows (2008) and Senge (1994), the call for an alternative systemic way of thinking has a somewhat ethical "taste", besides only problem-orientedness. Thinking in systems implies recognition of the interconnectedness of everything and therefore calls for the removal of boundaries, cooperation and altruism. Additionally, Senge (1994) and Senge et al. (2008) explicitly include spirituality as an important dimension of thinking in systems.

4.2. System

A system is the main object of investigation and modus of thinking in SD. The latter means that SD proposes to view and study things, processes and reality *as systems*. Thereby, "a system" is one the one hand a metaphor, a framework for representing reality. I will call this an *epistemological dimension* of the system concept. On the other hand, SD implies that reality is either comprised of systems or at least has systemic properties, and therefore it is useful to study it as a system. This I will call the *ontological dimension* of the system concept. The rationale for focusing on "things" as systems is substantiated by arguably the main assumption of all systems domains – systems or *wholes* have their own properties of organization which cannot be inferred from the properties of individual parts (Bertalanffy, 1968). This premise is often metaphorically described as "the whole is bigger than the sum of its parts" (Bertalanffy, 1968, p. 18).

A system is defined as "an interconnected set of elements that is coherently organized in a way that achieves something" (Meadows, 2008, p. 10) or "a grouping of parts that operate together for a common purpose" (Forrester, 1968, p. 1-1). So, a system is comprised of *elements* - its elementary units. Systems elements can be anything material and/or abstract. The nature of elements partially defines what the system is, for example, people form a society, ideas form a theory (as a system of knowledge), organs form an organism. What turns the separate elements into a system is the *interconnections* – the relationships between them. Interconnections can be also physical and abstract. The former implies a flow and exchange of matter, for example, flowing of blood through organs, and the latter - information, for example, culture and shared meanings unite people into a society. Lastly, the system's elements are interconnected not randomly, but in such a way that they form an organized whole which has a certain *purpose*. For example, we can say that all parts of an organism are

interconnected and interacting to sustain one's living. Or, an "automobile is a system of components that work together to provide transportation" (Forrester, 1968, p. 1-1).

It is argued that the system's purpose can be inferred from its behaviour. For example, common sense tells me that my organism has a goal to sustain my living because it regulates itself to maintain my normal being in different conditions or when I am sick. However, the system's purpose is a rather complex and "floating" idea. That is, the purpose of a system is not something predefined and can change from the change of perspective of the person who studies that system. Moreover, different people may define "the same" system differently and consequently its purpose too. Here we come to the idea of the *system's boundary*. I assume to know the boundaries of my organism since I can see where it "ends". However, my organism is also dependent on the environment and actively exchanges matter and information with it, which arguably forms a larger system, making it hard to say where my organism starts and ends. "There are no separate systems. The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion" (Meadows, 2008, p. 190). Thereby, in SD the *closed system's boundary* idea works as an epistemological tool. Since ultimately SD is used to comprehend reality and to solve problems in the general sense, and systems appear to not have boundaries along with the fact that their parts at a closer look appear to be systems themselves, the boundary of any studied system *is purposefully set* and depends on the problem at hand, and the purpose of the investigation. Even if boundaries are not set explicitly, they exist in the implicit assumptions of a person about what forms a specific system (problem). Hence, when I write, for example, "to study a system", I imply studying a problem which in turn defines its system meaning that everything which I find important about that problem I include within the boundaries of its "system".

Thereby, a system is a very abstract and flexible term. While the focus of SD is primarily on *social systems*, arguably, everything can be imagined as a system. However, in my view, here lies the significant unresolved dilemma of SD. On the one hand, a system is a metaphor and thus any system is a soft, fluid abstraction. However, the usage of that metaphor in an attempt to find out something about reality *forces the assumption that reality can be studied as a system* and that ontologically a system is an appropriate framework for it. Otherwise, there would not have been any point in using SD. This dilemma is approached in SD in two ways. First, an extreme form, where "things" in reality are assumed to be systems with specific structures and the goal then is to uncover these structures as accurately as possible. However, this approach called "naïve realism" by Olaya (2009) is rather unpopular in the SD community. Forrester (1968), Moxnes (personal communication, 25.03.2019) and Sterman (2000; 2018) suggest another approach which I will call "problem-orientedness". It acknowledges that it is impossible to find out the "real system", if there even is one, and holds the

position that understanding of anything is an assumptions-based simplification and hence cannot be absolutely "true". However, even the second approach still holds the assumption that reality can be studied as a system, even while accepting the intrinsic limitations of what can be known and that "things" in reality might not be systems at all. Another word, there is still an attempt to study something *as a system*, which imposes that this something should at least somehow resemble a system.

Moreover, even while a system, as well as other related concepts which will be discussed later, are acknowledged by all four authors to be flexible, not fixed or predetermined metaphors or mental constructs, each of them still sometimes refers to systems as "real systems". I will illustrate this with several examples. Sterman (2000) argues that: "In real systems, there must be shifts in feedback loop dominance, and therefore there must be important nonlinearities in all real systems" (p. 284). Meadows (2008) writes: "Of course, in real systems feedback loops rarely come singly" (p.34) and "As long as fertility and mortality are constant (which in real systems they rarely are), this system has a simple behavior" (p.42). Similarly, "His [human's] scientific research is exposing the structure of nature's systems" (Forrester, 1968, p. 1-1). Of course, I can't know what exactly was meant by these authors when they wrote "real system" or "nature's system". The "realness" could be not the statement about existence in reality, but the degree of coherence with the definition of a system. That is, the extent to which some understanding of a system concept is coherent with its canonical definition and characteristics. However, it still appears that there exists ambiguity in the understanding of the term system. That is, is a system in SD only an epistemological tool, or also an ontological statement? This unresolved dilemma can lead to ambiguity in methodology and hence affect the generated knowledge outcomes and how such are treated since they are dependent on our stance in whether we study real systems (which system dynamicists commonly argue they don't) or systems as in mental models, that is not making any claims about reality.

4.3. Feedback and Feedback Loop

Feedback is "…the basic operating unit of a system" (Meadows, 2008, p. 5). To discuss the concept of feedback, I need to first refer to *causality*. Often, science attempts to infer about phenomena through studying unidirectional singular influences: "A (cause) →B (effect)". Here, the hypothesis is that A is the cause of the change of the effect B and by understanding the "A→B" relationship we can explain the phenomenon of interest. In SD, this approach to science is referred to as reductionistic because it reduces the explanation to multiple singular isolated parts of causes-and-effects. In turn, SD argues that causality is never unidirectional, but is intrinsically *circular* and *mutual*. That is, not only change in A causes B to change, but also the occurred change in B feeds back to A making it change in turn ("A→B→A"). Hence, A and B form a *feedback loop*. In this way, SD suggests that everything happens through feedback and all processes are ultimately feedback processes.

However, the "problem" is that people are used to explaining in terms of chains of unidirectional causalities. "We are taught from an early age that every event has a cause, which in turn is an effect of some still earlier cause" (Sterman, 2018, p. 10). "Reality is made up of circles [of causality] but we see straight lines" (Senge, 1994, p.58). Thereby, if an event Y happens, we treat it as the effect and seek for the cause X which led to this event. If we want to go deeper, we attempt to understand which event Z lead to the origination of X. Hence, the following logical proposition is built: "Z→X→Y". Thereby, every cause is treated as *exogenous (external)* relative to the subsequent effect. The idea of feedback suggests another way or explaining. "The concept of feedback opens up the idea that a system can cause its own behaviour" (Meadows, 2008, p. 34). If A causes B to change and in turn, B feeds back to A, the latter will change further which will influence its effect on B. Thereby, the mutual influence between elements within feedback loops and the interaction among these feedback loops is what causes the dynamics of a system. Hence, to understand why a certain phenomenon or problem "behaves" the way it does, one should "identify" the *feedback structure* of the studied problematic system. This way of explanation is called *endogenous (internal)*, meaning that it implies that systems generate their own behaviour. Richardson (2011) and Sterman (2018) argue that the endogenous point of view represents the essence, the most important premise of SD.

Next, causality in SD is primarily viewed as "dynamic causality". That is, the main interest is not in what causes A to emerge and exist, but in what causes A to change. In this way, causality has two polarities: 1) positive (+) – the increase in A makes B increase, and 2) negative (-) – the increase in A makes B decrease. Feedback loops can be also of two types: *reinforcing* (+) and *balancing* (-). A reinforcing feedback loop represents any self-amplifying process where the growth of an entity increases the rate of its growth, making it grow faster. Typical examples are population growth or market adoption of a new product. A balancing feedback loop represents any self-correcting process which attempts to maintain or reach a certain *goal*. Any goal-directed behaviour implies balancing feedback, for example filling a glass with water (Forrester, 1968). Homeostasis of bodily temperature is also a balancing process – an organism is trying to maintain the desired temperature and adjusts itself in case of deviations (Meadows, 2008).

Finally, feedback happens through the *flow of information and matter*. For example, information about the bodily temperature is perceived by the organism, which in turn triggers the response – adjustment of the temperature through biochemical reactions at a certain intensity.

4.4. Systems Structure

A system can be represented by its *structure*. "In concept a feedback system is a closed system. Its dynamic behaviour arises within its internal structure" (Forrester, 1968, p.4-2). Another word, the (feedback) structure of the system constitutes what the system is and determines its dynamic behaviour.

This premise is commonly expressed in SD as "structure drives behaviour". However, a system's structure is not something fixed, unless we adopt a naïve realism perspective. Rather, a system's structure with its closed boundary represents a number of deliberately chosen main interrelated feedback loops and their elements which *should be sufficient to endogenously explain the dynamic behaviour* of the problematic system. Another word, a system's structure is a *dynamic hypothesis*, a *theory* about the cause of a certain dynamic behaviour. Hence, a closed feedback structure along with the endogenous explanation is the SD way to frame hypothesis about the behaviour of a phenomenon - a system, and the way to represent that system relative to its behaviour. Another word, it is the way to structure knowledge about the studied phenomenon (Forrester, 1968). Hence, a system's structure is both a theory and a meta-theory – a way to structure a structure of something.

To describe the idea of a system's structure, Olaya (2009) uses the metaphor of a "mechanism". The mechanism here means a specific type of explanation – "explanation of the principle" (Olaya, 2009, p. 825). That is, instead of explaining phenomena merely in terms of causality, SD attempts to identify the specific organization of elements, the principle standing behind some dynamic behaviour. This principle or mechanism is then the feedback structure of the studied system.

4.5. Stock and Flow

Forrester (1968) argues that any system and its structure can be described via only 2 types of basic elements or variables – *a stock (level)* and *a flow (rate)*. A stock is an accumulation of anything or anything which accumulates over time. Almost anything can be represented as a stock, for example: amount of water in a glass, temperature, population, money in a bank account or memory. Stocks characterize *the state of the system* and represent its actual condition (Forrester, 1968; Sterman, 2000). Stocks are also the system's "memory" meaning that they *integrate* all the changes happening in the system into themselves. Thus, the present state of a stock is the consequence of the integration of all historical changes which happened in the system to this stock. The idea of a stock also implies that all processes of nature are the processes of *integration* (Forrester, 1968). Moreover, any dynamic, that is time-varying behaviour is possible and happens due to integration and the ability of stocks to accumulate change (Forrester, 1968; Meadows, 2008).

The change in stocks does not happen instantaneously, but over time and at a certain rate. The rate of change represents the second type of systems element – the flow. Basically, flows are what changes the stocks and the only "things" which can change them. The examples of flows are water-flow rate, temperature adjustment rate, birth rate, net-rate of income/spendings and net-rate of studying/forgetting. Flows represent actions of different intensity which increase or decrease the stocks. Thus, flows are called inflows and outflows correspondingly. In this way, the integration process discussed above is the stocks' integration of the change made through flows.

4.6. Systems Behaviour (Dynamics)

The focus of SD is not on systems per se, but on their *dynamics* – time-varying behaviour or changes which occur within them. The goal of SD is to understand and explain these changes by developing a "dynamic theory" – the feedback structure of the problematic system which should explain its historical behaviour. The practical purpose of doing that is to subsequently re-design the problematic system in the way that it would produce a more desirable behaviour.

As already discussed, the dynamics of a system are produced by its structure and the interaction of feedback loops within it. This interaction often occurs with *shifting loops' dominances*. That is, different feedback loops existing in a system consecutively "dominate" the whole system by pulling it into a certain direction. Shifting loop dominance often stands behind the complexity and unpredictability of systems behaviour.

Some systems have common feedback structures. These are called *systems archetypes*. These archetypical structures produce certain *behavioural modes (patterns)*, the most common of which are: equilibrium, exponential growth, oscillations, S-shaped growth and overshoot and collapse. For example, the "limits to growth" archetype, which includes just one reinforcing and one balancing loop, can explain the growth process of any entity, be it a population of humans or bacteria, or diffusion of a new technology. The idea of archetypes is also important since having observed a certain typical behavioural mode, one can have an indication of the structure standing behind it.

4.7. Idea of a Model and Idealism

So, system dynamicists, attempting to find an endogenous explanation of how a certain phenomenon "works" develop its closed feedback structure. Basically, what they do is create *a model* of that phenomenon or more specifically the problematic system under investigation. There are two main types of models used in SD: *qualitative causal-loop-diagrams* (CLD) and *simulation models*. CLDs are graphical representations of the main elements and feedback loops of the problematic systems. Thus, CLDs are often called as systems maps. Simulation models are computer-based "virtual worlds… formal models, simulations, or microworlds in which decision-makers can refresh decision-making skills, conduct experiments and play" (Sterman, 2000, p. 34) made to "…aid our mental process in dealing with time-varying systems" (Forrester, 1968, p. 3-2). Basically, relationships between variables in simulation models are represented through mathematical equations which allows performing simulation. That is, to see how the modelled system will behave over time in a virtual environment. Thereby, simulation allows testing different scenarios to see how the system will respond to certain actions which could have been made in reality. Ultimately, simulation models are aimed at

helping people to learn about the studied problem, test their assumptions about it and find effective policies.

However, the idea of a model in SD does not end in the graphical representation of a system and simulation. Sterman (2000) argues that a model has been the central concept for SD since its origins. But what is a model? "A model is a substitute for an object or system." (Forrester, 1968, p. 3-1). Another word, a model is a constructed representation of some object. In relation to the mental realm, a model is a construct, an idea or rather an aggregation of such, which represents the understanding of some object(s) from reality. SD takes the stance that models form the basis of human's cognition and thinking. That is, in comprehending the world, people construct and later base their thinking and decision-making on *mental models*. "Everything we think we know about the world is a model. Every word and every language is a model… Our models do have a strong congruence with the world… However, and conversely, our models fall far short of representing the world fully… None of these [models] is or ever will be the real world" (Meadows, 2008, p. 87). Since SD considers causal relationships between variables, a more "SD-specific" definition of a mental model is given by Sterman (2000): "… our beliefs about the networks of causes and effects that describe how a system operates, along with the boundary of the model (which variables are included and which are excluded) and the time horizon we consider relevant…" (p. 16). Hence, as all other models, mental models are simplifications of the object(s) they represent. Every model is always incomplete and will never be fully correct.

The idea of a mental model, in my view, illustrates the position of SD about *knowledge and its validity*. Similarly, Olaya (2009) argues that SD takes the stance of *Idealism* – a philosophical school which asserts that reality is essentially mentally constructed in the sense that humans cannot know any other reality. Hence, all we know is ideas and abstract constructs (i.e. models) which do not have an obvious connection with what they represent. Epistemologically, that implies that there is nothing which can be "really known" and that absolute knowledge is impossible since every fact will ultimately remain a fact of mental reality (Olaya, 2009). This has the following implications: 1) system dynamicists model "meta-models", that is models of their own mental models and not the real world itself (unless they adopt the naïve realism perspective); 2) causal assertions in SD are "soft", that is the stated causal relationships do not make claims about the world but designate causality as it is viewed by the modeller. Consequently, complete "… validation and verification of models are impossible…" (Sterman, 2000, p. 846) and deciding that a model is valid or rejecting it is a matter of choice. However, all this does not mean that validation of SD models as dynamic theories is impossible at all. Neither that means that all models are equally wrong – this would have made any deliberate modelling effort meaningless (Sterman, 2000). While acknowledging that there is no absolute knowledge, SD also does not take the

premise that any knowledge is "completely relative" (Olaya, 2009; Sterman, 2000). The latter would imply that everybody is equally wrong about everything. As argued by Bertalanffy (1968), such assertion would not have been correct since human's cognition in its origination was dependent on the environment in which it evolved and hence cannot work based on a completely random mechanism and thinking categories which do not have any connection with what they represent. Another word, human's cognition might not provide "the true" information, but it fits its purpose (Bertalanffy, 1968; Sterman, 2000). Therefore, model validation in SD is a continuous process of gaining confidence in the model in which the purpose of the modelling effort plays the central role for the decision about the model validity and utility (Forrester, 1968; Olaya, 2009; Sterman, 2000).

4.8. Systems Properties

Systems properties are certain features or qualities characteristic distinctively for systems or anything with the systemic way of organization. SD is not concerned with systems properties as much as, for example, GST (Bertalanffy, 1968), but some properties are nevertheless highlighted and discussed as being important. First, systems are characterized by *delays*. Stocks create delays by accumulating the change over time and not instantaneously. Besides, it often takes a lot of time until the full effect of some cause will realize itself fully. Hence, systems are often hard to study due to the significant time difference between the primary cause and effect. Next, any system is *self-organizing*, not only in the sense that it drives its behaviour, but also because of its "ability to structure itself, to create new structure, to learn, or diversify" (Meadows, 2008, p. 188). From that follows that systems are also *resilient* since they can evolve, change and adapt to changing conditions (Meadows, 2008). What makes systems self-organizing and resilient is their feedback structure – without feedback, no learning or adaption would have been possible (Meadows, 2008). Systems organize themselves in a *hierarchy* – higher-level systems are formed by lower-level subsystems. Another word, every part of a system is a system itself. Next, as any other physical entity, systems have *constraints* in terms of growth and resilience. There will always be a *constraining factor*. Lastly, systems behaviour is commonly characterized by *non-linearity* which implies the following: 1) the relationships between systems elements are often non-linear, with effects being not proportional to causes; 2) the interaction of feedback loops leads to shifting loop dominance and the non-linear behaviour of the system. Non-linearity is often considered as one of the main reasons why systems behaviour is perceived as counter-intuitive and hard to understand.

4.9. Systems Thinking

The discussion above already showed that SD entails thinking in systems or *systems thinking*. However, there exists some ambiguity in what the term means, whether it entails a separate discipline or only a certain perspective, way of thinking, and what its relationship with SD is (Ison, 2008). Senge (1994)

defines systems thinking as "…a discipline for seeing wholes… a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots" (p. 53). So, systems thinking is about studying "things" as systems with all the implications which such thinking entails. Moxnes (personal communication, 25.03.2019) argues that SD is an advanced form of systems thinking since it adds simulation to it as an extension of a rather qualitative, system-metaphor-based inquiry. I will not attempt to resolve the question about the position of SD relative to systems thinking, and will just summarize the main features of systems thinking which are also characteristic for SD.

Arguably, the main feature of systems thinking is the substitution of reductionism with *holism* – studying phenomena as wholes comprised of interrelations rather than as multiple separated individual parts and relationships. Here, holism also implies the *interrelatedness* of everything in the world (Meadows, 2008; Senge, 1994). Next, systems thinking is characterized by the view on causality as intrinsically mutual, with feedback, rather than unidirectional. In turn, if everything is formed through interdependencies and feedbacks, it is impossible to distinguish a cause and an effect. Moreover, it also makes it hard to define something as an individual entity. This shifts the focus from "substance-thinking" to *process-thinking* (Meadows, 2008; Senge, 1994). That is, seeing interrelations in their dynamic interaction rather than individual "things". Systems thinking also implies a *dynamic perspective* with a long-term focus. Last, but not least, the endogenous approach to explaining is an important if not the central characteristic of systems thinking.

4.10. Systems Ethics

What I call here as *systems ethics* are the moral principles, guiding values and, as called by Meadows (2008) "behavioural consequences" (p. 170) which stem from the premises of systems thinking. Systems thinking provides the rationale and justifies the reason why one should adopt and live up to these ethical principles (Meadows, 2008). Systems ethics are explicitly mentioned in Meadows (2008) and Senge (1994) and somewhat implied in Sterman (2000). Meadows (2008) dedicates a separate chapter to systems ethics which she calls "systems wisdoms". Before I will further elaborate on what the premises of systems ethics are, I would like to make a short digression into the history of systems domains since the notion of systems ethics started emerging before the appearance of SD. Moreover, following Bertalanffy (1968), I propose that the emergence of the systems approach in the West was not only a scientific, but also *an ethical, cultural*, and even a *spiritual* movement (Macy, 1991; Senge et al., 2008).

As a movement for the re-orientation of scientific thinking, systems ideas started emerging in different scientific fields independently in the first half of the XX century as a response to the presently common reductionistic approach to science (Bertalanffy, 1968; Churchman, 1979). Technological advances and

scientific discoveries increased the complexity which scientists had to deal with, which made it evident, that to deal with that complexity, it is not enough "to know just one thing" (Bertalanffy, 1968). Rather, a more holistic and multi-disciplinary approach to science is necessary. Hence, for the greatly separated scientific domains at the time, the systems approach and its first formal manifestation - GST - promised unification and a meta-approach which would enable the integration of the different knowledge and approaches (Bertalanffy, 1968). In this way, GST attempted to become "the skeleton of science" (Boulding, 1956; p. 197). At the same time, Bertalanffy (1968) writes that another factor which spurred the systems movement was the historical and cultural happenings of the time. The similar stance is briefly described in Forrester (1968). On the one hand, technology was making the world more interconnected and globalized. On the other, growing political tensions between some countries simultaneously set the world apart. However, unlike in the past, these tensions were no longer local, but global, and to such an extent, that potential escalation threatened the existence of the whole world in a form of a nuclear crisis. Besides, humanity also started observing, that it had other common problems, for example, the environmental ones. Thereby, problems were "becoming" more global, interconnected and co-evolving. Thereby, Bertalanffy (1968) argues that the notions that everything in the world is interconnected and interdependent, like in a system, were emerging in opposition to the common mechanistic rationality-based worldview established after the Industrial Revolution. Another word, the emergence of the systems ideas was a consequence of the gradually changing culture which started viewing everything as mutually dependent and reality being not as simple or straightforward as a machine. According to Macy (1991), this cultural crisis of rationality happening in the XX century also started bringing back the ideas of spirituality into Western societies. In this way, the system's idea not only assumes the interdependence between the mental and physical "realities", but also provides a bridge for the integration of the dimension of spirituality into the rationality-based thinking (Macy, 1991; Senge et al., 2008). Lastly, I suggest that another important aspect here is that the system's idea *decentralizes the idea of the individual self*. That is, if I accept that I am dependent and intrinsically interrelated with "all the rest", this should at least put under question my innate egocentrism and the priority of my own being for myself to the being of "the rest".

Next, I will describe the premises of systems ethics which I find central. The first and probably the most important one is the already mentioned idea of *the interrelatedness of everything* (Meadows, 2008). As already suggested, by removing boundaries and decentralizing every individual "thing", this idea provides justification of why one should not act out of only own selfish interests, but rather out of altruism and as written by Meadows (2008) "*for the good of the whole*" (p. 178). Next, the endogenous explanation principle suggests that one should embrace *personal responsibility* for problems and look for their causes innerly, rather than blaming "external" events (Meadows, 2008; Senge, 1994; Sterman, 2000). *Ignorance*, in the sense of not knowing the structure of the problematic system, is portrayed as

the cause of actions which lead to problems (Meadows, 2008; Sterman, 2000). Hence, the importance of *learning* is emphasized. At the same time, systems ethics acknowledge that when something happens, people often try to find somebody specific to be accountable for it. "Tendency to blame the person rather than the system is so strong… In complex systems different people placed in the same structure tend to behave in similar ways" (Sterman, 2000, p. 28). Hence, as suggested by Senge (1994), it is the unmanageable system which should "blamed" rather than individuals. Next, Meadows (2008) argues that people should accept the complexity of systems and *avoid attempting taking them under full control* since such is impossible. *Embracing the system's complexity* also entails accepting that absolute knowledge is impossible (Meadows, 2008; Senge, 1994). Hence, one should not get stuck or defensive over one's opinion, but be mentally flexible, open to different opinions and humble about one's knowledge. Systems ethics also suggest that *prioritization of the immediate gains* over the long-term ones often eventually *makes one worse off* since short-term solutions often get counter-acted within the system which makes the situation even worse (Meadows, 2008; Senge, 1994; Sterman, 2000). Hence, a long-term perspective should be adopted instead of a short-term.

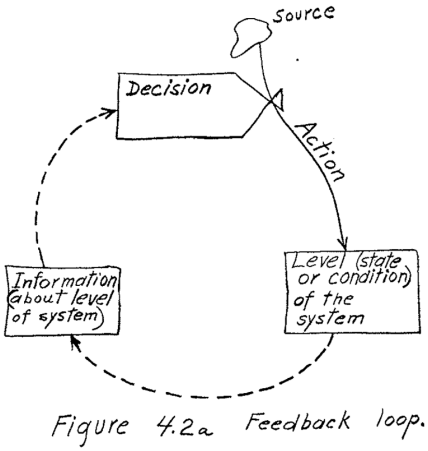
Additionally, Pruyt & Kwakkel (2007) suggest that SD can provide an interesting perspective on *the issue of responsibility* in the group or public issues. "In system dynamics terms, the issue of responsibility is clearer: all those who could actually do something – anything – are jointly responsible. This requires however a fundamental understanding of the system, which could be researched by means of system dynamics." (Pruyt & Kwakkel, 2007, p. 8). The authors also suggest that SD, in general, can help in solving certain ethical dilemmas in decision-making under uncertainty since the method can help in revealing the long-term consequences of decisions and shed light on their desirable and undesirable effects.

4.11. System Dynamics Theory of Decision-Making Process and Goal-Oriented Behaviour

The last category which will be described in this chapter is *the theory of the decision-making process* based on Forrester (1968) which is derived from the idea of balancing feedback. Simple balancing feedback structure can be used as a generic model for any *goal-oriented behaviour*. "Every decision is made within a feedback loop. The decision controls action which alters the system levels which influence the decision." (Forrester, 1968, p.4-4). An example of purposeful behaviour I will use here is learning a new language. First, let's consider the basic balancing feedback structure (see *Figures 2* and *3* below).

The structure contains the following components: 1) *state* (stock) - the actual state of the system (real, but unknown knowledge of the language); 2) *observed state (condition)* - the perceived information about the actual state (perceived or known level of the language knowledge which can be attained for

example in conversations with native speakers); 3) *goal* - the desired state of the system (the level of the language knowledge one wants to reach); 4) *discrepancy* - comparison of the difference between the perceived state and the desired state (how fluently one communicates with native speakers relatively to how fluent he wants to be), and 5) *decision rule* - the response to the discrepancy which determines the *action* towards bringing the actual state to the desired level (based on the observed discrepancy in fluency, how one will continue learning the language and with which intensity).



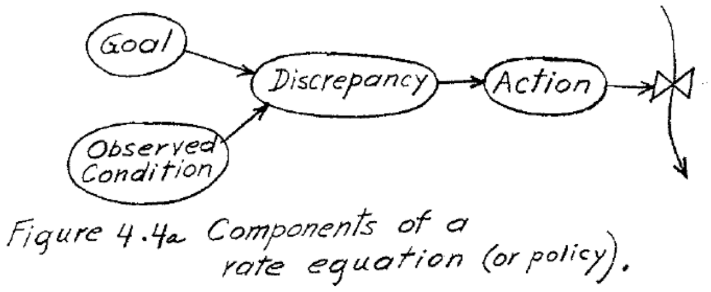


Figure 2 (left). Basic Balancing Feedback Loop. Copied from "Principles of Systems" by J. W. Forrester, 1968, p. 4-3. Pegasus Communications: Waltham, MA. Copyright: 1968 by J. W. Forrester.

Figure 3 (right). Components of a Decision Rule. Copied from "Principles of Systems" by J. W. Forrester, 1968, p. 4-15. Pegasus Communications: Waltham, MA. Copyright: 1968 by J. W. Forrester.

Thereby, goal-oriented behaviour can be defined here as bringing one's (observed) state towards the desired state (goal) by attempting to adjust this state through acting, with the type and intensity of adjusting (acting) being proportional to the size of the present discrepancy between the desired and perceived states. Another word, the further away the language learner will be from his desired level of knowledge, the more he will attempt to learn the language. As he would be approaching his desired level of knowledge, he would be gradually decreasing the efforts in learning the language.

The central component in this model is the decision rule. Basically, a decision rule represents an "algorithm" of *how* a decision-maker reacts to the *incoming information* – the observed state and its discrepancy with the goal, and *how* he decides to act upon this information to reach the goal. Another word, the decision rule concept implies that on every input information, there is "a policy", a response pattern which determines the action. In turn, this action changes the decision-maker's state and provides him with new information based on which he will further adjust his behaviour until the goal is eventually reached. The language learner may for example initially decide to take up a language course when he would see that his knowledge is far away from his desired level, and later switch to self-learning having gotten closer to the desired level of speaking fluency.

5. Comparison of System Dynamics and Buddhist Philosophy

This chapter presents the discovered conceptual similarities between SD and Buddhist philosophy by discussing how the main concepts of SD are represented and interpreted in Buddhist philosophy. Additionally, it provides suggestions on how the consonant concepts of Buddhist philosophy can be integrated into SD to further develop its philosophical foundations, considering the dilemmas and points for improvement discussed in *Introduction*. The chapter is structured into sections which correspond to the major general connection points discovered between the two domains. Additionally, all SD concepts which were found to be represented in Buddhist philosophy were depicted in a series of CLDs along with their Buddhist counterparts to visually summarize the main discovered conceptual similarities between the two domains. Such can be found in *Appendix E*.

5.1. "Dependent Origination 1": Mutual Causality (Feedback) and Systems View

The major connection point between Buddhism and systems domains discussed in the literature is related to the Buddhist *dependent origination axiom* (Khisty, 2006; MacKee, 2008; Macy 1991; Massoudi, 2006; Shen & Midgley, [illegible], Stinson, 2018). Macy (1991) suggests that dependent origination represents the foundation of systems theory and contains the notion of a system itself, and thereby Buddhism and systems theory hold the similar ontological stance on how reality functions and "things" happen to be. Stinson (2018) hypothesizes that by introducing the dependent origination axiom, Buddhism had defined the systems paradigm long before it was scientifically formulated in the early XX century. Churchman (1979) makes a similar proposition arguing that oriental philosophy contains the first traces of the systems view of the world. Thereby, I will start by discussing the connection points between Buddhist philosophy and SD relatively to the *ontological interpretation* of the dependent origination axiom.

5.1.1. Causality

The dependent origination axiom illustrates the Buddhist view on *causality* which is viewed as the universal law of reality in Buddhist philosophy (Prebish & Keown, 2010). The axiom denotes that it is through causality everything happens, not randomly, and not out of some inner volition (Piatigorsky, 2007; Prebish & Keown, 2010). In that sense, nothing decides or chooses to arise. Nothing arises out of nothing. To positively reframe the last statement – everything arises in dependence and being conditioned by something. Let's again consider the logical form "A→B". Macy (1991) suggests that Buddhist causality can be illustrated with the "IF THEN ELSE" function. Thereby, if the cause A arises, then the effect B arises, else B would not have arisen or would have been completely different. So, B would not have been there if not A. In this way, A creates the condition, the context in which B may arise. But, what probably is more important here is that B arises the way it does - having certain

qualities or properties - being conditioned by A (Macy, 1991). Another word, what arises as B is determined by A. If A was different, B would have been completely different too. Strictly speaking, it would not have been B then, but something else.

SD also considers causality as the mechanism behind how "things" in reality work. At the same time, as I have shown previously, causality is framed in SD differently than in Buddhist philosophy – as dynamic causality. That is, the focus is on how things change over time rather than how they come to exist. To illustrate this, I need to change the logical form above into, for example, "A$\rightarrow^{+}$B". If we apply the same "IF THEN ELSE" logic, we will obtain: if the cause A changes, then the effect B would change towards the same direction as A, else B would not change. Thereby, the specificity of the change of the cause A conditions the change of the effect B. In this way, causality in SD can be described as a process of flowing, exchange and transformation of matter, energy and information from one entity to another through which the change happens (Forrester, 1968). However, we can also say that new "things" can emerge out of this process. Thus, dynamic causality of SD does not reject the explanation of the origination of "things", such is just not the main interest of SD. Moreover, as it will be shown later, Buddhist philosophy also regards causality as a process, it is just not elaborated with the thermodynamics notion of a flow. Thereby, *I conclude that the SD concept of causality as the modus of explaining of how "things" arise and/or change is present in Buddhist philosophy and consonantly interpreted through the dependent origination axiom in its ontological form*.

5.1.2. Mutual Causality (Feedback), System and Systems Thinking

As discussed, dependent origination states that no phenomenon exists by itself, not being dependent or conditioned by something. In this way, causality in Buddhist philosophy as the mechanism through which the dependence or conditioning occur is not linear, but reciprocal and mutual (Macy, 1991). Speaking in SD terms, such view on causality implies a feedback process rather than a unidirectional chain of influences from some primary and assumingly independent cause towards some final effect. Thus, *Buddhist philosophy shares the idea of mutual causality with SD and contains the concept of feedback*. Furthermore, by suggesting that all phenomena are interdependent, the dependent origination axiom implies the *pluralistic view on causality* (Shen & Midgley, 2007). Such is also characteristic for SD. In this way, we can say that reality from the perspective of Buddhist philosophy can be described as a whole comprised of a network of interconnected elements, standing in interaction (Macy, 1991; Shen & Midgley, 2007). Such "worldview" resembles the SD concept of *a system* and appears similar to the "systems worldview" or *systems thinking*. *Thus, I conclude that feedback and system concepts are represented in the Buddhist "ontological dependent origination". The axiom also entails the pluralistic view on causality as well as the holistic systems thinking perspective.*

5.1.3. Endogenous Explanation (View)

Bajracharya (2010) and Macy (1991) suggest that dependent origination also contains the notion of the endogenous view. Indeed, if we acknowledge that everything is interconnected, there can be nothing exogenous or external. However, it appears to me that such connection is of rather superficial nature. As I have discussed, the SD endogenous explanation does imply that all system's elements are interconnected through feedback. However, it does not end up in mere interconnectedness. Rather, the endogenous explanation is the special way of explaining systems behaviour in terms of the closed feedback structure. In turn, the closed feedback structure is not only a theory of why a system behaves in a specific way but also a way to frame such theory and to literally structure the knowledge about the studied system. In this way, the endogenous explanation is more of an epistemological tool than an ontological concept. This study was not able to find any indication of the presence of such notion of the endogenous view and the concept of a system's structure in Buddhist philosophy. Hence, *I conclude that the concepts of endogenous explanation and systems structure are not represented in Buddhist philosophy.* What is represented is the concept of *interconnectedness* which is only a part of the endogenous explanation.

5.1.4. Process Thinking, Boundaries and Dynamics

Feedback view on causality implies that everything exists in the state of constant *dynamics*, and leads to *process thinking* (Macy, 1991; Meadows, 2008; Senge, 1994) which is as I will demonstrate now characteristic for both SD and Buddhist philosophy. Let's again consider the two properties of phenomenal reality which are derived from the dependent origination axiom: no-self and impermanence. The former suggests that since all phenomena arise in reciprocal dependence, none of them has an individual essence or intrinsic properties (Prebish & Keown, 2010). Because of the same reason, all phenomena are constantly changing and have impermanent existence (Prebish & Keown, 2010). Thereby, Buddhist philosophy suggests that all phenomena exist in the state of *constant becoming* rather than being as the latter "requires" individual essentiality or at least some enduring unchangeable state (Macy, 1991; Prebish & Keown, 2010). Hence, all phenomena according to Buddhist philosophy can be more accurately defined using the process metaphor rather than as substances (Macy, 1991). If we define something as a substance, we distinguish it from the rest as an individual thing and set its *boundaries*. However, following the logic of dependent origination, it is neither possible to establish boundaries between phenomena nor to identify any of them as having individuality in the general sense (Macy, 1991; Prebish & Keown, 2010). Similarly, SD holds the premise that systems have no boundaries and consequently the phenomena which they represent also have no separable individuality (Meadows, 2008; Senge, 1994; Sterman, 2000). Therefore, we can say that setting "substantial" boundaries for both SD and Buddhist philosophy is an implicit or explicit

mental act of conceptualization, that is creation of an abstract construct representing some phenomenon. Artificial boundaries, then, are merely derivatives of the process of cognition necessary to comprehend reality. Thereby, *I conclude that both SD and Buddhist philosophy view phenomena as dynamic processes rather than as individual substances which implies process thinking, and contain the notion of "the absence of real boundaries".*

5.2. "Dependent Origination 2": Mental Models and Relativity of Knowledge

To remind the reader, the second interpretation of dependent origination shares the same core premise with the ontological one – all phenomena arise conditionally, in dependence. However, here this statement is related to the mental phenomena only and is not extrapolated to any realm outside of the mind (Shulman, 2007). In fact, early Buddhism which originally suggested dependent origination as what I call a theory of mind and psychic did not draw the line between mental and physical realms. The mental realm was considered as the only one available in the sense that any statement about a physical realm ultimately remains a statement about something as a physical realm, but within the mind (Piatigorsky, 2007). That does not imply that reality outside of the mind is non-existent, as a matter of fact, this was not of any importance for early Buddhism (Piatigorsky, 2007). What is suggested is the primacy of the mind, that the mind precedes all (Shulman, 2007). In this way, all that is known and experienced, that is all mental phenomena (dharmas) - sensations, mental states, thoughts, feelings - have a conditioned nature of existence (Piatigorsky, 2007; Prebish & Keown, 2010). That is, they are conditioned by the mind and arise out of and in dependence on the mind. Another word, there is no pure knowledge, no information which can be separated from the mind. Varela et al. (2016) expand this Buddhist idea and suggest that reality contains no information in itself – all knowledge is actively constructed through the process of living. In this way, the Buddhist no-self, its derivative emptiness and the impermanence characteristics obtain a slightly different "colouring". That is, no knowledge has any individual essence, any intrinsic meaning or qualities. Another word, change the mind and you will obtain a completely different and potentially incompatible worldview (Varela, 1983). Having no essentiality, all mental phenomena are impermanent – all mind states, moods, feelings and beliefs are transient, change along with the change of the mind and eventually fade.

5.2.1. Idealism and Dependent Origination

What has been discussed in this section so far has an important epistemological implication – *every knowledge is relative* and cannot be separated from the subject of this knowledge - the knower (Piatigorsky, 2007). *This interpretation of the Buddhist dependent origination axiom is similar if not identical at least on the present level of analysis with the idealistic philosophical stance adopted in SD*. The famous statement of Immanuel Kant, arguably the most prominent philosopher-idealist, suggesting that we cannot know "things in themselves" in the sense that no mental object exists

independently from observation and the observer, appears as an alternative framing of the Buddhist dependent origination (Piatigorsky, 2013). Thereby, Idealism and consequently SD also accept the idea of the relativity of knowledge and reject the possibility of absolute knowledge and its complete validation (Olaya, 2009; Sterman, 2000). In this way, SD suggests that all that we know and can know is ultimately a mental model – a simplified representation of objects and phenomena from reality. That implies that all that can be empirically discovered from reality is reduced to the knowledge available in the form of mental models (Meadows, 2008; Sterman, 2000). Such are the only sources of knowledge. Thus, it is not the real system which is modelled in SD, but the system as it is perceived in the mental model of the investigator. As discussed, the same holds for other core SD concepts such as systems structure, feedback and causality. Therefore, *I conclude that the Buddhist dependent origination axiom in its "epistemological interpretation" represents the SD idealistic stance about knowledge. Additionally, both domains emphasize the primacy of the mental realm*.

Furthermore, while SD and Buddhist philosophy acknowledge the relativity of knowledge, both also accept that knowledge is not "completely relative" or random (Macy, 1991; Olaya, 2009; Sterman, 2000). As discussed, SD argues that gaining confidence in the model, that is partial model validation is possible. In that sense, while all models are wrong, they are also not equally wrong. Similarly, dependent origination implies that human's cognition is not something independent – it originates in a certain environment which conditions its properties (Macy, 1991; Varela et al., 2016). Thereby, it suggests that what we know also cannot be completely unrelated to the world we live in.

5.2.2. Mental Model as Conditioned Knowledge

The mental model concept implies that we can't know any object as it is (Forrester, 1968). Rather, we construct its substitute – "*a model*". That implies that there exists the *subject of the mental model* – the one who constructs it. In turn, the properties of the object's substitute which the subject constructs in the form of the mental model are conditioned by the subject himself with all his life experience and properties of cognition (Forrester, 1968). In this way, I suggest that "mental model construction" is an SD way to describe the process of cognition (i.e. the process of getting to know). Furthermore, SD assumes that cognition is a feedback process (Sterman, 2000). Mental models affect the individual's decision-making and actions. The latter change the individual's environment in a specific way which affects his future life experience and further shapes his mental models. Therefore, *I conclude that not only SD and Buddhist philosophy share the idealistic stance, but Buddhist philosophy also implicitly (that is, not naming it such) contains the concept of a mental model. Moreover, Buddhist philosophy proposes a theory of how mental models are constructed – the dependent origination axiom - which as it was shown before also suggests that cognition is a feedback process.*

5.2.3. Mental Model and Dependent Origination as Pedagogical Tools

Next, I suggest that the mental model concept has *a pedagogical notion in SD*. It is used to illustrate the idea of imperfection of human's knowledge and cognitive abilities, to explain how the multiplicity of potentially conflicting opinions and worldviews on the same matter can emerge and to emphasize the importance of openness and learning (Meadows, 2008; Sterman, 2000). In line with that, SD advocates for the multidisciplinarity and inclusivity of stakeholders into the model-building process (Sterman, 2000). Similarly, Buddhist philosophy also claims that human's understanding is limited, emphasizes the importance of critical reflection on one's beliefs, rejects absolutism and encourages openness to different opinions (Macy, 1991; Prebish & Keown, 2010). In that sense, the dependent origination axiom is in itself a pedagogical instrument aimed at showing the followers of Buddhism the relative and somewhat illusionary nature of their knowledge as well as the whole phenomenal reality and their experience of self (Macy, 1991; Piatigorsky, 2007). An important aspect here is that the person should understand that it is he and not any external agency who creates his own "reality", or mental models in SD language (Piatigorsky, 2007). Another word, it is the individual way of thinking and responding to the happenings in the world which make one have certain beliefs, attitudes, mind states and ultimately the way of living (Piatigorsky, 2007). Thus, *I conclude that Buddhist philosophy contains the same as in SD pedagogical notion relatively to the mental model concept*.

5.3. Integration of Buddhist Dependent Origination and Reflective Practices into SD

As discussed, the central conclusion of the dependent origination axiom in its "epistemological interpretation" is that there is no abstract knowledge that can be separated from the subject of that knowledge – the knower himself. Another word, studying a problem X, I cannot isolate the knowledge which I will gain about it from myself with my specific way of thinking as well as the method(s) I use. Acknowledging that, Buddhist philosophy emphasizes the importance of meditation as a method to study and reflect on one's mind and cognition (Piatigorsky, 2007). In this way, instead of focusing on abstract knowledge only – the what is or can be known, Buddhist philosophy suggests focusing on how that knowledge comes to be known (Piatigorsky, 2007). As I have shown, by adopting the mental model concept, SD shares the Buddhist premise about the subject-dependent nature of all knowledge. Thus, what should be accepted in SD then is that *by means of improving understanding of one's thinking process, the understanding of the object towards which that thinking is directed will be also improved*. Thereby, I will now discuss how the insights from the Buddhist reflective practices can be incorporated into SD. Specifically, the practice in which a practitioner reflects on how his beliefs and thoughts had come to exist by distancing oneself from their meanings and tracing back their origins is part of Vipassana meditation techniques (Prebish & Keown, 2010).

Normally, system dynamicists study some phenomenon (a problem) as a system. Thereby, their focus is placed on what can be discovered about that problem *as an object of investigation*. At the same time, the way how that object is investigated, that is the whole iterative process of learning and model-building conditions the ultimate understanding of that object. Thus, the specificity of the thinking process occurring during the problem investigation and modelling should be of equal importance for the modeller as the object towards which that thinking is directed since the former affects the knowledge which will be gained about that object and therefore the developed model too. In this way, by neglecting reflection on the investigation process and one's thinking, the modeller risks that the developed model will become a mere self-fulfilling prophecy for his own assumptions and beliefs. Thus, *I propose to add an additional object of investigation into the modelling process*. That is, in addition to studying "something as a system", I suggest that the modeller's focus should also be formally placed on studying "*oneself (one's thinking process) studying something as a system*". That is, to distance oneself from the external problem being investigated, from all existing knowledge and beliefs about it, make is temporarily unimportant, and reflect on the thinking process of how one has been researching this problem to understand how one's assumptions had emerged and projected themselves on the created model (Prebish & Keown, 2010). In this way, modellers should continuously reflect on themselves by literally questioning how and why certain assumptions originated in them, what made them implement these assumptions into the model, and why other assumptions were left out. That should include reflecting on the information which was used, how it was used, whom the modeller spoke to, which prior assumptions were present and even what mood or mental state the modeller had during the process. I suggest that it is important to start such reflection from the start of the modelling project to have the ability to follow the whole development of the thinking process. Practically, such self-reflection can be made after the accomplishment of every milestone of the modelling process, for example finishing the problem statement or adding a new section into the model.

Because of the same reason, involving problem-owners - the clients for which the modelling effort is made becomes crucially important since their knowledge is one of the main inputs for the constructed model. The clients should be also pushed to reflect on the origins of their knowledge by attempting to reveal what kind of individual thinking, historical occurrences and context lead to them. This could be achieved by constantly verifying with each client what makes him think in one way or another. In this way, illustrating the clients the fact that they do construct mental models and shedding light on how they do it may contribute to more learning than only by presenting them with abstract, in relation to their own thinking, model and simulation insights. Surely, this suggestion is not something new. It had already been suggested that SD can be effectively used as a method for visualizing and making explicit mental models of the problem-owners (Sterman, 2000; Vennix, 2001). However, what is suggested here is that making mental models explicit is not enough as such may not necessarily lead to the

understanding of how one's thinking created the specific mental model. Thus, to achieve the goal of learning proclaimed in SD, the individual thinking process through which the existing mental models emerged should be also made apparent. Furthermore, the proposed formal inclusion of reflection on the thinking process as an additional object of investigation implies that every insight gained during the modelling process by the modeller and clients should be considered as an equally valuable outcome as simulation findings. In this way, I suggest that the modelling process should be designed in such a way that simulation will not be the only source in which insights and learning will be sought.

Finally, it is important to add that developing a well-elaborated method for the proposed thinking process reflection is outside of the scope of this research. The aim is to illustrate the need for such a method and to outline how Buddhist philosophy can provide its foundation based on the conceptual similarity with SD. In fact, similar reflection methods already exist in the field. For example, the "system boundary critique" proposed by Ulrich (2003). This method can be used as a basis for the further development of the thinking process reflection suggested here.

5.4. Mental Models: Enhance or Suspend?

Let's further consider the concept of the mental model and the approach for working with mental models suggested in SD. As discussed, mental models are considered in SD as not the primary, but the only possible sources of information since all human's knowledge exists in the form of mental models. Hence, the goal of SD is not in the discovery of some ultimate truth, such is accepted to be unattainable, but rather in learning - *enhancement of the mental models* of the problem-owners (Meadows, 2008; Senge, 1994; Sterman, 2000). Thus, a substantial part of the SD method is concerned with eliciting the existing mental models of problem-owners and/or the modeller himself, confronting them, achieving the common problem understanding and generally creating a process during which individual mental models would be changing and expanding, the significant role in which is given to simulation and model experimentation (Richardson, 2011; Sterman, 2000, 2018; Vennix, 2001). In this way, even though the information within every single mental model is incomplete and significantly distorted, it is assumed that each contains some small piece of the puzzle (Vennix, 2001). Thereby, by "summing up" and "throwing" the mental models together, system dynamicists assume to solve a bigger part of that puzzle (Vennix, 2001).

However, what is also accepted in SD is that every problem is unique (Sterman, 2000; Vennix, 2001). In this way, the previously obtained experience, knowledge and solutions simply might not be applicable to the new problem (Vennix, 2001). Another word, what if the existing mental models of problem-owners just do not contain any information relevant for the new problem? Essentially, the only content of mental models is memory (Varela, 1983; Vennix, 2001). Mental models can be metaphorically described as *ingrained structures of meanings* which every individual with his own life

experience and way of cognition has constructed (Varela, 1983). Moreover, being integrated, these meanings' structures shape the individual's cognition by establishing behavioural routines, thinking patterns and interpretation schemes (Sterman, 2000; Vennix, 2001). Therefore, the existing mental models also condition the overall individual's way of thinking and approach to problems (Vennix, 2001). In this way, not only certain knowledge might be missing to deal with a new problem, but also the overall thinking way adequate to approach this problem.

A big part of the Buddhist meditation practice is targeted on firstly understanding and after alleviation of one's typical thinking patterns and existing structures of meanings (Piatigorsky 2013; Prebish & Keown, 2010). These often remain unrecognized, but nevertheless shape the individual's perception of self, life, its happenings and further "force" one to the extremes of liking and disliking, loving and hating, aspiring and avoiding (Piatigorsky 2013). For Buddhists, the problem in that process is that it blurs the mind and hinders a clear understanding of the phenomenal reality and its selfless "empty" nature (Piatigorsky 2013). And, probably even more importantly, it hinders self-reflection (Piatigorsky 2013). Thus, it also makes one get further entrapped in Samsara. For the matters relevant for the SD scientific inquiry, not concerned with the goal of self-liberation, it implies that one's thinking gets more conditioned, under-reflected and biased.

Now, let's briefly consider the mentioned meditation practices. One type of such meditation is the practice of mindful observation – Vipassana (Prebish & Keown, 2010). As discussed, Vipassana entails observing one's thoughts, sensations and mind states as they occur and cease in the mind and body while avoiding reacting, interpreting and getting fixed on any of them (Prebish & Keown, 2010). Basically, this meditation trains a neutral and open attitude towards the comprehension of phenomena and avoidance of judging (Prebish & Keown, 2010). For Buddhist philosophy, any form of judging is ultimately derived from thinking in extreme (dualistic) categories, for example, "if X is this, then X is not that", and is therefore based on an incomplete and biased understanding (Piatigorsky 2007). Pragmatically speaking, it is impossible to avoid making concrete judgements at all, but such can be improved by adopting a more neutral and self-conscious attitude (Piatigorsky 2007). Another type of Buddhist meditation with similar aims is the "techniques for spontaneity" (Prebish & Keown, 2010). An example of such is the sitting meditation of the Zen Buddhist tradition (Prebish & Keown, 2010). The meditation entails that the practitioner should stay in the sitting posture for an extended amount of time being free from any volition, intension, or reacting (Suzuki, 1964). Unlike Vipassana, the sitting meditation suggests that the meditator should not intendedly focus his mind on any internal or external object – he literally needs to just sit allowing his mind to be in its natural flow and to not disturb it with any effort (Suzuki, 1964). If the mind gets focused on something by itself, the meditator should just stay aware of it and let it happen. In this way, in addition to the neutral attitude, the meditator also

learns to be less self-controlling, calm, open and observant. Besides the sitting meditation, Zen Buddhism suggests another method for reaching the same goal - "koans" (Prebish & Keown, 2010; Suzuki, 1964). Koans are absurd riddles often contradictory to common sense given by Zen masters to their disciples to shatter their normal way of thinking and get them unfixed from it (Prebish & Keown, 2010). In attempting to solve these riddles, the disciples should learn that the purely logical and common sense reasoning are never completely correct or sufficient (Prebish & Keown, 2010).

Thereby, *I suggest that Buddhist philosophy and meditation practices can propose an alternative, but complementary with the currently used in SD approach to working with mental models*. As discussed, the latter is characterized by the direct usage and confrontation of the information available within mental models of the problem-owners and/or modeller(s), and focus on their enhancement. In turn, Buddhist philosophy suggests to partially *"switch off" mental models*, to get the person unattached from his current beliefs and worldview so as to mitigate their projection on the object of inquiry (Varela, 1983). Using these Buddhist insights, Varela et al. (2016) propose a method called "*suspension*". Suspension is the ability to suspend (cease, put off) one's existing structures of meanings and thinking process in order to get oneself disassociated from them, release their "pressure" and ultimately decrease self-projection on one's life experience and knowledge inquiries. Varela (1983) suggests that every creative process requires suspension since for any new idea to emerge, it is important to leave oneself with one's existing framing of thinking out from the creative process. Senge et al. (2008) elaborate on the original idea of suspension and argue that only by suspending their mental models, people can understand and reflect on what is happening around them. The authors suggest that to achieve suspension, it is first necessary to stop one's thinking process and to reflect on it. "Once you actually stop [the thought process], you move to the third stage: samadhi, or calmness. When you reach true calmness of mind, then you'll be able to reach true quietness or stillness. You'll be in a state of peacefulness in which you can truly think. When you can truly think, then you can attain the goals that you're supposed to achieve" (Senge et al., 2008, p.183). The second component of suspension as suggested by Senge et al. (2008) is related to the development of the "right" attitude towards the individual self ("I"). As already discussed, Buddhist philosophy argues that the nature of everything including the sense of "I" is emptiness. In this way, the experience of self is a dharma – a mental phenomenon conditioned by the five aggregates of individual existence – material form (body), feelings and sensations, perceptions, mental formations, and consciousness (Piatigorsky, 2007; Prebish & Keown, 2010). By associating oneself with these naturally given "aggregates", the individual starts clinging to the worldview which he had constructed through these aggregates and becomes attached to it (Piatigorsky, 2007). Strictly speaking, this makes one's thinking become a constant self-projection and any new knowledge or experience - a self-fulfilling prophecy of the existing meanings structures (Piatigorsky, 2007). In this way, by disassociating "oneself from the self", from the belief that this

experienced sense of "I" represents the true essence or "substance" of one's individuality, it would be simpler for the person to also get unattached from the meanings structures he had constructed since such also cannot be intrinsically "mine", and hence there is no point in clinging to them (Piatigorsky, 2007; Senge et al., 2008; Varela et al., 2016).

5.5. "The Promise of System Dynamics" or How Much Religion is There in SD?

I started discussing the main concepts of SD by suggesting that all four reviewed canonical SD authors begin by introducing the narrative which I called as "the characteristics of the normal human thinking". That is, the way how people ordinarily tend to think and approach problems. In brief, such is characterized by limited cognitive abilities, reductionism, non-systemic worldview, simplifications, biases and event-orientedness. The "normal thinking" is argued to be inadequate for the modern world challenges, often results in poor decision-making and creates even more problems by attempting to solve the existing ones. Hence, there is a "need for the new alternative way of thinking" – the second part of that narrative. Specifically, SD with its holistic systems thinking perspective is suggested as such an alternative. By adopting SD and its systems perspective one should achieve a better understanding of one's problems and find effective solutions to them. Or, a reversed statement - by sticking to the "old" normal non-systemic way of thinking and methods, one condemns himself to remain in the state of ignorance and continue falling into the same problems which he himself creates. Altogether, the discussed narrative represents what I call as "*the promise of System Dynamics*". Though to be fair, a similar promise is characteristic for all systems domains, and not only for SD (Bertalanffy, 1968).

Now, what does this have to do with religion? I already discussed that the core part of any religion is its soteriological inclination. The soteriological essence of Buddhism is represented by its Four Noble Truths (Piatigorsky, 2007). I will now reframe the discussed "promise of SD" using the structure of the Four Noble Truths. First, there exists a discontent state of human's existence which manifests itself in the occurrence of different social problems. Second, the cause of this "problematic state" is the normal way of how people tend to think and approach problems. Third, the discontent state and the re-occurring social problems can be ceased. Fourth, there exists a way to cease that discontent state and to solve social problems – System Dynamics. In this way, by adhering to SD and thinking in systems people can fix their problems by eliminating or changing the main cause of these problems – their old way of thinking. By not adopting SD, the discontent state will remain. This discourse has a feel of a comedy. Nevertheless, "the promise of SD" perfectly fits into the Four Noble Truth structure. Moreover, I suggest that this SD narrative contains a soteriological and therefore a religious notion which is as I will demonstrate further even similar to the one of Buddhism with the exception that,

unlike other religions, the discontent state of SD is related to rather down-to-earth matters of the everyday living (and therefore SD is of course not a religion).

The discontent state in which humans exist according to Buddhist philosophy is the state of suffering in Samsara (Prebish & Keown, 2010). Social problems discussed in SD entail suffering, but certainly not in the same sense as in Buddhist philosophy. However, similarly to SD, Buddhist philosophy also argues that what causes the present discontent state of being is exactly the way how the normal human's thinking operates, or more generally – how the normal mind works (Piatigorsky, 2007; Prebish & Keown, 2010). Moreover, Buddhist philosophy explicitly contains the differentiation of the normal and transcendental ways of thinking or mind states (Piatigorsky, 2007). Thereby, *there exist similar notions of the "characteristics of normal human thinking" and the "need for a new way of thinking" in Buddhist philosophy since only by transforming one's mind the individual can escape from the world of suffering and reach the state of Nirvana*. The Buddhist method for achieving the new way of thinking is the Eightfold Middle Path. Furthermore, *both domains share the idea of ignorance as the cause of the ultimate discontent state, be it social problems in SD or suffering in Buddhism*. SD suggests that due to not knowing or another word being ignorant about the systemic properties of the problem at hand as well as the system's structure which generates the problematic behaviour, people make ill-fated decisions which lead them to the creation of further problems (Meadows, 2008; Sterman, 2000). In turn, in Buddhist philosophy, ignorance about one's state of suffering and the inability to reflect on and understand that state is the reason why one stays trapped in Samsara (Piatigorsky, 2007).

However, there also exist two major differences in the way how the discussed narrative is interpreted in SD and Buddhism. First, the aims of Buddhism are purely soteriological and have no relation to problem-solving in the SD sense (Prebish & Keown, 2010). Second, especially early Buddhism is a rather anti-social discipline focusing mainly on the individual suffering and salvation (Piatigorsky, 2007), while SD is society-oriented and primarily concerned with the group-level problems (Meadows, 2008). In this way, there is of course not much interest for SD in the Buddhist ideas about suffering. However, what can be of interest are the characteristics of the "normal ways of thinking" suggested in Buddhist philosophy as such can contribute to the SD understanding of human's cognition and decision-making. As I have demonstrated, similarly to SD, Buddhist philosophy also acknowledges that human's cognitive abilities are limited and that all human's knowledge is conditioned by the individual life experience and properties of cognition, and exists in the form of mental models. However, the central characteristic of the normal human's thinking described in Buddhist philosophy, and absent in SD literature is the tendency of the human's mind to think in extreme categories, dualistically. In this way, the "new alternative way of thinking" suggested in Buddhist philosophy is

the non-dualistic "middle way thinking". Thereby, I will discuss the middle way principle in relation to SD in the next section.

5.6. Non-Dualism in Buddhist Philosophy and System Dynamics

5.6.1. Why is Non-Dualism Characteristic for System Dynamics?

In basic terms, the Buddhist middle way suggests *non-dualism* as a specific kind of thinking which is not derived from dual extreme categories (Piatigorsky, 2007). I suggest that SD with its system, feedback and mental model concepts also conform to non-dualism. The system's idea implies that any "self", that is any individual entity cannot be separated but is rather interrelated with its context – "the rest" (Macy, 1991; Meadows, 2008). In fact, this statement represents the essence of the open system concept, that is the system which through feedback exchanges matter, energy and information with its environment (Bertalanffy, 1968; Meadows, 2008). In turn, all systems, as all "selves", are suggested to be open, and not closed systems (Forrester, 1968; Meadows, 2008). That implies that it is rather impossible to distinguish any individual "self" and to separate it from its environment as such are interdependent. In turn, dualism is built on such differentiation as for example in the well-known mind-body duality (Macy, 1991). However, what about the basic dualistic properties like "cold/hot", "good/bad" or "pleasant/unpleasant" as such imply a different form of opposition than "self/the rest"? As discussed, the mental model concept relativizes all possible knowledge which implies that at least on the level of the mental realm which it assumes to be the only one available for the human's experience, no object can have any absolute properties independent from the subject which experiences that object. In this way, properties like "cold/hot" or "bright/dark" become relativized and remain opposites only in relation to the specific subject of experience, instead of being dualistic in absolute terms. Thereby, *while SD does not reject the notion of dualism completely, its central concepts – system, feedback and mental model – imply non-dualism and suggest relativity*. Thereby, having demonstrated that non-dualism is characteristic for both SD and Buddhist philosophy, I will further discuss the middle way principle to conclude if some of its premises could be adopted into SD.

5.6.2. Relevance of the Buddhist Middle Way for System Dynamics

As discussed, the middle way principle suggests that people naturally tend to think in dual extreme categories. More precisely, it is proposed that the mind operates based on the dualistic categories which condition the way how people think and the worldview they create (Piatigorsky, 2007). At the same time, Buddhist philosophy views any knowledge derived from dualistic thinking as incomplete, simplified and literally biased towards one of the extremes (Piatigorsky, 2007). Thus, the middle way as an alternative way of thinking is suggested. However, Piatigorsky (2013) argues that discarding "the dualistic heuristic" is extremely challenging. He suggests that the "distance" between the two extremes

is smaller than from each of them and the middle way position. Another word, it is simpler to shift towards another extreme than to the non-extremes-based thinking. Essentially, the middle way position is absent from any definitive categories (Piatigorsky, 2013). Thus, taking the non-dualistic position implies remaining in the state of uncertainty relative to the object of investigation, since the definitive dualistic categories are no longer present (Piatigorsky, 2013). Another word, establishing what a certain object is and/or what its properties are becomes more problematic. Hence, I suggest that the tendency for dualism can be related to the individual's will for having certainty in one's knowledge. That is supported by Kruglanski & Orehek (2011), who propose that people have different capacity for dealing with knowledge uncertainty and tend to adopt extreme positions in situations when such uncertainty is high. At the same time, Meadows (2008) suggests that when people start thinking that they know something definitely, they become closed and protective of their own short-sighted paradigms. Thereby, *the tendency for dualistic thinking can be a direct hindrance to learning and embracing of the complexity of reality which SD argues for*. In that sense, adopting the dualistic VS non-dualistic position is like balancing between increasing of bias (or, simplification) and uncertainty.

Next, Piatigorsky (2013) argues that a lot of automatic psychic responses and thinking patterns which are formed and change over the individual's lifetime are based on the dualistic operation of the mind. Such affect how one assesses one's life experiences, acts and makes decisions. In this way, people automatically, that is without any intention or self-reflection may tend to react towards events, situations, problems and other people in a certain way. Some things may be experienced as positive and thus aspired, while other as negative and avoided. At the same time, such experiences tend to be unstable and constantly changing (Piatigorsky, 2013). For example, today I think that SD is the answer to all world problems and feel an urge to tell all people about it, but tomorrow I already blame myself for being so naïve and thinking in such way. Or, yesterday I loved my partner and wanted to spend all my life with her, but today I hate her and would have preferred to not see her again. Similarly, yesterday I was happy and today feel miserable. However, what has changed in my life in a day? In some sense – nothing at all. And in fact, what are my life, my partner or SD if one day they can be one and the day after – the opposite? A slightly different example: how come killing a man during a war is a heroic deed, and in peaceful time – a murder, killing a deer on a hunt is something in between, and crushing a mosquito with one's thumb is not even worthy of any consideration? What I want to illustrate with these examples is the idea suggested in Buddhist philosophy that *the mind, operating based on the dualistic categories, can easily flow from one tendency, state or belief to another, making the individual with his worldview, opinions and way of living drift along* (Piatigorsky, 2013). In this way, the dualistic position enables the possibility that the same object can be perceived oppositely in different contexts (Piatigorsky, 2013). At the same time, Buddhist philosophy suggests that the nature of all objects as all mental phenomena is emptiness and impermanence (Prebish & Keown, 2010). The objects change

with the change of the position of observation because they exist only in dependence on the subject with his position of observation and thus do not have any perpetual individuality or properties (Prebish & Keown, 2010). At the same time, the dualistic tendency of the mind forces one to attribute dualistic properties to the observed objects (Piatigorsky, 2013). *In relation to SD and its practice, that implies that such tendency can not only increase the bias in one's knowledge but generally induce the biased approach to thinking and problem understanding*. Moreover, Buddhist philosophy suggests that such often happens unrecognized, in an automatic manner since the dualistic tendency is deeply ingrained into the organization of human's thinking (Piatigorsky, 2013).

Next, let's consider the practices suggested in the Buddhist Eightfold Noble Path for the attainment of the non-dualistic middle way position. As discussed, the "higher level" of the middle way practice lies in the transformation of the mind in such a way that it will not tend to dualistic thinking at all, won't have attachment and craving towards any objects, and hence would not have the inclination to think in extremes (Piatigorsky, 2007). However, as suggested by Piatigorsky (2007), such is almost impossible to attain. At the same time, the "medium level" of the middle way, that is the basic avoidance of leaning towards extremes in ones living and judging, and development of *the neutral non-evaluative attitude to knowing* appears more achievable (Piatigorsky, 2007). The right Morality part of the Eightfold Noble Path is the foundation of the "medium level" middle way (Prebish & Keown, 2010). It entails individual practice of self-discipline in one's livelihood, speech and actions. The main goal of the practice is to find the "golden middle" in the way how one lives, works, speaks and views life in order to avoid falling into "living out of extremes", for example: being obsessed with the idea of earning money or rejecting the importance of such at all; indulging oneself into sensual pleasures or living life of only self-restrictions; believing in superiority of specific values and ideas or complete denial of such and adoption of the nihilistic position (Piatigorsky, 2007; Prebish & Keown, 2010). Practically, the right Morality is developed in one's everyday living by establishing the habit of reflecting on oneself and being self-aware, and through this become less susceptible to fluctuations in one's mind like in the "yesterday I was happy and today feel miserable" example I made above (Prebish & Keown, 2010). Another important aspect of the right Morality is the development of the attitude towards oneself as one of the many other "selves", equally valuable, not less or more (Prebish & Keown, 2010). That includes being considerate to not only own wants, feelings and thoughts, but also to the ones of others.

Thereby, *I suggest that the Buddhist idea of non-evaluative and non-judgemental thinking should be incorporated into SD and its modelling practice as such can help to counteract the discussed dualistic tendency as well as the biased approach to problem-understanding which it can induce*. Arguably, by means of self-reflection and constant awareness of one's thought process, non-evaluative thinking can be trained as a skill even without doing any meditation practices (Prebish & Keown, 2010).

5.7. Middle Way as Negative Feedback… Karma as a Stock

Fenner (1995) suggests that there exists a similarity between the Buddhist middle way and the concept of negative feedback. As discussed, the Eightfold Noble Path as a method for achieving the middle way position implies the practice of the right Morality, Meditation and Wisdom. In this way, the practitioner should be constantly seeking the "golden middle" in his stance on these components and adjusting oneself from the deviations from the right Morality, Meditation and Wisdom. At the same time, all three components are interlinked and hence following the middle way implies a process and not a step-by-step achievement of the right state in each component separately (Fenner, 1995; Prebish & Keown, 2010). Hence, following the middle way entails a constant comparison of one's state of mind, actions and meditative practice in aspiration of the goal of the ideal middle way position and adjusting oneself towards this goal based on the observed through self-reflection discrepancy with one's state (Fenner, 1995). Similarly, the negative feedback concept also implies a self-adjusting process in which a system corrects one's state attempting to bring it to some desired state (goal) based on the observed discrepancy between the actual state and the goal (Forrester, 1968).

However, the negative feedback model is in general representative of any purposeful goal-oriented behaviour, be it filling in a glass of water or following the Eightfold Noble Path (Bertalanffy, 1968; Forrester, 1968). Thus, I suggest that the similarity proposed by Fenner (1995) is rather an observation of an obvious fact than a significant finding. There appears to be no other rationale uniting the two concepts, except for that both middle way and negative feedback imply goal-directed behaviour. In the same manner, it could be argued that the Buddhist idea of karma contains the notion of a stock since the former represents the accumulation of karmic potency gained through one's deeds during the present and past lives (Prebish & Keown, 2010). Even if karma can be represented as a stock, such analogy does not entail any deeper conceptual similarity. Therefore, *I suggest that the proposition of Fenner (1995) which also had been listed as one of the significant connection points between Buddhism and systems thinking by Shen & Midgley (2007), should not be considered as such and thus not included into the subsequent research on the topic*.

5.8. Time in System Dynamics and Buddhist Philosophy

This section will discuss how the SD concepts of *time* and *delay* are represented in Buddhist philosophy. Time is one of the central concepts in SD. "Feedback systems are of interest because of the way they act through time" (Forrester, 1968, p. 2-7). In this way, as suggested by Perelman (1980), all SD research focuses on studying the behaviour of systems "through a flow of time" (p.75). In turn, time is a similarly important concept in Buddhist philosophy (Siderits, 2016). In such, it can be distinguished into two "types": cosmic time and time as a mental phenomenon (dharma) (Siderits, 2016). The latter implies the way how people perceive time. Another word, it is time as a thinking

category, conditioned by the properties of human's cognition, and thus existing within the mental realm only (Piatigorsky, 2007; Siderits, 2016). Thus, time as a dharma does not have any intrinsic properties. In turn, cosmic time, that is the universal time which exists outside of the mental realm is cyclical in Buddhist philosophy (Siderits, 2016). The cyclical understanding of time is partially attributed to the Buddhist idea of karma: all being originates, exists and then ceases to exist to reappear again. In this way, the idea of cyclical time contains an ethical notion since it is the polarity of karma which is caused by one's deeds and intentions which determines the quality of the individual's life in the next cycle of rebirth (Siderits, 2016). The second rationale for the cyclical understanding of time in Buddhist philosophy is related to the axiom of dependent origination and rejection of the possibility of any absolute being (Piatigorsky, 2007). The dependent origination axiom contains an unresolved dilemma relatively to what I call as "the primary cause". That is, if all originate in dependence on something and there exists no independent transcendental being or god, then how did the initial impulse for the existence of being or the universe emerge? If it emerged by itself out of nothing, then the dependent origination axiom should be rejected. This dilemma is resolved in Buddhist philosophy by the introduction of the idea of infinity of the universe which suggests that it has always existed (Piatigorsky, 2007). In fact, the present universe is viewed as just one of the many universes which have existed - universes also cyclically appear, disappear and reappear (Prebish & Keown, 2010). Thereby, cyclical time in Buddhist philosophy is a form of existence of everything while cosmic time is viewed as infinite and having no starting or ending points (Piatigorsky, 2007; Siderits, 2016).

While no specification about the understanding of time was found in the reviewed canonical SD literature, we can confidently assume that SD implies physical (cosmic) time because the mathematics behind integration, differentiation and hence simulation imply such (Olaya, 2009). Generally, Perelman (1980) suggests that the concept of time remains under-elaborated and is rather taken for granted by system dynamicists. Specifically, he suggests that in SD it is a somewhat incompatible mix between the notion of time in Newtonian mechanics and thermodynamics. The major difference between the two is related to the concept of reversibility (Perelman, 1980). Thermodynamics with its Entropy Law suggests that "every transformation of a real system produces a change in the universe which is both qualitative and irrevocable" (Perelman, 1980, p. 77). This statement is consistent with the open system concept adopted in SD which also suggests irreversibility of any system's change because of its active exchange with the environment (Bertalanffy, 1968; Richardson, 2011). At the same time, SD models are programmed using the Newtonian understanding of time (Perelman, 1980). That is, SD models can be run backwards, reversed in the way that one would get the same output behaviour since the structures of these models remain constant during the whole simulation period. From the thermodynamics position, that is wrong as systems change structurally over time and their initial conditions are not determinant of their ultimate states (Perelman, 1980). Nevertheless, both

thermodynamics and Newtonian mechanics time imply a *unidirectional forward-moving progression* (Perelman, 1980). At the same time, in Newtonian mechanics, this progression suggests that systems behaviour is like an evolutionary development while in thermodynamics - a downhill slide towards entropy (Perelman, 1980). In this way, neither of the two contains the notion of cyclical time, a cyclical form of system's existence or an indication of the infinity of the universe. Thereby, *I suggest that the SD interpretation of time is not equivalent to the one of Buddhist philosophy.*

At the same time, time in SD is more elaborated through the concept of a delay. The delay concept is used in SD relatively to several aspects. First, stocks integrate flows not instantaneously, but with a delay (Sterman, 2000). Second, delay is suggested to be a common property of systems which implies the presence of a time delay between the initial cause and the realization of its full effect in a system (Meadows, 2008; Sterman, 2000). In this way, delays can produce complex non-linear systems behaviour (Meadows, 2008; Sterman, 2000). Finally, any information perception happens with a delay (Forrester, 1968). In turn, the only mentioning of such notion of a delay in Buddhist philosophy found during this study is related to the concept of karma. The accumulated karmic potential realizes itself with a delay (Piatigorsky, 2007). As metaphorically described by Piatigorsky (2007), karma needs to "ripe" before it will produce its full consequences on the individual's life. Thus, except for this arguably insignificant reference, *the SD concept of a delay is not represented in Buddhist philosophy*.

In this way, *I have demonstrated that while the SD concept of time is represented and plays an important role in Buddhist philosophy, its interpretation is different from the one of SD*. However, the concept of time in SD is significantly under-elaborated which puts under question the feasibility of its comparison. Lastly, *I suggest that the SD concept of a delay is also not represented in Buddhist philosophy*.

5.9. Systems and Buddhist Ethics

This section discusses how the premises of systems ethics are represented and interpreted in Buddhist ethics and proposes how the latter can contribute to the further development of systems ethics.

5.9.1. The "Interrelatedness Ethics"

Macy (1979) argues that Buddhist ethics are grounded in the dependent origination axiom. In this way, she suggests that a large part of Buddhist ethical premises is revolving around the notions of interrelatedness and interdependence. Thus, *SD and Buddhist philosophy in its later development in which dependent origination obtained the ontological interpretation and to which Macy (1979) is referring contain the same foundation of ethics - the systemic notion of interrelatedness*. Basically, the "interrelatedness ethics" in both SD and Buddhist philosophy imply that since everything exists in interdependence, happiness and well-being of every single person is interrelated with such of the other

people and the whole environment they live in (Macy, 1991; Meadows, 2008). In this way, "the interrelatedness ethics" provide the rationale of why one should act not only out of selfish egoistic interests but strive for "the good of the whole" (Meadows, 2008). In turn, the latter signifies the need for *holism* and *inclusivity* since to understand what is good for the whole, it's necessary to consider and know the different opinions existing in that whole (Macy, 1991; Meadows, 2008). In this way, similarly to SD, Buddhist philosophy also emphasizes the importance of openness and attention to different perspectives, worldviews and values (Prebish & Keown, 2010). Rejecting the possibility of absolute knowledge, Buddhist ethics contain literally the same teachings as the "systems wisdoms" suggested by Meadows (2008), specifically: acceptance of limitations of one's knowledge and impossibility of knowing the ultimate truth, embracement of complexity as well as mental flexibility and non-attachment to paradigms and personal beliefs (Macy, 1991). Moreover, the modern socially engaged Buddhism strain argues for the need of the *participatory approach to problem-solving* which is also characteristic for SD (Prebish & Keown, 2010). Additionally, it advocates for the active involvement into political and social lives suggesting that no individual can exist unaffected or independent from such (Khisty, 2006). The similar position can be found in relation to systems ethics in Khisty (2006), Macy (1991) and Meadows (2008). Socially engaged Buddhism also introduced the concept of "*interbeing*" to represent the idea that there is no such "thing" as an independent being and suggest that every being is rather an interbeing (Khisty, 2006; Prebish & Keown, 2010). The concept is used to emphasize the equality of people as well as the need for care and altruism towards all living beings and the natural environment. In this way, the Buddhist interbeing concept also represents the notion of the interrelatedness-based systems ethics. Thus, *I conclude that the interrelatedness ethics is characteristic and represented in both systems and Buddhist ethics*.

5.9.2. Decentralization of Self

Next, what I find as an important ethical premise derived from the system's idea is the *decentralization of the understanding of the individual self* ("I"). The systems view implies a non-dualistic position relatively to the notion of "I" as an individual experience of selfness, and "the rest" as everything that is experienced outside of that selfness (Macy, 1991). It suggests that the two exist in mutual dependence and any selfness cannot be identified independently of what is in fact experienced as being outside of it ("the rest"). As I previously suggested, such position advocates against egocentrism and in favour of *non-self-centeredness*. The same idea of the decentralization of self is present in Buddhist philosophy. Such is represented by the already discussed principle of no-self (Prebish & Keown, 2010). Moreover, a significant part of Buddhist ethics and practice is related to not only the development of the non-egocentric stance but also the "right" attitude towards one's experience of self (Macy, 1991; Piatigorsky, 2013). That is, to realize its conditioned and empty nature. Thus, *I suggest that systems*

and Buddhist ethics contain the same position relative to the notion of the individual self and both advocate for the personal development of non-self-centeredness. In this way, the Buddhist teaching about self appears as a natural and compatible elaboration of the systems ethics stance about self and non-self-centeredness, and thus can be integrated into it. This suggestion is supported by Senge et al. (2008) who attempted to incorporate the Buddhist notions of no-self and emptiness into systems thinking.

5.9.3. Personal Responsibility

The SD endogenous explanation contains an ethical notion of *personal responsibility* by suggesting that all sources of problems should be sought within instead of blaming some external agency (Meadows, 2008). Buddhist ethics contain the same notion of personal responsibility suggesting that people cause their own suffering due to the way how they think and live and not because of any external life circumstances (Piatigorsky, 2007; Prebish & Keown, 2010). Additionally, the idea of karma as the consequence of one's intentions and actions which determines the future condition of one's living is a direct suggestion for the embracement of personal responsibility for one's living (Prebish & Keown, 2010). Thus, *the notion of embracement of personal responsibility for one's living and actions is present in both systems and Buddhist ethics*.

5.9.4. Non-Dualism and Systems Ethics

Another important group of Buddhist ethical premises is related to its middle way axiom (Piatigorsky, 2007). As already discussed, such suggest that one should avoid extremes in one's thinking and way of living, and instead develop the habit of *non-evaluative and non-dualistic thinking*. That also includes being disciplined in maintaining self-awareness and development of the habit of self-reflection (Prebish & Keown, 2010). As I have demonstrated, non-dualism is also characteristic of SD. However, no reference to non-dualism in relation to system ethics was found during this study. In this way, *I suggest that the Buddhist notion of non-dualistic thinking should be integrated into systems ethics*. As it was shown previously, the dualistic tendency introduces bias in one's thinking and hinders holistic understanding of reality which systems ethics advocate for.

5.9.5. Motivation as Criterion for Evaluation of Human Affairs

Finally, I will consider the concept of *motivation* as such plays an important role in what is understood as good or bad in Buddhist ethics. Buddhist ethics suggest that the value or property of any deed is constituted not by the deed itself, but rather by the intention and the quality of the thought standing behind it (Piatigorsky, 2007; Prebish & Keown, 2010). In this way, the seemingly same deed can have different evaluative quality for Buddhist ethics if the intentions behind it were different. The focus on motivation in Buddhist ethics is substantiated in the following way: 1) deeds do not exist without a

doer and thus do not have any independent intrinsic properties; 2) thought always precedes action and thus determines it (Piatigorsky, 2007; Prebish & Keown, 2010). Thereby, Buddhist ethics suggest that no deed bears any meaning in itself and thus cannot be evaluated separately from the doer and his intentions. At the same time, that does not mean that the deed itself has no importance. Rather, such is manifested in the fact of its occurrence or non-occurrence (Piatigorsky, 2007). That is, there might be bad intentions, but if such are not implemented into action, their "badness" will remain only in potency and will not actualize (Piatigorsky, 2007).

Next, we need to consider which intentions are viewed as good and bad in Buddhist ethics. First, any intentions and therefore actions which lead to the suffering of sentient beings are bad (Prebish & Keown, 2010). Second, violation of the five basic moral precepts (killing, stealing, lying, abusing intoxicants and twaddling) is also bad (Prebish & Keown, 2010). Third, thinking and acting out of three impurities (greed, hatred and delusion) is bad in the sense that such blur the mind and get one further entrapped in Samsara (Piatigorsky, 2007). However, except for the aforementioned objectively bad deeds (i.e. the intentions which stand behind them), the evaluative quality of other kinds of deeds in Buddhist ethics is considered to be context-dependent and not absolute (Shen & Midgley, 2007). In relation to this, Piatigorsky (2007) suggests that people rarely make decisions while not knowing their intentions. In most cases, a person knows one's motives or at least can find them out if tries. Therefore, Buddhist ethics suggest that individuals should constantly stay self-reflective about their motives before committing any deeds (Piatigorsky, 2007).

At the same time, except for the notion of "the good of the whole", systems ethics lack a normative evaluative criterion for assessing which action should be considered as good or bad. In turn, providing the rationale for making such assessments is one of the goals of the field of ethics in general (Siderits, 2016). Thus, *I suggest that the Buddhist motivational dimension described above can be adopted into systems ethics as a criterion for making value-judgments about human affairs based on the commonality of the foundation of Buddhist and systems ethics (the "interrelatedness ethics")*. Additionally, the idealistic philosophical stance of SD implies the primacy of the mental realm which is consistent with the Buddhist position which suggests that mental processes always precede actions and thus pre-determine their (intended) properties (Olaya, 2009; Prebish & Keown, 2010). That indicates another rationale for the compatibility of the Buddhist motivational dimension and systems ethics.

5.10. Unrepresented Concepts

The final section of this chapter will describe the SD concepts which were found to be unrepresented in Buddhist philosophy. First, while the "ontological dependent origination" implies the concept of a system, Buddhist philosophy never studied systems in the same sense as it is done in SD. Thus, no

indication about the notion of a *system's purpose* or *function* as well as any concepts of the *"systems properties" category* was found. In this way, it should not be surprising that such concepts as *"modes (patterns) of behaviour"*, *"systems archetypes"* and *"loop dominance"* are also not represented in Buddhist philosophy. Similarly, as I have demonstrated, the idea of the *endogenous view and explanation* of systems behaviour in terms of the *closed feedback structure* is also unrepresented in Buddhist philosophy. Similarly, no analogues for the *stock*, *flow* and *integration* concepts were discovered. Finally, Buddhist philosophy does not contain a theory consonant with the SD *theory of decision-making and goal-oriented behaviour* based on the findings of this study.

6. Conclusion and Discussion

The following chapter summarises *the key findings* of this study and discusses its *knowledge contribution*. Additionally, the chapter presents the analysis of the limitations of this study and provides recommendations for future research.

6.1. Key Findings and Contributions

6.1.1. Reflection on the Foundations of System Dynamics

This study has made a thorough analysis of the canonical SD literature as well as other major publications existing in the field. In the result of this work, the main concepts which underlie the dynamic systems paradigm, that is the philosophical foundations of SD as a theory and a method were identified, defined in *The Main Concepts of System Dynamics*, and substantiated in *Appendix B*. Thereby, *this study reflects on and discusses the meaning of arguably every core concept and paradigmatic assumption of SD while adopting a broad perspective*. Even solely this is a contribution of the present study to the domain of SD since the literature search made during this research showed that there exist only a few publications which broadly reflect on the philosophical foundation of SD, while not focusing on one of its specific aspects.

6.1.2. "Systems Domains and Buddhism" Literature Review

This study has reviewed and summarized all academic publications on the topic of the comparison of systems domains and Buddhism which were discovered during the literature search. The summaries of the reviewed publications which include an indication of the specific systems domain and tradition of Buddhism as well as their concepts being compared are presented in *Appendix A*. This is another contribution of this study since none of the reviewed publications contains the same "all-inclusive" overview of the existing findings on the "systems domains and Buddhism" topic. Rather, such are discussed fragmentarily in the existing literature.

6.1.3. Conceptual Similarities between System Dynamics and Buddhist Philosophy

This section concludes the central findings of this research relative to its objective of exploring how the main concepts of SD are represented and interpreted in Buddhist philosophy by presenting *the main discovered conceptual similarities* between the two domains.

- **Causality**. Buddhist philosophy and SD hold the same stance relative to the concept of *causality*. In both domains, causality is viewed as an ontological mechanism standing behind the origination or change of all phenomena and is therefore used as the most basic modus of explanation of how everything comes to be.

- **Systems view of reality**. The Buddhist dependent origination axiom in its ontological interpretation contains the notions of the SD concepts of a system and feedback. The axiom suggests that causality is intrinsically mutual and pluralistic and implies a holistic and systemic view of reality as a network of interconnected elements standing in interaction. Moreover, by holding the feedback view on causality, dependent origination suggests that all phenomena should be understood as dynamic processes rather than as individual substances which implies process thinking. In this way, nothing for Buddhist philosophy has substantial boundaries or individual essentiality. Thus, Buddhist philosophy conforms to the SD notion of the "absence of real boundaries". Altogether, *this shows that later Buddhist philosophy in which the dependent origination axiom obtained the ontological interpretation and SD share the system's idea as an ontological view of reality*.

- **Epistemological similarities**. *Buddhist philosophy shares the idealistic epistemological position of SD and acknowledges the conditioned (subject-dependent) nature of knowledge*. In this way, both domains suggest that all knowledge is relative and reject the notion of absolutism while accepting the possibility of relative knowledge validation. Moreover, Buddhist philosophy implicitly contains the concept of a mental model and similarly to SD acknowledges that mental models are the only possible "sources" of knowledge.

- **"Soteriological narrative"**. I have demonstrated that SD contains a soteriological notion in its narrative about the "*characteristics of normal human thinking*" and the "*need for a new way of thinking*". Moreover, *the similar narrative is present in Buddhist philosophy* which also suggests that it's the way how people "normally" tend to think which creates the discontent state they end up in and proposes an alternative way of thinking aimed at putting an end to that state – the middle way.

- **Non-dualism**. This study has shown that *non-dualistic thinking is characteristic for both SD and Buddhist philosophy.*

- **The "interrelatedness ethics"**. *Buddhist ethics in their later development and systems ethics are based on the same core premise – the (systemic) idea of "the interrelatedness of everything"*. In this way, both domains promote holism, inclusivity and the participatory approach to problem-solving. Additionally, systems and Buddhist ethics share the same stance relative to the idea of the individual self ("I") and both advocate for the personal development of non-self-centeredness and altruism. Furthermore, Buddhist ethics contain the systems ethics' notion of the embracement of personal responsibility in its views on suffering and karma.

Some of the connection points discussed above were derived from the existing findings. However, this study also presents novel insights. Specifically, the identified similarities in the epistemological stance and "soteriological narratives" of SD and Buddhist philosophy have not been yet described in the

literature. Thereby, *in addition to "translating" the existing findings to the field of SD, this study generally broadens the understanding of the relationship between systems domains and Buddhism* as the two aforesaid connection points are also characteristic and can be attributed to the broader domain of GST (Bertalanffy, 1968).

6.1.4. Discussion of the Main Insights

Next, I will summarise and discuss *the main insights* gained during this study about how the consonant Buddhist ideas can be incorporated into SD to further develop its philosophical foundations.

- **"The system assumption"**. According to Wilson (1998), consilience or similarity between the premises of different scientific domains can support the validity of their theoretical presuppositions. In this way, by holding the system's idea as an ontological view of reality, *Buddhist philosophy partially supports the primary assumption of SD that real phenomena can be studied as systems and have systemic properties*. Partially, since what is supported are the ideas of interrelatedness and mutual causality as the process through which everything emerges and changes. At the same time, no indication was found about the presence of the systems purpose concept in Buddhist philosophy, and the endogenous explanation – the key distinctive feature of SD.

- **Dependent origination as a pedagogical tool for teaching SD.** The "ontological dependent origination" provides an interesting view of the system and feedback concepts as well as the systems thinking perspective in general. Furthermore, dependent origination as a mind theory suggests the similar with SD idealistic philosophical stance on knowledge, implies the mental model concept and describes how mental models are constructed. Therefore, *I suggest that the Buddhist dependent origination axiom can be included in SD as an alternative way of presenting the system and mental model concepts*. The proposition is in line with Macy (1976) who suggests that Buddhism and systems theory can be used for mutual interpretation and elaboration. Moreover, based on the suggestion of Churchman (1979), Stinson (2018) and Macy (1991) as well as the findings of the present research, Buddhist philosophy can be mentioned in SD literature as one of the potential precedents of the systems paradigm. Additionally, I suggest that the two characteristics of reality derived from dependent origination - no-self and impermanence - can become useful pedagogical tools for teaching SD. First, no-self illustrates the conditioned nature of all knowledge and can help to explain the idealistic epistemological stance of SD and the idea of relativity of knowledge. Second, both no-self and impermanence illustrate why one should avoid clinging towards one's mental models and thus can help to develop such attitude in SD students.

- **The issue with definitions**. Buddhist philosophy rejects the possibility of a priori, absolute thinking categories by suggesting that any category in which humans can think is conditioned and

"enabled" by the properties of their cognition and thus cannot be considered as a statement about reality. As discussed, Idealism holds the same proposition and in this way, Buddhist philosophy supports its stance. Therefore, the main thinking categories, that is in terms of what the studied phenomena are represented in SD - "system", "systems structure", "feedback", "causality", and "stock and flow" - should be treated in SD strictly as metaphors, abstractions and epistemological tools, and by no means as claims about reality. Given the existing ambiguity in the usage of the system concept and its derivatives in SD literature discussed in *Introduction*, I suggest that the formal definitions of these concepts need to be reconceptualised by emphasizing their metaphorical and strictly epistemological notion. Finally, based on my experience of studying SD, I suggest that training of every system dynamist should include a compulsory reflection on the discussed concepts. Equally importantly, the metaphorical notion of these concepts needs to be always explained to the clients and problem-owners involved in the modelling process so that they wouldn't start searching for some real systems and their structures.

- **Dual focus of the SD inquiry**. Buddhist philosophy suggests that the focus of SD inquiry (as any other scientific inquiry) should be dual. Specifically, *the understanding of how a certain problem is investigated should be equally important for any researcher as the understanding of that problem itself since the former conditions the ultimate problem understanding*. I have also demonstrated that the idealistic position of SD conforms to this premise. This implies that SD modellers should be continuously reflecting on their thinking, and the process of problem-investigation to understand how they have come to the specific problem-understanding and model structure, and avoid falling into the path-dependent self-fulfilling prophecies. To incorporate this reflection process, I suggest to formally include it as an additional object of investigation into the SD practice.

- **Suspension approach to mental models**. Buddhist philosophy suggests an alternative approach to working with mental models – the suspension approach. The main goal of the suspension approach is *to mitigate the investigator's projection of oneself and existing knowledge on the object of inquiry, create an open-minded attitude towards problem-solving and enable the on-the-spot creative process in which the insights are generated based on the happenings in the present moment, and not only on the prior knowledge and thinking patterns*. Arguably, "suspension" can assist in solving the creative dilemma of the enhancement approach to mental models used in SD, that is when mental models of the problem-owners and their synthesis cannot provide any novel insights or when problem-owners cannot step outside of their thinking boundaries. Otherwise, as argued by Varela (1983), everything will remain only memory, meaning that understanding of any new phenomena will be just projections of the existing knowledge. Hence, *I suggest that the idea of mental models' suspension should be incorporated into the SD modelling practice*.

- **Dualistic tendency of thinking**. I suggest that the Buddhist idea about the dualistic tendency of human's thinking should be incorporated into the SD understanding of the "characteristics of normal human thinking". The dualistic tendency induces a biased approach to problem-understanding and can be a hindrance to the holistic understanding of reality which SD advocates for. Moreover, as I have demonstrated, *non-dualistic thinking is consonant with systems thinking and thus can become its complementary component*.

- **Non-evaluative thinking**. In addition to the point above, *I suggest that SD modellers should incorporate the Buddhist idea of the non-evaluative and non-judgemental thinking into their practice* as a countermeasure to the aforementioned dualistic tendency. Moreover, the discussed basic propositions of the Buddhist right Morality practice can be included in the training of SD modellers to develop their skills in such thinking.

- **Contributions to systems ethics**. This study has revealed that except for the abstract notion of "the good of the whole", systems ethics lack a normative criterion for making value judgements about decisions, occurrences, deeds and human affairs in general. In this way, *I have suggested adopting the Buddhist notion of motivation as such criterion into systems ethics based on the commonality of the foundations of the two domains*.

6.2. Limitations and Recommendations for Future Research

Due to its exploratory objective, the present study has a broad scope. It outlines and discusses a wide range of conceptual similarities between Buddhist philosophy and SD, and thus may lack the depth of analysis. I suggest that future research work on the present topic should adopt a more targeted and in-depth approach, and separately investigate the connection points presented in this study. At the same time, I do not recommend to further investigate the direction related to the "ontological dependent origination" since such has already been substantially discussed in the literature (see: Khisty, 2006; MacKee, 2008; Macy 1991; Massoudi, 2006; Shen & Midgley, 2007; Stinson, 2018). Additionally, it appears to me that except for certain ethical notions derived from the "ontological dependent origination" and an obviously peculiar fact that Buddhism contains the foundation of the modern scientific systems paradigm and thereby partially supports its validity, this is a "dead-end" discussion which gets stuck in constant exclamations about "the interconnectedness of everything" and "the greatness/importance of the holistic view". I suggest that dependent origination as a mind and psychic theory, as well as the Buddhist reflective practices, are more fruitful areas for further research as such can offer valuable epistemological and even methodological insights for SD and science in general. Another promising direction for future research is related to the further development of systems ethics. This study has demonstrated that Buddhist and systems ethics have considerable common grounds and thus Buddhist ethics can help to develop the yet under-elaborated domain of systems ethics.

Next, the suggestions about the integration of the consonant Buddhist premises into SD made in this study need to be developed and empirically tested as such work was outside of the present research scope. The formal method of the suggested "dual focus of the SD inquiry", that is the practice of modeller's self-reflection on one's thinking during the process of problem-investigation and modelling needs to be designed. Additionally, while Senge et al. (2008) and Varela et al. (2016) outline the suspension approach to working with mental models, they do not describe the concrete method of how it can be incorporated into the setting of the SD model-building process. Hence, further development of the suspension method is the recommendation for future research. Furthermore, more research is necessary about the integration of the practices of non-evaluative and non-judgmental thinking into SD as well as their testing "in the fields".

As a final note, I would like to remind that Buddhist philosophy is the domain of enormous complexity. In this way, comparing Buddhist philosophy with SD, or any other domain is a challenging task full of ambiguities and non-definite answers. Besides, it appears that some of the issues which were discussed here may not be definitively solvable at all. Thus, I acknowledge that the conclusions made in this study could not escape from the effect of individual interpretations (i.e. mine) and my own subjectivity. Nevertheless, what is hard in life is often also very interesting and rewarding. Thus, I would like to encourage anyone passionate about systems sciences and Buddhism to not be afraid to experiment and to investigate anything that appears of interest or a slight hint of a connection between the two domains, even if the final outcome of such investigation is completely unclear in the beginning. Experiments and new ideas drive science forward.

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Appendix A

Appendix A contains the following information: 1) description of the process of search and selection of publications used in this study in addition to the four main selected textbooks to elaborate on some of the identified main concepts of SD; 2) detailed description of the conducted search and selection process of the literature on comparison of ideas of various systems domains and Buddhism; 3) summaries of the content of each of the selected publications on comparison of the ideas of systems domains and Buddhism.

Additional Literature on the Topic of the Main Concepts of SD

First, Richardson (2011), Sterman (2018) and Vennix (2001) were selected based on my familiarity with these publications. The publications were part of the EMSD program. Next, Olaya (2009) was found via the Google Scholar database using the "system dynamics philosophy" keyword. On the date of the search - February 25, 2019 - the article was unique among the reviewed first 200 search results (from the total of 4050000) since it discussed philosophical stances of SD broadly, not focusing on one of its specific aspects. Other displayed publications had a more targeted approach, for example the most cited search result - Barlas (1996), which focused mainly on the philosophy of simulation and model validation, and not the "philosophy of SD" in the general sense. Lastly, the article of Pruyt & Kwakkel (2007) was selected in the following way. The Google Scholar search for articles with "system dynamics, ethics" keywords in title made on March 9, 2019 gave 7 results, out of which Pruyt & Kwakkel (2007) was the most cited one and appeared credible given the prominence of Eric Pruyt in the field of SD.

Existing Comparisons of Systems Domains and Buddhism

Two online databases were used for the search of the existing comparisons of systems domains and Buddhism: first, *Google Scholar*, and second - *Researchgate*. The primary search was made on *March 7, 2019*. The following keywords were used in the search: "*Buddhism systems theory*", "*Buddhism system dynamics*", "*Buddhism systems thinking*" and "*Buddhism systems philosophy*". The search results as well as the selected articles for each keyword are described below. Since literature on the topic is relatively limited and thus there was no possibility to choose between publications, the following selection criteria were used: 1) the keyword should be present in the article; 2) the abstract/description should indicate that the topic of the publication is

comparison, synthesis or relating in some sense of the ideas of one of the systems domains in general (GST, systems thinking, Cybernetics, SD or Systems Philosophy) or a specific system's concept with Buddhism, Buddhist philosophy or the concepts of the latter. The sequence of the keywords' usage during the search was consistent with the way they are presented in *Table 1* below (from top to bottom). Some articles appeared with several keywords' searches. Hence, only unique selections are represented per each keyword.

Table 1. Details of Literature Search on Topic of Systems Domains and Buddhism Comparison

Keyword	Google Scholar	Researchgate	Selected articles
"Buddhism systems theory"	**Search results:** 220,000 **Previewed**: 200 top search results **Date of search**: 07.03.2019	**Search results:** unknown **Previewed**: 100 top search results **Date of search**: 07.03.2019	1) Fenner (1995) *Reasoning into reality: A system-cybernetics model and therapeutic interpretation of Buddhist middle path analysis*. Found via Google Scholar 2) Ishii (1998). Developing a Buddhist En-Based Systems Paradigm for the Study of Japanese Human Relationships. Found via Google Scholar 3) MacKee (2008). Sustaining Cultural Heritage in South And Southeast Asia: integrating Buddhist philosophy systems theory and resilience thinking to support sustainable conservation approaches. Found via Google Scholar 4) Macy (1978). Interdependence: Mutual Causality In Early Buddhist Teachings And General Systems Theory. Found via Google Scholar 5) Macy (1991). *Mutual Causality in Buddhism and General Systems Theory: The Dharma of Natural Systems.* Found via Google Scholar 6) Massoudi (2006). A system theory approach to interfaith dialogue. Found via Google Scholar 7) Shen & Midgley (2007). Toward a Buddhist Systems Methodology 1: Comparisons between Buddhism and Systems Theory. Found via Google Scholar 8) Stinson (2018). Did the Buddha Define a Natural System Theory? Insights from Bowen's Natural System Theory of the Family. Found via Researchgate

"Buddhism system dynamics"	**Search results:** 123,000 **Previewed**: 200 top search results **Date of search**: 07.03.2019	**Search results:** unknown **Previewed**: 100 top search results **Date of search**: 07.03.2019	1) Kim (2010). Understanding System Dynamics with Eastern Philosophy. Found via Researchgate
"Buddhism systems thinking"	**Search results:** 170,000 **Previewed**: 200 top search results **Date of search**: 07.03.2019	**Search results:** unknown **Previewed**: 100 top search results **Date of search**: 07.03.2019	1) Bajracharya (2010). Systems Thinking, Dependent Co-Arising and Mental Model in Decision Making. Found via Researchgate 2) Khisty (2006). Meditations on Systems Thinking, Spiritual Systems, and Deep Ecology. Found via Google Scholar
"Buddhism systems philosophy"	**Search results:** 230,000 **Previewed**: 200 top search results **Date of search**: 07.03.2019	**Search results:** unknown **Previewed**: 100 top search results **Date of search**: 07.03.2019	1) Macy (1976). Systems Philosophy as a Hermeneutic for Buddhist Teachings. Found via Google Scholar

Additionally, Varela et al. (2016) was included into the review since the publication was mentioned by Shen & Midgley (2007) as one of the major publications on the topic. Lastly, Senge et al. (2008) was included into the review based on the reference of a colleague from the EMSD program who argued that what the book describes is the blend between the ideas of systems thinking, Buddhism and oriental philosophy.

Summaries of the Reviewed Publications on the Topic of Comparison of Systems Domains and Buddhism

Table 2 presented provides a short description of each selected publication about the comparison of systems domains ideas and the ones of Buddhism. The major and arguably most distinctive publications are highlighted with bold font and underlined.

Table 2. Summaries of Reviewed Publications on Topic of Comparison of Systems Domains and Buddhism

Publication	Description
Bajracharya (2010) Systems Thinking, Dependent Co-Arising and Mental Model in Decision Making	**Domains/Concepts**: Mental model in *systems thinking* and *Buddhism* (generally, a specific school not specified). **Description**: Bajracharya (2010) explores the relationship between the concept of a mental model in systems thinking and Buddhism. Systems thinking argues that human's decisions are based on mental models and the goal of systems thinking is to improve the mental models of decision-makers. By doing so, systems thinking emphasizes the primacy and focuses on mental realm. Similarly, Buddhism holds the "*Mind precedes all* [position], which is one of the central pieces of the teaching of Buddha – meaning the mental action precedes all the verbal and physical ones, and the mental action is solely responsible for the stock of mental volition and the state of one's being" – would definitely support the given emphasis on the mental model in systems thinking approach." (p.5). The author concludes that since all decisions are based on mental models and processes, improving one's reflective capabilities and awareness about them will be beneficial for decision-making.

Fenner (1995) Reasoning into reality: A system-cybernetics model and therapeutic interpretation of Buddhist middle path analysis	**Domains/Concepts**: Negative feedback concept in *Cybernetics* and the middle way path in *Madhaymika Buddhism*. **Description**: Fenner (1995) makes a parallel between the idea of a middle path in Buddhism and the concept of negative feedback loop in Cybernetics. According to the author, the middle path idea implies constant comparing one's state of mind, actions, moral stances and meditation with the ideal "golden middle" and adjustment oneself towards it based on the observed discrepancy. Similarly, the Cybernetics negative feedback concept, characteristic for any goal-directed process, also implies correcting one's state towards the desired state, based on its discrepancy with the actual state.
Ishii (1998) Developing a Buddhist En-Based Systems Paradigm for the Study of Japanese Human Relationships	**Domains/Concepts**: View on self ("I") and human relations in GST and Japanese Buddhism. **Description**: ISHII Satoshi (1998) discusses human relations and the concept of self in Japanese society as well as the scientific approach for studying them. He argues that Japanese worldview and consequently human relations are largely based on idea of "En" – Japanese adoption of the Buddhist idea of Dependent Origination with an arguably more fatalistic, life-deterministic notion. Based on Satoshi, En can be interpreted is a global context, as concatenation of all circumstances stemming from dynamics of the interrelatedness of everything which like fate, determine human's life and place in society. In this way, Japanese perception of self is not like of an independent "I", but as an intrinsic part of a greater whole. For Satoshi, this constitutes a holistic view on human relations and self. Because of that reason, Japanese human relations' studies should be made adopting the holistic perspective, rather than the more commonly used Western analytical and individualistic approaches which "value the division of wholes into components and the analysis of characteristics of each component" (p.116). Satoshi then argues that the General Systems Theory approach to human relations provides such a holistic perspective and fits into the Japanese En-based worldview.

Khisty (2006) Meditations on Systems Thinking, Spiritual Systems, and Deep Ecology	**Domains/Concepts**: Integration of spirituality and ethics from Buddhism (specific school not specified) into systems thinking and deep ecology. **Description**: Khisty (2006) relates the ideas from systems thinking, deep ecology and Buddhism, arguing that there is consonance between the three domains. He departs from the premise that Western science as well as society in general has been neglecting spirituality, aesthetic values and basically everything non-objective, irrational, non-measurable and intuitive. Khisty views this lack of guiding ethical principles in science and life as well as the associated egoism and self-centeredness as a cause of modern ecological problems. Systems thinking embraces the interconnectedness of everything and hence rejects the possibility of individual independent self. However, while making the first step towards spirituality, systems thinking still lacks certain ethical basis. Buddhism can provide systems thinking practitioners with the dimension of spirituality and the necessary ethical considerations which are often omitted by the latter.
Kim (2010) Understanding System Dynamics with Eastern Philosophy	**Domains/Concepts**: Feedback loop in SD and "Yin-Yang" in Eastern Philosophies. **Description**: Kim (2010) reflects on his experience in teaching System Dynamics in Korea and argues that the similarity between the ideas of SD and Eastern philosophies can provide a way to simplify teaching of SD to Korean students. Specifically, he relates the Taijitu idea (commonly known as "Yin-Yang") with the feedback loop concept in System Dynamics.
MacKee (2008) Sustaining Cultural Heritage in South And Southeast Asia: integrating Buddhist philosophy systems theory and resilience thinking to support sustainable conservation approaches	**Domains/Concepts**: Holistic view in GST and Buddhism (specific school not specified). **Description**: Mackee (2008) "explores the interconnections between Buddhism, resilience thinking and systems theory in the context of developing a sustainable approach for the conservation of non-secular built heritage in the South and Southeast Asian region" (p.845). He argues that both Buddhism and GST are based on a holistic worldview and summarises their three main common ideas: interconnectedness, interdependence, mutual conditioning.

Macy (1976) Systems Philosophy as a Hermeneutic for Buddhist Teachings	**Domains/Concepts**: GST, Systems Philosophy and Buddhism (specific school not specified). **Description**: Macy (1976) suggests that the similarity between the ideas of Systems Philosophy and Buddhism can be used for mutual interpretation and elaboration. "…Buddhism could endow systems' insights into cybernetic process with religious meaning-helping us see, in systemic patterns, causes for both man's suffering and his liberation, and offering methods for utilizing these insights in religious techniques. At the same time, systems philosophy could (a) provide a schema for interpreting the principles of causal process perceived in Buddhist thought and at work in Buddhist practice; and (b) both broaden this vision and integrate it with the sciences by revealing the operation of these principles throughout the observable universe." (p.21).
Macy (1978) Interdependence: Mutual Causality in Early Buddhist Teachings And General Systems Theory	**Domains/Concepts**: Mutual causality in GST and Dependent Origination in early Buddhism. **Description**: This is the PhD dissertation which lay the foundation for the further main publication – Macy (1991) .
Macy (1991) **Mutual Causality in Buddhism and General Systems Theory: The Dharma of Natural Systems**	**Domains/Concepts**: Mutual causality in GST and the Dependent Origination principle in Buddhism (multiple traditions considered). **Description**: The most well-known, comprehensive and cited publication on topic up-to-date. The main argument of the book is that GST and Buddhism with its Dependent Origination principle (Patticca Samupadana) both have a holistic, systemic worldview, as opposed to reductionist's linear worldview, "see" interconnectedness and wholes rather than parts, and consider causality as mutual, reciprocal, with feedback loops rather than unidirectional and linear. Macy provides an in-depth analysis of the implications of the common idea of mutual causality and the concepts revolving around it within both domains. This work is

	also unique because it contains a significant amount of references to the original early Buddhist texts to justify the argumentations.
Massoudi (2006) A system theory approach to interfaith dialogue	**Domains/Concepts**: Dependent Origination in Hua Yen Buddhism and the open system concept in GST. **Description**: Massoudi (2006) uses the ideas of systems theory to analyse the process of an interfaith dialogue. Massoudi views dialogue as a system, a whole which emerges from the feedback process of interaction between the dialogue participants. From that stance, a dialogue has a life on its own, is affected by and in turn affects the dialogue participants. In this way, Massoudi suggests that the dialogue itself and its participants can be regarded as "open systems" – a GST concept which stands for a system which exchanges energy and matter with its environment. The author then suggests that the open system concept has an analogous idea in Hua Yen Buddhism - Net of Indra. The "Net of Indra" is a metaphor which is sometimes visualized as a multidimensional web and represents the Dependent Origination principle, and interrelatedness of everything in the universe (Keown, 2004). In this way, Massoudi not only views the Buddhist Dependent Origination as being similar to the systems theory perspective, but rather literally equates the two.
Senge, P. M., Scharner, C. O., Jaworski, J. & Flowers, B. S. (2008) Presence: exploring profound change in people, organizations, and society	**Domains/Concepts**: Systems thinking, Buddhism (specific school not specified) and other Eastern philosophies. **Description**: The book largely builds upon the work of Varela et al. (2016) and makes an important step in re-integration of spiritual practices into Western thinking, and, specifically – systems thinking. Senge et al. (2008) demonstrate with their work that the two are a great "couple" - the holistic perspective of systems thinking already makes a huge leap from the common in the West reductionist thinking, while arguably still lacking guiding (ethical) values as well practices on how to achieve personal transformation which in turn have been existing and well-developed in Buddhism during many centuries. Hence, these practices can be naturally adopted given the common grounds of the two domains. Lastly, it appears interesting that Senge et al. (2008), in line with Bertalanffy (1968), argue that their discussions represent a broader thinking trend.

	That is, not only relating the ideas of Eastern philosophies with systems domains, but also the growing prominence of the systems domains themselves as a basis of certain ethical worldview stances. Another word - as scientific domains which have certain underlying assumptions which make it possible to integrate them with ethical and spirituality-related ideas from, as one possibility, Buddhism, which is arguably a necessity since this aspect of human life has been neglected by science.
Shen & Midgley (2007) **Toward a Buddhist Systems Methodology 1: Comparisons between Buddhism and Systems Theory**	**Domains/Concepts**: broad comparison of ideas from various systems domains and Humanistic Buddhism. **Description**: Shen & Midgley (2007) explore "the similarities between [Humanistic] Buddhist philosophy and various systems perspectives" (p.168) to "spark debate" (p.167) about the topic in the systems sciences community. It's worth mentioning that exploration of similarities was a part of their work, while their ultimate goal was to develop a Buddhist systems methodology (BSM) – adaptation of soft systems methodology (SSM) for application in context of Buddhist's organizations. The authors start with listing three major comparisons made prior to their work – Macy (1991), Fenner (1995) and Varela et al. (2016). Next, they propose original comparison of a few purposefully selected concepts so as "to identify connection points" necessary to integrate ideas from Buddhism with systems perspectives. Shen & Midgley intentionally consider systems perspectives broadly and do not focus on a specific perspective, however the systems thinking background of both authors does seem to set the direction of thought in the paper. Lastly, the authors also emphasize the existence of "major points of difference" (p.176) between the systems domains and Buddhism, for example Buddhist belief in reincarnation.
Stinson (2018) Did the Buddha Define a Natural System Theory? Insights from Bowen's Natural System Theory of the Family	**Domains/Concepts**: Systems theory, family systems theory and Dependent Origination in Buddhism as taught by Goenka S.N. **Description**: Stinson (2018) relates the "family systems theory" developed by Murray Bowen based on the ideas of systems theory with Buddhism as taught by S.N. Goenka. Stinson argues that the Buddhist's "Paticcasamuppada" (Dependent Origination) law has consilience with the ideas of the natural systems and family systems theories. He suggests that the historical Buddha has even to a certain extent "defined"

	(Stinson, 2018, p.5) the natural systems theory with his "Dependent Origination" law. On a general level, this is another publication, in addition to Macy (1991), which takes the "Dependent Origination" pricniple as the basis for similarity between Buddhism and systems domains and further elaborates from that starting point.
Varela, F. J., Rosch, E., & Thompson, E. (2016) **The embodied mind: Cognitive science and human experience**	**Domains/Concepts**: Systems view of mind and cognition; Integration of cognitive science and Madhyamika Buddhism; **Description**: Authors argue that Western philosophical and scientific tradition is largely reductionist and dualistic in terms of the mind and body debate. In turn, they advocate for the systems-based approach to cognitive science, and propose the idea of the "embodied mind" which implies interdependence and inseparability of human's knowledge and the process of cognition itself. Meaning and knowledge are not intrinsic properties of reality, they are actively constructed through the process of living using the available (embodied) cognitive abilities and the cultural symbolic system. What is known cannot be separated from how it is known – the properties of one's cognition determines what one knows or can know. In turn, gained knowledge shapes one's actions and changes the process of cognition. Authors suggest that the similar stance is present in Buddhism where "there is no abstract knower of experience that is separate from the experience itself" (Shen & Midgley, 2007, p. 174). Buddhism has never considered knowledge as something purely analytical, separate from the process of finding out. This is represented by the fact that meditative and mind contemplation practices play the central role in Buddhism. Meditation, as a process of observing one's mind and cognition, helps in understanding of how thinking happens and allows the meditator to experience ideas, which otherwise would have remained empty words. Hence, Varela et al. (2016) advocate that meditative practices from Buddhism should be integrated into science. Interestingly, while making no link with Buddhism, the same direction of reasoning is proposed by Bertalanffy (1968), founder of GST, who argues that the basic categories of thinking, like causality or time, are not a priori categories, but are determined by "biological as well as cultural factors" (Bertalanffy , 1968, p.248). He argues that we think in terms of Newtonian time or Euclidian geometry because it is "convenient", suitable for our living and

	environmental conditions which historically shaped our cognition. These categories of thinking are one possibility to represent reality, but there can be others.

Appendix B

Table 3 presented below contains *the initial list* of the 50 main concepts of SD identified in Forrester (1968), Meadows (2008), Senge (1994) and Sterman (2000). The left part of the table indicates the concept, provides its general description and a list of related concepts based on the aggregation of information from all four authors. The other four sections of the table indicate the following: 1) whether each of the four aforesaid authors mentioned and/or defined these main concepts *(yes/no)*, and 2) if yes, provides a literate quote(s) to prove the original reference to these concepts by every author. In few cases, when authors either implied the concept, or only somewhat described it, but did not mention explicitly, a "yes/no" indication was used. Lastly, the underlined concepts are the ones which were eventually used in the comparison (see *Appendix D*), while the non-underlined ones were removed from the final list.

Table 3. The Main Concepts of System Dynamics

Concepts and description	Sterman (2000)	Meadows (2008)	Forrester (1968)	Senge (1994)
1) Characteristics of "normal" human thinking **DESCRIPTION:** Opposed to systems thinking. Hinders "true" and systemic understanding of the world. Properties and imperfections of human thinking. Limitations of humans thinking, especially in understanding of complex systems. **RELATED CONCEPTS:** Reductionist thinking; Linear thinking; Selective perception; Event-oriented thinking; Bounded rationality; Limited information-processing capacity; Limited sensual experience capacity; Habits, routines; Understanding parts than wholes; Open loop thinking; Exogenous reasoning; Not seeing the larger	**YES** Aggregated from multiple parts of the book. Predominantly, from Chapter 1 and especially: 1.3.4 – 1.3.9. **QUOTE:** "Our cognitive maps of the causal structure of the systems are vastly simplified compared to complexity of systems themselves" (p.27).	**YES** **QUOTES:** "People tend to seek for external causes of behaviour" (p.1). "People tend to focus on events instead of looking at the long-term dynamics of the system" (p.88). "So the world often surprises our linear-thinking minds" (p.91).	**YES** **QUOTES:** "Our mental models are ill-defined" (p.3-2). "Assumptions are not clearly identified in the mental models" (p.3-2). "Mind is not adequate in constructing and understanding models of complex systems. Hence, simulation and computer models should help as long	**YES** **QUOTES:** "…our inability to grasp and manage the increasingly complex systems of our world" (p.14). "When people in organizations focus only on their position, they have little sense of responsibility for the results produced when all positions interact." (p.18).

whole, or feeling as part of the larger whole - "I am my position" (Meadows, 2008, p. 107).		"The bounded rationality of each actor in a system may not lead to decisions that further the welfare of the system as a whole" (p.110). Additionally, see Chapter 4: "Why systems surprise us?".	as the brain cannot construct and "simulate" models of complex systems" (p.3-2 - 3-3).	
2) Feedback, feedback loop **DESCRIPTION:** Everything happens through feedback, all processes fall within feedback loop structure (Sterman, 2000). Basic operating unit of a system (Meadows, 2008). Forrester (1968) argues that the concepts of feedback will structure the scattered knowledge in social sciences. Hence, SD and systems' domains can provide the structure to sciences. Reality is built of circular, not linear causality (Senge, 1994). **RELATED CONCEPTS:** Reinforcing, balancing feedback; Circular causality; Growth; Goal-seeking, self-correcting; Information feedback; Interaction.	**YES** Dedicated section in Chapter 1: 1.1.3 Feedback. **QUOTES:** "All dynamics arise from interaction of just two types of feedback loops…" (p.12). "Feedback is one of the core concepts of System Dynamics" (p. 137).	**YES** **QUOTES:** "…system thinkers see the world as a collection of "feedback processes" (p.25). "A feedback loop is a closed chain of causal connections from a stock, through a set of decisions or rules or physical laws or actions that are dependent on the level of the stock, and back again through a flow to change the stock" (p.27).	**YES** **QUOTES:** "A feedback system, which is sometimes called a "closed" system, is influenced by its own past behaviour" (p.1-5). "A feedback loop is a closed path connecting in sequence a decision that controls action, the level of the system, information about the level of the system, the latter returning to the decision-making point" (p.1-7). "A feedback loop as the basic element from which systems are assembled" (p.4-1).	**YES** **QUOTES:** "The practice of systems thinking starts with understanding a simple concept called "feedback" that shows how actions can reinforce or counteract (balance) each other" (p.58). "Reality is made up of circles (of causality) but we see straight lines" (p.58).

3) Systems (feedback) structure **DESCRIPTION:** Key interrelations which influence systems behaviour. A system has (or, can be represented) as having a causal feedback loop structure. A structure is also a theory of something. So, structure is about how things are related. SD offers a knowledge structure, represents the world in a certain way (similarly to the "skeleton of science" in GST). Hence, structure is not an intrinsic system's structure, but a knowledge structure about something. Systems structure is also a way to represent a system relatively to its behaviour. **RELATED CONCEPTS:** Elements, variables (stocks and flows); Structure drives behaviour; Interacting feedback loops; Dynamic hypothesis.	**YES** **QUOTE:** "The behaviour of a system arises from its structure" (p.107).	**YES** **QUOTES:** "Once we see the relationship between structure and behaviour, we can begin to understand how systems work" (p.1) "System structure is the source of system behaviour. System behaviour reveals itself as a series of events over time" (p.89).	**YES** **QUOTES:** "His [man's] scientific research is exposing the structure of the nature's systems" (p.1-1). "The structure of a subject guides us in organizing information" (p.4-1). "In concept a feedback system is a closed system. Its dynamic behaviour arises within its internal structure" (p.4-2). Additionally, contains a dedicated part to structure: "Chapter 4: Structure of systems".	**YES** **QUOTES:** "Structure Influences Behaviour. Different people in the same structure tend to produce qualitatively similar results" (p.31). "Structure…means the basic interrelations that control behaviour." (p.31) "The reason that structural explanations are so important is that only they address the underlying causes of behaviour at a level that patterns of behaviour can be changed" (p.40)
4) Stock and flow **DESCRIPTION:** Basic elements which are sufficient to describe any system – stocks and flows. **A stock:** Stocks characterize system's state, represent its actual condition; Stock is determined by all past rates, not the present one; Tangible (example: inventory) and intangible (examples: beliefs, memory); Stocks are system's memory. They accumulate all change. Their current state is the consequence of all historical changes which have been happening to it; Quantity of stock is conserved (unless outflowed);	**YES** **QUOTE:** "Stocks and flows, along with feedback, are the two central concepts of dynamic systems theory" (p.191).	**YES** **QUOTES:** "A stock is the foundation of any system." (p.17). "A stock is the memory of the history of changing flows within the system" (p.18). "Stocks change over time through the actions of a flow" (p.18).	**YES** **QUOTE:** "There are two fundamental types of variable elements within each feedback loop – the levels, and the rates. Both are necessary. The two are sufficient" (p.4-5). Additionally, Chapter 4.3 is dedicated to stocks and flows.	**NO**

A flow: Rates are actions (streams of actions); Not measured instantaneously; Change stocks; Include decision rules Work through information/matter flow				
5) System, social system **DESCRIPTION:** A set of purposefully interconnected and interacting elements. Main object in SD. Interconnected in a way that they produce their own pattern of behaviour, purpose (Meadows, 2008). Purpose and boundary depend on the observation viewpoint. **RELATED CONCEPTS:** Elements, variables**;** Interaction, interdependence**;** Goal**;** State**;** Consists of causal feedback loops**; "**Whole is bigger than a sum of parts"**;** Open system / feedback system (Forrester, 1968).	**YES** **QUOTE:** "System dynamics is a method to enhance learning in complex systems" (p.4).	**YES** "A system is an interconnected set of elements that is coherently organized in a way that achieves something" (p.11). "[A] conglomeration without any particular interconnections or function [is not a system]" (p.12). "Social systems are the external manifestations of cultural thinking patterns and of profound human needs, emotions, strengths, and weaknesses" (p.167).	**YES** "Man lives and works within social systems" (p.1). "As used here a "system" means a grouping of parts that operate together for a common purpose" (p.1-1).	**YES** **"**Business and other human endeavours are also systems" (p.10). "I was already convinced that most of the problems faced by humankind concerned our inability to grasp and manage the increasingly complex systems of our world" (p.14).
6) Idea of a model **DESCRIPTION:** A model is a substitute for an object or a system (Forrester, 1968, p. 3-1). **Mental model** Basis of thinking and decision making. View on mind in SD. Constructed representation of reality.	**YES** **QUOTES:** **Mental model:** "The concept of mental models has been central to system dynamics from the beginning of the filed" (p.16). **Simulation model:**	**YES** **QUOTES:** **Mental model:** **"**Everything we think we know about the world is a model. Our models do have a strong congruence with the world. Our models fall far short of representing the real world fully" (p. 87).	**YES** Contains a dedicated Chapter 3: "Models and Simulation". **QUOTES:** "A model is a substitute for an object or system" (p.3-1).	**YES** **QUOTE:** **"**Mental models are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action" (p.11).

RELATED CONCEPTS: Model boundary; Beliefs about causes and effects' network; Framing of thinking; Simplification; Constructs are not real objects or systems; Paradigms and mental models are sources of systems (Meadows, 2008); Importance of reflection on mental models (Senge, 1994). **Simulation model, simulation** Solves the barriers to learning and helps people to learn about behaviour of complex systems to understand systems and to solve problems. **RELATED CONCEPTS:** Virtual worlds**;** DT**;** Experimentation**;** Model boundary**;** Equations and computation**; "**All models are wrong".	"Virtual worlds … are formal models, simulations, or microworlds in which decision-makers can refresh decision-making skills, conduct experiments. and play" (p.34). "In systems with significant dynamic complexity, computer simulation will typically be needed" (p.34).	**Simulation model:** No emphasis on simulation (it is only implied as the graphs over time and SFDs which produce them are presented)	"The human mind is well adapted for building [mental] models that relate to objects in space" (p.3-2). "This book develops a foundation for constructing computer [simulation] models to aid our mental process in dealing with time-varying systems" (p.3-2). "We can never prove that any model is an exact representation of reality" (p.3-4) "The process of step-by-step solution is called simulation" (p.3-5).	**Simulation model:** Simulation is not defined
7) Dynamics (behaviour) of a system **DESCRIPTION:** Systems are dynamic – they behave in a certain way. SD focus is on the behaviour of systems over time. **RELATED CONCEPTS:** Change; Feedback loops' interaction; Over-time; Behaviour reveals itself in a set of events; Dynamic means time-varying.	**YES** **QUOTES:** "Dynamic complexity arises from the interactions among agents over time" (p.21). "Dynamic is one of the feature of systems" (p.22).	**YES** **QUOTES:** "Dynamics - the behaviour over time of a system or any of its components" (p. 187). "Complex behaviours of systems often arise as the relative strengths of feedback loops shift, causing first one loop and then another to dominate behaviour" (p.45).	**YES** **QUOTES:** "This book is devoted to theory, principles and behaviour of feedback systems" (p.1-7). "As an introduction to the dynamic (that us, time-varying) behaviour of feedback loops, this chapter presents several feedback systems to illustrate…" (p.2-1). "In the following sections several systems will be examined to see how the	**YES** **QUOTE:** "Structure produces behaviour, and changing underlying structures can produce different patterns of behaviour" (p.40).

			foregoing behaviour patterns can occur" (p.2-3). Contains a dedicated chapter about feedback dynamics (Chapter 2).	
8) Modes (patterns) of behaviour **DESCRIPTION:** Typical pattern of systems behaviour often produced by specific structures. **RELATED CONCEPTS:** Dynamic, static equilibrium; Oscillations, cycles; Exponential growth, decay; Goal-seeking; Randomness.	**YES** **QUOTE:** "The basic modes of behaviour in dynamic systems are identified along with the feedback structures generating them" (p.107).	**YES** **QUOTES:** "Systems with similar feedback structures produce similar dynamic behaviours" (p. 50). "There are many forms of systems trouble, some of them unique, but many strikingly common. We call the system structures that produce such common patterns of problematic behaviour archetypes. Some of the behaviours these archetypes manifest are addiction, drift to low performance, and escalation" (p.111).	**YES** **QUOTE:** "The interplay of activity within negative feedback can range from smooth achievement of the goal that the loop is seeking, to wild fluctuation in search of the goal. Positive feedback loops show growth or decline" (p.2-1).	**YES** **QUOTE:** See point 9 – "System archetypes".
9) Systems archetypes **DESCRIPTION:** General common systems structures which produce certain behavioural patterns. **RELATED CONCEPTS:** Path dependence; Limits to growth; Fixes that fail; Tragedy of the commons.	**YES** **QUOTES:** "Understanding model behaviour goes beyond the invocation of simple archetypes such as "the oscillation is caused by negative loops with delays" or "S-shaped growth results from the limits to growth on a reinforcing feedback" (p.767).	**YES** **QUOTE:** "We call the system structures that produce such common patterns of problematic behaviour archetypes" (p.111).	**NO**	**YES** **QUOTES:** "The purpose of the systems archetypes is to recondition our perceptions, so as to be more able to see structures at play, and to see the leverage in those structures" (p.82).

	"More complex modes such as S-shaped growth and overshoot and collapse arise from the nonlinear interaction of these basic structures" (p.107).			"…certain patterns of structure recur again and again. These "systems archetypes" or "generic structures"…" (p. 81).
10) Properties (principles) of systems **DESCRIPTION:** Characteristics, descriptions and qualities of systems. **RELATED CONCEPTS:** (Dynamic) complexity; Self-organising, self-maintaining; Uncontrollable (Meadows, 2008); Unpredictable, understandable to a limit (Meadows, 2008); Persistent behaviour (Senge, 1994); Counter-intuitive, hard to understand; Non-linearity; Tightly-coupled; Order; Delays; History dependent (path dependence).	**YES** **QUOTE:** "Dynamic complexity arises because systems are…" (p.22).	**YES** **QUOTE:** "Systems can change, adapt, respond to events, seek goals, mend injuries, and attend to their own survival in lifelike ways, although they may contain or consist of non-living things. Systems can be self-organizing, and often are self-repairing over at least some range of disruptions. They are resilient, and many of them are evolutionary. Out of one system other completely new, never-beforeimagined systems can arise" (p.12).	**YES** **QUOTES:** "This book deals with the structure and the principles of systems…" (p.1-4). "This book is devoted to theory, principles and behaviour of feedback systems" (p.1-7).	**NO**
11) Cause and effect **DESCRIPTION:** SD is looking for causes. Everything has a cause, happens not randomly. The focus is on "dynamic causality". Systems structure consists of networks of causes and effects (circular). Things emerge not randomly, but caused by something. **RELATED CONCEPTS:** Circular causality; Causality, not correlation; Causality as in mental models, not reality; Feedback structure as the cause of behaviour, not separate causes.	**YES** **QUOTES:** **Linear view on causality:** "We are taught from an early age that every event has a cause, which in turn is an effect of some still earlier cause" (p.10). **Feedback view on causality:** "Our decisions alter the state of the world, causing changes in nature and triggering others to	**YES** **QUOTES:** "The concept of feedback opens up the idea that a system can cause its own behaviour" (p.34). "In other words, if you see a behaviour that persists over time, there is likely a mechanism creating that	**YES** **QUOTE:** "System is the cause of dynamic behavior through interacting components" (p. 1-6).	**YES** **QUOTES:** |By "effects," I mean the obvious symptoms that indicate that there are problems… By "cause" I mean the interaction of the underlying system that is most responsible for generating the symptoms, and which, if recognized, could lead to changes

	act, thus giving rise to a new situation which then influences our next decisions" (p.22).	consistent behaviour. That mechanism operates through a feedback loop. It is the consistent behaviour pattern over a long period of time that is the first hint of the existence of a feedback loop" (p.25).		producing lasting improvement" (p.48). "Reality is made up of circles (of causality) but we see straight lines" (p.58). "In systems thinking it is an axiom that every influence is both cause and effect. Nothing is ever influenced in just one direction" (p.60).
12) Time, delays **DESCRIPTION:** Systems behaviour over time are studied in SD. Time dimension is important. Besides, ubiquitous delays between cause and effects hinder problem understanding. Delays are important for systems behaviour. **RELATED CONCEPTS:** Continuous, linear time; Long-term perspective; A stock takes time to change as flows take time to flow.	**YES** **QUOTES:** **Delay:** "Delays are critical sources of dynamics in nearly all systems" (p.409). **Time:** "The development of systems thinking is a double-loop learning process in which we replace a reductionist, narrow, short-run, static view of the world with a holistic, broad, long-term dynamic view…" (p.18). "Cause and effects are often distant in time. Considering sufficient time horizon is important in SD" (p.91).	**YES** **QUOTES:** "Delays are pervasive in systems, and they are strong determinants of behaviour. Changing the length of a delay may (or may not, depending on the type of delay and the relative lengths of other delays) make a large change in the behaviour of a system" (p.57). "Systems thinkers use graphs of system behaviour to understand trends over time, rather than focusing attention on individual events" (p.20).	**YES** **QUOTES:** **"**Feedback systems are of interest because of the way they act through time" (p.2-7). "There may be additional delays and distortions appearing sequentially in the loop" (p.1-9).	**YES** **QUOTES:** "In addition, many feedback processes contain "delays," interruptions in the flow of influence which make the consequences of actions occur gradually" (p.65). "Nowhere is this more evident than in delays—interruptions between your actions and their consequences" (p.74). "…they distract us from seeing the longer-term patterns of change that lie behind the events and from understanding the causes of those patterns" (p.19).

13) Endogenous explanation (view) **DESCRIPTION:** Endogenous – arising from within. Endogenous theory generates the dynamics of a system through the interaction of the variables, loops and agents represented in the model (Sterman, 2000). Opposed to exogenous explanation. **RELATED CONCEPTS:** "Structure drives behaviour"	**YES** **QUOTES:** "System Dynamics seeks endogenous explanation for phenomena" (p.95). "Formulate a dynamic hypothesis that explains the dynamics as endogenous consequences of the feedback structure" (p.86).	**YES** **QUOTE:** "The system, to a large extent, causes its own behaviour!" (p.2).	**YES** **QUOTES:** "Systems as a cause of dynamic behaviour" (p.4-1). "In concept a feedback system is a closed system. Its dynamic behaviour arises within its internal structure" (p.4-2).	**YES** **QUOTE:** "The systems perspective tells us that we must look beyond individual mistakes or bad luck to understand important problems. We must look beyond personalities and events. We must look into the underlying structures which shape individual actions and create the conditions where types of events become likely" (p.33).
14) Systems thinking **DESCRIPTION:** Ability to see the world as a complex system. A skill(s). Additionally, in Senge (1994) is also a discipline, integral for all other ones. **RELATED CONCEPTS:** Holistic worldview; Event-oriented, open-loop worldview; Feedback view; Multiple perspectives; Organizing complexity; Long-term orientation; Not static, but dynamic world; The whole, not parts; Systems' perspective; Seeing interrelations rather than things.	**YES** **QUOTE:** "Systems thinking – the ability to see the world as a complex system, in which we understand that "you can't just do one thing" and "everything is connected to everything else" (p.4).	**YES** **QUOTES:** "Once we see the relationship between structure and behaviour, we can begin to understand how systems work, what makes them produce poor results, and how to shift them into better behaviour patterns… systems thinking will help us manage, adapt, and see the wide range of choices we have before us. It is a way of thinking that gives us the freedom to identify root causes of problems and see new opportunities" (p.2). "The systems-thinking lens allows us to reclaim our intuition about whole systems and…" (p.6).	**NO**	**YES** **QUOTES:** "Systems thinking is a conceptual framework, a body of knowledge and tools that has been developed over the past fifty years, to make the full patterns clearer, and to help us see how to change them effectively" (p.10). "Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots" (p.53).

15) Learning **DESCRIPTION:** Learning as the main goal of SD. Most emphasized goal along with problem-solving. **RELATED CONCEPTS:** Challenges of learning about systems; Learning about and within systems (Sterman, 2000).	**YES** **QUOTE:** "Learning in and about complex systems" (p.3). "System Dynamics is a method to enhance learning in complex systems" (p.4).	**YES** **QUOTE:** "There is much to be learned about systems without using a computer. However, once you have started to explore the behavior of even very simple systems, you may well find that you wish to learn more about building your own formal mathematical models of systems" (p.195).	**YES** **QUOTE:** "The principles of system's dynamics discussed in this book should serve a structure of knowledge about the world, which is necessary for learning" (p.1-2).	**YES** **QUOTE:** "Real learning gets to the heart of what it means to be human. Through learning we re-create ourselves. Through learning we become able to do something we never were able to do. Through learning we reperceive the world and our relationship to it. Through learning we extend our capacity to create, to be part of the generative process of life. There is within each of us a deep hunger for this type of learning" (p. 14).
16) Policy resistance **DESCRIPTION:** Systems are often "resisting" the change and counteract the implemented policy, hindering its performance. **RELATED CONCEPTS:** Unanticipated (side)-effects; Cause and effect distant in time.	**YES** **QUOTES:** "Our policies may create unanticipated side effects" (p.5). "These unexpected dynamics lead to policy resistance, the tendency for interventions to be delayed…" (p.5). Additionally, a dedicated section on causes of policy resistance. See: 1.1.2 (p.10).	**YES** **QUOTE:** "Despite efforts to invent technological or policy "fixes," the system seems to be intractably stuck, producing the same behaviour every year" (p.112).	**NO**	**YES** **QUOTE:** "… policy resistance, [is] the tendency of complex systems to resist efforts to change their behaviour" (p.349).

17) Decision-making **DESCRIPTION:** Something which SD helps with (decision-making and policy-making). Hence, one of the main "interest areas" of SD. Additionally, SD incorporates certain knowledge from the domains studying decision-making. **RELATED CONCEPTS:** Policy, policy making; Policy design and evaluation; Decision-making as a feedback process.	**YES** **QUOTE:** "Effective decision making and learning in a world of growing dynamic complexity requires us to become systems thinkers-to expand the boundaries of our mental models and develop tools to understand how the structure of complex systems creates their behaviour" (p.vii, preface). Additionally, a dedicated	**YES** **QUOTE:** "Sometimes I challenge my students to try to think of any human decision that occurs without a feedback loop—that is, a decision that is made without regard to any information about the level of the stock it influences" (p.33).	**YES** Direct quote missing, but Forrester implies that SD as a method was made to help people in learning about complex systems as well as improve decision-making.	**YES** Direct quote missing, but improving decision-making is one of the integral goals of the book and Senge's systems thinking.
18) Model building, modelling process **DESCRIPTION:** SD emphasizes the importance of the process of model building. It is important not only for the quality of the model, but the process is also the source of learning itself. Iteration is important. **RELATED CONCEPTS:** Mental model elicitation**;** Mapping causal structure**;** Iteration.	**YES** **QUOTE:** "Modelling, as a part of the learning process, is iterative, a continual process of formulating hypothesis…" (p.83).	**NO** Not discussed.	**NO** Not discussed.	**YES/NO** Not described deliberately. But systems thinking as described by Senge implies a continuous process of learning
19) Purpose (of models and usage of SD) **DESCRIPTION:** SD is ultimately used to solve problems by means of helping in learning about complex systems and their behaviour. Not just to gain insights. For model-building, purpose has the primary	**YES** **QUOTE:** "The purpose [of modelling] is to solve a problem, not only to gain insight (though insight into the problem is required to design effective policies" (p.83).	**NO / YES** **QUOTE:** *Mentioned only in terms of drawing the model boundary: "Where to draw a boundary around a system depends on the purpose of the discussion—the	**YES** The principles of system's dynamics discussed in this book should serve as a structure of knowledge about the world, which is necessary for learning. Hence, learning is implied as the purpose of SD.	**YES/NO** The purpose of systems thinking is discussed. Discussions about model's purpose is absent. **QUOTE:**

importance. Purpose cuts out the unnecessary things from the model and sets model boundaries. **RELATED CONCEPTS:** Problem-oriented approach; Model purpose; Model utility.		questions we want to ask" (p.97). "It's a great art to remember that boundaries are of our own making, and that they can and should be reconsidered for each new discussion, problem, or purpose" (p.99).	**QUOTE:** "Principles of system provide a structure of knowledge and unites several disciplines" (p.1-4).	"Instead, we tend to focus on snapshots of isolated parts of the system, and wonder why our deepest problems never seem to get solved. Systems thinking is a conceptual framework, a body of knowledge and tools that has been developed over the past fifty years, to make the full patterns clearer, and to help us see how to change them effectively" (p.10).
20) Problem articulation **DESCRIPTION:** First, the importance of problem articulation is stressed. Because, depending on how the problem is framed, all the subsequent steps will be done. Besides, problems are framed in a specific way in SD – as dynamic hypothesises. **RELATED CONCEPTS:** Reference mode; Time horizon; Focus on sources (causes) than on symptoms	**YES** **QUOTES:** "The most important step in modelling is problem articulation" (p.89). "Two of the most useful processes [to define the problem dynamically] are establishing reference modes and explicitly setting the time horizon" (p.90).	**NO**	**NO**	**NO**
21) Tools for Systems Thinking **DESCRIPTION:** Primarily, visualization tools for representation of the system and its behaviour. **RELATED CONCEPTS:**	**YES** Contains a dedicated section: **"Part II (Tools for systems thinking)".** **QUOTE:**	**YES** Meadows illustrates stock-and-flow diagrams as one of the method to represent a system (p.18). **QUOTE:**	**YES** **QUOTES:** "The behaviour of a system is easier to comprehend in a time plot…" (p.2-35).	**YES** **QUOTE:** Systems diagrams: "When reading a feedback circle diagram, the main skill is to see the "story" that the diagram tells…" (p.61).

CLD; SFD; Model boundary chart; Time plot.	"In system dynamics we use several diagramming tools to capture the structure of systems, including causal loop diagrams and stock and flow maps." (p.137).	"Systems thinkers use graphs of system behaviour to understand trends over time, rather than focusing attention on individual events" (p.20).	"A verbal description is one approach to a system…but to show the relationships between parts… the flow diagram is better" (p.7-1).	
22) Leverage point **DESCRIPTION:** Sensitive and effective point of intervention in a system. "Places" to intervene into a system. **RELATED CONCEPTS:** Paradigms change as the most high-level leverage point (Meadows, 2008); System intervention: new way of thinking as the main (strongest) leverage (Meadows 2008; Senge, 1994)	**YES** **QUOTE:** "If people had a holistic worldview, it is argued, they would then… identify the high leverage points in systems, and avoid policy resistance" (p.4).	**YES** **QUOTE:** "…leverage points—places in the system where a small change could lead to a large shift in behaviour" (p.145). Additionally, Chapter 6 is dedicated to leverage points.	**NO**	**YES** **QUOTE:** "Leverage Often Comes from New Ways of Thinking In human systems, people often have potential leverage that they do not exercise because they focus only on their own decisions and ignore how their decisions affect others" (p.32).
23) Loop Dominance (shifting) **DESCRIPTION:** Complex dynamic behaviour of systems largely arises from shifting loop dominance – relative strength of loops change and they start pulling the system in different directions one after another. **RELATED CONCEPTS:** Tipping point; Breakdown point.	**YES** **QUOTE:** "In real systems, there must be shifts in feedback loop dominance, and therefore there must be important nonlinearities in all real systems" (p.284).	**YES** **QUOTE:** "Complex behaviours of systems often arise as the relative strengths of feedback loops shift, causing first one loop and then another to dominate the behaviour" (p.189).	**YES** **QUOTE:** "Nonlinear coupling can cause a shift of dominance from one system loop to another" (p.2-1).	**NO**

24) Messy problems **DESCRIPTION:** Complex interdependent problems in which it is hard to even understand what a problem is. Unclear, at the same time, the stakes of their resolution are also high. So, main two characteristics: high uncertainty and high importance.	**YES** **QUOTE:** "Modeling takes place in the context of real world problem solving, with all its messiness, ambiguity, time pressure, politics, and interpersonal conflict" (p. 83).	**YES** *Though, the exact term "messy problem" is not used. Instead, "a mess" is used. **QUOTES:** "Managers are not confronted with problems that are independent of each other, but with dynamic situations that consist of complex systems of changing problems that interact with each other. I call such situations messes… Managers do not solve problems, they manage messes" (p. 1). "And some problems, those most rooted in the internal structure of complex systems, the real messes, have refused to go away" (p.4).	**NO**	**NO**
25) Hierarchy **DESCRIPTION:** One of the properties of systems. Probably, the most mentioned one. It means that subsystems exist within and form larger systems forming hierarchies. **RELATED CONCEPTS:** Systems and subsystems; Purpose of higher level systems is to serve lower level ones (Meadows, 2008); Hierarchies of feedback structures.	**NO / YES** Hierarchy as a specific property of systems is not discussed. But, contains the statement that systems are formed by subsystems. **QUOTE:** "Diagrams mapping subsystems of system" (p.99). "Structure of market sub-system" (p.620).	**YES** **QUOTE:** "Hierarchy: Systems organized in such a way as to create a larger system. Subsystems within systems" (p.187).	**YES** **QUOTE:** "One must then recognize the hierarchy of feedback structures where the broadest purpose of the interest determines the scope of the pertinent system" (p.1-7).	**NO**

26) System's (re)-design **DESCRIPTION:** A way to deal with systems and problems. "Systems cannot be controlled, but can be designed and redesigned" (Meadows, 2008, p. 169). **RELATED CONCEPT:** General recommendations on systems' design (common structures).	**YES** **QUOTES:** "We are all passengers on an aircraft we must not only fly, but redesign in flight" (p.4). "…and so we can revise our mental models and redesign the system itself (double-loop learning" (p.25). "… most of the time high leverage policies will involve changing the dominant feedback loops by redesigning the stock and flow structure, eliminating time delays, changing the flow and quality of information available at key decision points, or fundamentally reinventing the decision processes of the actors in the system" (p.104).	**YES** **QUOTE:** "Systems can't be controlled, but they can be designed and redesigned" (p.169).	**NO**	**NO**
27) Systems purpose, function **DESCRIPTION:** A system is interconnected in a way that it produces purposeful behaviour. System's purpose is in its behaviour. In Forrester (1964) – a system's purpose is not its intrinsic property, but rather dependent on the observer's viewpoint in defining the purpose of the system. **RELATED CONCEPTS:** Systems behaviour; Purpose might change, interconnectedness might stay the same (Meadows, 2008); System's goal.	**NO / YES** Not mentioned explicitly, however the author discusses dysfunctions of systems, implying systems that work not as desired or according to some purpose. **QUOTE:** "Dysfunction in complex systems can arise from the misperception of the feedback structure of the	**YES** **QUOTES:** "A system must consist of three kinds of things: elements, interconnections, and a function or purpose" (p.11). "A system's function or purpose is not necessarily spoken, written, or expressed explicitly, except through the operation of the system. The best way to deduce the system's purpose is	**YES** **QUOTES:** "As used here a "system" means a grouping of parts that operate together for a common purpose" (p.1-1). "An automobile is a system of components that work together to provide transportation" (p.1-1).	**YES** Called as a "goal". **QUOTES:** "The reason that costs don't stay down is that the system has its own agenda. There is an implicit goal, unspoken but very real - the amount of work that is expected to get done" (p.69).

	environment… Dysfunction in complex systems can arise from faulty mental simulation-the misperception of feedback dynamics" (p.29).	to watch for a while to see how the system behaves" (p.14).	"The way in which the purpose of the system determines whether it is an open or feedback system…" (p.1-6).	
28) Systems elements **DESCRIPTION:** Units of system which it is comprised of. For example: people are the elements which form a society. One of the 3 system's components (Meadows, 2008). Also, related to the variables' dimensions in simulation modelling.	**YES** **QUOTE:** "…and structures such as sea shells and markets all emerge spontaneously from the feedbacks among the agents and elements of the system" (p.22).	**YES** **QUOTES:** "A system must consist of three kinds of things: elements, interconnections, and a function or purpose" (p. 11). "For example, the elements of your digestive system include teeth, enzymes, stomach, and intestines. They are interrelated through the physical flows of food, and through an elegant set of regulating chemical signals" (p.11). "Elements do not have to be physical things. Intangibles are also elements of a system" (p.13).	**YES** Elements are called as "parts". **QUOTES:** "A system is a grouping of parts that operate together for a common purpose" (p.1-1). "A system may include people as well as physical parts" (p.1-1).	**NO**
29) Interconnections, interconnectedness **DESCRIPTION:** Interconnections between system's elements. Second of the three system's components (Meadows, 2008). Something what connects elements – relationships between them.	**YES** **QUOTE:** "The actors in the system interact strongly with one another and with the natural world. Everything is connected to everything else" (p.22).	**YES** **QUOTE:** "A system must consist of three kinds of things: elements, interconnections, and a function or purpose" (p.11).	**YES / NO** The concept is present, but not emphasized. **QUOTE:** "Interconnecting feedback loops form any system" (p.4-5).	**YES** **QUOTES:** "Rather, "systemic structure" is concerned with the key interrelationships that influence behaviour

RELATED CONCEPTS: Flows of information; Physical flows; Shared meanings, culture and paradigms (Meadows, 2008).		"Interconnections [are], the relationships that hold the [system's] elements together" (p.13).		over time. These are not interrelationships between people, but among key variables, such as population, natural resources, and food production in a developing country; or engineers' product ideas and technical and managerial knowhow in a high-tech company" (p.34).
30) Decision rule, decision **DESCRIPTION:** In SD, decisions are made via decision rule. Decision rules tell how the decision stream will be generated in response the incoming information. Another word, they are policies which govern behavioural responses to certain conditions in order to bring the system's state to the desired on. Formally, a decision rule contains: observed condition, goal, discrepancy and action. The concept includes explicit and subconscious decision-making. **RELATED CONCEPTS:** Decision point; Theory of decision making (feedback, actual/desired); Every decision is based on feedback.	**YES** **QUOTES:** "Decisions are the result of applying a decision rule or policy to information about the world as we perceive it" (p.16). "Decisions are the result of applying a decision rule to the available information cues" (p.515). "Decision rules are the policies and protocols specifying how the decision maker processes available information. Decisions are the outcome of this process" (p.514).	**YES** **QUOTES:** "Even a delicate and intricate pattern, such as the Koch snowflake shown here, can evolve from a simple set of organizing principles or decision rules" (p.80).	**YES** Here, called as a "policy statement". **QUOTES:** "A rate equation is a policy statement" (p.4-12). "A policy or rate equation recognizes a local goal… to guide action" (p.4-16).	**NO**

31) Systems constraints **DESCRIPTION:** Every physical system is limited in its growth and for example level of resilience. **RELATED CONCEPTS:** Limits to growth; Limiting factor.	**YES** **QUOTES:** "No real quantity can grow (or decline) forever: eventually one or more constraints halt the growth" (p.118). "Eventually, one or more negative loops will become dominant as various limits to growth are approached" (p.117).	**YES** **QUOTES:** "In physical, exponentially growing systems, there must be at least one reinforcing loop driving the growth and at least one balancing loop constraining the growth, because no system can grow forever in a finite environment" (p.190).	**NO**	**YES** **QUOTE:** "There will always be more limiting processes. When one source of limitation is removed or made weaker, growth returns until a new source of limitation is encountered" (p.89).
32) Non-linearity **DESCRIPTION:** Non-linearity is a common property of systems because: 1) effects are not proportional to causes; 2) shifting loop dominance causes systems to behave non-linearly. The concept is often opposed to linearity and linear-thinking. **RELATED CONCEPTS:** Feedback loops interaction; Shifting dominance; Understanding of systems behaviour.	**YES** **QUOTE:** "One of the system's characteristic is that they are non-linear" (p.22).	**YES** **QUOTES:** "Many relationships in systems are nonlinear" (p.190). "Many relationships in systems are nonlinear. Their relative strengths shift in disproportionate amounts as the stocks in the system shift. Nonlinearities in feedback systems produce shifting dominance of loops and many complexities in system behaviour" (p.94).	**YES** **QUOTES:** "Most dynamic behaviour in social systems can only be represented by models that are nonlinear and so complex…" (p.3-1). "Non-linear coupling [of feedback loops or system's elements] can cause a shift of dominance from one system loop to another." (p.2-1).	**NO**

33) Model boundaries, absence of (real) boundaries **DESCRIPTION:** Everything is interconnected and there are no isolated systems. Boundaries of systems are not set, but rather determined by the observer's viewpoint. Hence, a boundary is a rather epistemological concept which means everything which is purposefully included as something important in studying of the given system or enough to explain its behaviour.	**NO / YES** Only model boundaries are discussed. Absence of boundaries as a property of systems is not discussed. **QUOTE:** "Modeling here includes the elicitation of the participants existing mental models, including articulating the issues (problem structuring), selecting the model boundary and time horizon, and mapping the causal structure of the relevant system" (p. 36).	**YES** **QUOTES:** "…because systems rarely have real boundaries. *Everything, as they say, is connected to everything else*, and not neatly. There is no clearly determinable boundary between the sea and the land, between sociology and anthropology, between an automobile's exhaust and your nose. There are only boundaries of word, thought, perception, and social agreement - artificial, mental-model boundaries" (p.95). "There are no separate systems. The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion" (p.190).	**NO**	**YES** **QUOTES:** "But the boundaries that make the subdivisions are fundamentally arbitrary — as any manager finds out who attempts to treat an important problem as if it is purely "an economic problem," or "an accounting problem," or "a personnel problem" (p.258).
34) Resilience **DESCRIPTION:** A key property of systems which implies that they are self-corrective, adaptive and can restore after perturbations. One of the reasons why systems "work well" (Meadows, 2008). Resilience, however, has limits in terms of the extent to which a system can "stretch" and then come back to its original state. Resilience arises from the feedback structure of systems. Resilience is opposed to rigidness, stability and inability to adapt.	**NO**	**YES** **QUOTE:** "[Resilience is] The ability of a system to recover from perturbation; the ability to restore or repair or bounce back after a change due to an outside force" (p.188).	**NO**	**NO**

35) Self-organization **DESCRIPTION:** A system's property. System's ability to structure itself, diversify, complexity and learn. Derived from multiplicity of connections in systems and their feedback structure.	**YES** **QUOTE:** "Systems are self-organizing" (p.22).	**YES** **QUOTE:** "The ability of a system to structure itself, to create new structure, to learn, or diversify" (p. 81).	**NO**	**NO**
36) "Need for a new way of thinking" **DESCRIPTION:** Linked to point 1. There is a message that systems' principles need to be recognized, that a new way of thinking – holistic systems thinking - should be adopted to meet the challenges of the modern world. Basically, all four authors share the following idea: the human's mind is not working good enough or is not suitable to solving complex dynamics systems' problems. Hence, systems thinking and SD are necessary and represent the "new way thinking" as I call it here. **RELATED CONCEPTS:** Thinking in closed loops, not open loop; Metanoia (Senge, 1994); Transcendence (Senge, 1994); Sense of connection to a larger whole (Meadows, 2008); Holistic thinking as opposed to reductionist thinking; Inability to comprehend systems.	**YES** **QUOTE:** "A steady stream of philosophers … calling for similar leaps to fundamental new ways of thinking and acting. Many advocate the development of systems thinking… If people had a holistic worldview, it is argued, they would then act in consonance with the long-term best interests of the system as a whole, identify the high leverage points in systems, and avoid policy resistance. Indeed, for some, the development of systems thinking is crucial for the survival of humanity" (p.4). Chapter 1 contains this narrative about the "need for a new way of thinking".	**YES** **QUOTES:** "People tend to look for causes of problems externally, tend to think in terms of linear chains of cause and effects. They tend to look at events and parts, rather than looking at how the whole works. Additionally, they tend to neglect feedback processes. Hence, this kind of thinking causes problems. Systems thinking is there to help with the matter" (p.3-4). "At a time when the world is more messy, more crowded, more interconnected, more interdependent, and more rapidly changing than ever before, the more ways of seeing, the better. The systems-thinking lens allows us to reclaim our intuition about whole systems…" (p.6).	**YES** **QUOTE:** "Gradually over the last hundred years it has become clear that the barrier to understanding systems has been, not the absence of important general concepts, but only the difficulty in identifying and expressing the body of universal principles that explain the successes and failures of the systems of which we are a part" (p. 1-2).	**YES** **QUOTES:** "The essence of the discipline of systems thinking lies in a shift of mind: • seeing interrelationships rather than linear cause-effect chains, and • seeing processes of change rather than snapshots" (p.58). "The most accurate word in Western culture to describe what happens in a learning organization… is «metanoia» and it means a shift of mind" (p.14). Additionally, a chapter dedicated to the topic is present called: "Chapter 5. Shift of mind".

37) Model utility, validity, knowledge validation **DESCRIPTION:** Criteria for knowledge and model's validity and utility. The importance of iteration is emphasized. Additionally, the idea of validity is linked to the idea of the modelling purpose. It is stressed that models can never be ultimately verified, however confidence in them can be gained.	**YES** **QUOTES:** "Unfortunately, testing is often done to prove the model is "right" (p.845). "In fact, validation and verification of models are impossible…" (p.846). "The impossibility of validation and verification is not limited to computer models. Any theory that refers to the world relies on imperfectly measured data…" (p.847). "The decision to abandon a theory is never forced upon us by reality, but is always essentially a human choice" (p.849). "Modelling is inevitably a process of persuasion and communication among modellers, clients and other affected parties" (p.850) "[Validation is] Process by which you and your clients can build confidence that a model is appropriate for the purpose" (p.845).	**YES** **QUOTE:** "Model utility depends not on whether its driving scenarios are realistic (since no one can know that for sure), but on whether it responds with a realistic pattern of behaviour" (p. 190).	**YES** "Model validity and usefulness of dynamic models should be judged… in comparison with the mental and descriptive models which we would otherwise use" (p.3-3). "Model validity is a relative matter" (p.3-4).	**NO**

38) Systems ethics **DESCRIPTION:** The moral principles, guiding values and, as called by Meadows (2008, p. 170) "behavioural consequences" which stem from the premises of systems thinking. Systems thinking provides the rationale and justifies the reason why one should adopt and live up to these ethical principles. **RELATED CONCEPTS:** "The interconnectedness of everything"; Everything is a mental model, a paradigm; All paradigms are ultimately not true; looking at how systems behave prior to acting is important; Exposure of mental models is important; Acceptance of "not-knowing" – every knowledge is just a mental model; Mental flexibility; Not acting out of only selfish interests, but also of benefits of the whole; Long-term perspective; Humbleness and modesty; Systems cannot be fully controlled; Responsibility is a matter of a broader system than individuals; Embracing the fact that we create our own problems; Personal responsibility	**NO / YES** Not mentioned explicitly, but somewhat implied. **QUOTES:** "Tendency to blame the person rather than the system is so strong… In complex systems different people placed in the same structure tend to behave in similar ways" (p.28). "All models are wrong" (p.846) while "All decisions are based on models" (p.16).	**YES** Meadows call systems ethics as "system's wisdom" and dedicates a whole chapter to the topic: "Chapter 7: Living in a World of Systems". **QUOTE:** "I want to end this chapter and this book by trying to summarize the most general "systems wisdoms" I have absorbed from modelling complex systems and from hanging out with modellers These are the take-home lessons, the concepts and practices that penetrate the discipline of systems so deeply that one begins, however imperfectly, to practice them not just in one's profession, but in all of life. They are the behavioural consequences of a worldview based on the ideas of feedback, nonlinearity, and systems responsible for their own behaviour. When that engineering professor at Dartmouth noticed that we systems folks were "different" and wondered why, these, I think, were the differences he noticed" (p. 170).	**NO**	**YES** Notions of systems ethics are described in "Chapter 4: Laws of the Fifth Discipline". **QUOTE:** "Today's problems come from yesterday's solutions" (p.42).

39) Scenarios' testing **DESCRIPTION:** SD models allow making scenario-testing and asking "what if?" questions which helps in experimentation, learning and understanding how the potential consequences of one's actions and decisions.	**YES** **QUOTE:** Sterman includes scenario specification and testing of "what if" scenarios in the steps of the modelling process" (p.86).	**YES** **QUOTES:** "System dynamics models explore possible futures and ask "what if" questions" (p.190). "A systems analysis can test a number of scenarios to see what happens if the driving factors do different things. That's usually one purpose of a systems analysis" (p.46).	**NO**	**NO**
40) Systems management best practices **DESCRIPTION:** Best practices and heuristics stemming from SD and systems' principles which help to manage systems more effectively. **RELATED CONCEPTS:** Manage systems for both stability and resilience; Systems' archetypes and solutions to problems within them.	**YES** Multiple chapters which consider typical structures and discuss how to manage them appropriately form the SD point of view. For example, see: "Chapter 9: S-Shaped Growth: Epidemics, Innovation Diffusion, and the Growth of New Products" (p. 295).	**YES** Contains a dedicated section: "Chapter 5: Systems Traps… And Opportunities". **QUOTE:** "Educate and exhort the users, so they understand the consequences of abusing the resource. And also restore or strengthen the missing feedback link, either by privatizing the resource so each user feels the direct consequences of its abuse or (since many resources cannot be privatized) by regulating the access of all users to the resource" (p.121).	**NO**	**YES** **QUOTE:** "The deepest insights in the beer game come from seeing how these learning disabilities are related to alternative ways of thinking in complex situations. For most, the overall experience of playing the game is deeply dissatisfying because it is purely reactive. Yet, most eventually realize that the source of the reactiveness lies in their own focus on weekby-week events. Most of the players in the game get overwhelmed by the shortages of inventory, surges in incoming orders, disappointing arrivals of new beer. When asked to explain their decisions, they

				give classic "event explanations." I ordered forty at Week 11 because my retailers ordered thirty-six and wiped out my inventory." So long as they persist in focusing on events, they are doomed to reactiveness" (p.39).
41) Systems boundary **DESCRIPTION:** The idea of a closed system's boundary as an epistemological tool. Since ultimately SD is used to comprehend reality and to solve problems in a general sense, and systems appear to not have clear boundaries along with the fact that their parts at a closer look appear to be systems themselves, the boundary of a studied system is purposefully set and depends on the problem at hand and the purpose of the investigation. Even if boundaries are not set explicitly, they exist in the implicit assumptions of a person about what forms a specific system (i.e. problem). Thereby, in SD system's boundaries are dynamic and dependent on the problem under investigation.	**NO**	**YES** **QUOTES:** "…because systems rarely have real boundaries. *Everything, as they say, is connected to everything else*, and not neatly. There is no clearly determinable boundary between the sea and the land, between sociology and anthropology, between an automobile's exhaust and your nose. There are only boundaries of word, thought, perception, and social agreement - artificial, mental-model boundaries" (p.95). "There are no separate systems. The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion" (p.190).	**YES** **QUOTE:** "In concept a feedback system is a closed system. Its dynamic behaviour arises within its internal structure. Any interaction which is essential to the behaviour mode being investigated must be included inside the system boundary" (p.4-2).	**NO**

42) Open system / Feedback system **DESCRIPTION:** SD classifies systems as open systems and closed systems. "An open system is one characterized by outputs that respond to inputs but where outputs are isolated from and have no influence on the inputs" (Forrester, 1968, p. 1-5). Another word, an open system does no feedback to itself. "A feedback system, which is sometimes called a "closed" system, is influenced by its own past behaviour. A feedback system has a closed feedback loop structure that brings the results from past action of the system back to control the future." (same). However, this classification is epistemological and implies two different ways of explaining: exogenous (open system) and endogenous (closed system). Whether a system is closed or open depends on the observer's viewpoint.	**NO**	**NO**	**YES** **QUOTES:** "Systems can be classified as open systems and feedback systems" (p. 1-5). "Whether a system should be classified as open or a feedback system… depends on the observer's viewpoint in defining the purpose of the system" (p.1-6).	**NO**
43) Information, information links **DESCRIPTION:** Feedback (often) happens through information. Available information governs behaviour. Information and information links connect conservative subsystems. **RELATED CONCEPTS:** Actual/Perceived state of the system; True information never available at decision points.	**YES** **QUOTES:** "Information feedback is an important part of decision making" (p.16). "Systems therefore consist of networks of stocks and flows linked by information feedbacks from the stocks to the rates" (p.202).	**YES** **QUOTE:** **"**Many of the interconnections in systems operate through the flow of information. Information holds systems together and plays a great role in determining how they operate" (p.14).	**YES** Contains a dedicated section to information: Chapter 9. **QUOTES:** "In the structure of a system, information links connecting levels to rates have quite a different character from the flow streams between levels" (p.9-1). "Information is not conserved. It can be used without being depleted" (p.9-4). "Only information links can connect between	**NO**

			conservative subsystems" (p.9-6).	
44) Conservation of matter **DESCRIPTION:** The concepts of stocks are conserved in them unless moved to other stocks. In turn, an output from every stock is an input to another one. Information does not follow the conservation rule since it cannot be consumed.	**YES** **QUOTE:** "The contents of the stock and flow networks are conserved I the sense that items entering a stock remain there until they flow out" (p. 201).	**NO**	**YES** **QUOTE:** "The quantity within the level is "conserved", that is, it does not change except as controlled by its flows" (p.9-1).	**NO**
45) Integration **DESCRIPTION:** Related to the concept of a stock. Implies that all processes in nature are processes of integration. Stocks integrate the change through flows at a certain rate, not instantaneously. Integration is also the basis for dynamic behaviour.	**NO**	**NO**	**YES** **QUOTE:** "Such emphasis on integration is plausible when one notices that all the processes of nature are the processes of integration" (p.6-12). "Dynamic behaviour arises from the process of integration" (p.10-1).	**NO**

46) Components of rates: goal, apparent condition (observation), discrepancy and action **DESCRIPTION:** Flows or rates contain several components: goal, perceived state, discrepancy and decision rule. These are substructures withon flows. Actual system's state is perceived and hence called apparent state. A goal is the desired system's state. Discrepancy – comparison of apparent and perceived states. Next, a decision rule describes the action response to the observed discrepancy, that is to response to the available information. In positive feedback a system is departing from the goal.	**YES/NO** Not mentioned explicitly as components of flows. **QUOTES:** "All negative feedback loops contain goals, system's actual and observed states, discrepancy and corrective action" (p.111). "Decision rules guide how actions are made" (p.513).	**YES/NO** Not mentioned explicitly as components of flows. **QUOTES:** "…balancing feedback loop must have its goal set appropriately to compensate for draining or inflowing processes that affect that stock" (p.40). "The change is faster at first, and then slower, as the discrepancy between the stock and the goal decreases" (p.30).	**YES** **QUOTES:** "One can look for a sub-structure within the levels and rates… a rate equation does contain an important and helpful internal structure… A rate equation is a policy statement" (p.4-13). "For concepts are to be found within the rate equation (this is, policy statement): a goal, observed condition of a system, discrepancy, a statement how action is based on discrepancy" (p.4-14).	**NO**

47) Theory of decision-making **DESCRIPTION:** Related to point 46. A theory of decision-making process based on Forrester (1968) which is derived from the idea of balancing feedback. Simple balancing feedback structure is a generic model of any goal-oriented behaviour. "Every decision is made within a feedback loop. The decision controls action which alters the system levels which influence the decision." (Forrester, 1968, p.4-4). Additionally, mind itself can be represented as a system. In this case, a stock can be for example a state of the mind. The present state of mind is the consequence of integration of all "flows" changing it up till now.	**NO**	**NO**	**YES** See Chapter 4.2 (p.4-3) and whole Chapter 4.4. **QUOTES:** "The "decision process implies a far broader concept than merely human decision-making in accordance with the common usage of the word "decision". As used here, a decision process is one that controls any system action" (p.4-4). "Every decision is made within a feedback loop. The decision controls action which alters the system levels which influence the decision" (p.4-4).	**NO**

48) Learning organization **DESCRIPTION:** "Organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together" (Senge, 1994 p.8). A concept present only in Senge (1994).	**NO**	**NO**	**NO**	**YES** **QUOTE:** "Organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together" (p.8).

49) Process thinking **DESCRIPTION:** Thinking not in terms of “things”, but relations and processes. An important component of thinking in systems. Stems from the fact that in mutual causality, cause and effect are not distinguishable. So, the focus shifts from thinking in terms of one “thing” does something to another, but rather them being in a continuous process of interaction. Besides, mutual causality also implies that since everything is dependent, it is difficult to identify anything as an individual entity. In turn, this shifts the focus from “substance-thinking” to “process-thinking”.	**NO** Not mentioned explicitly.	**YES** **QUOTE:** “That means system thinkers see the world as a collection of “feedback processes” (p.25).	**NO**	**YES** **QUOTES:** “Thinking in terms of processes of change rather than "snapshots" is another” (p.50). “They are artefacts of "snapshot" rather than "process" thinking, and appear in a whole new light once you think consciously of change over time” (p.50).

50) Systems thinking as a discipline **DESCRIPTION:** Senge (1994) presents systems thinking not merely a skill or a set of tools, but rather a discipline which should be practiced and developed continuously, day to day. Another word, systems thinking is understood as a series of practices and principles that must be mastered and applied continually for them to become useful.	**NO**	**NO**	**NO**	**YES** **QUOTE:** "This is why systems thinking is the fifth discipline. It is the discipline that integrates the disciplines, fusing them into a coherent body of theory and practice. It keeps them from being separate gimmicks or the latest organization change fads" (p.13).

Appendix C

The initially identified main concepts of SD presented in *Appendix B* were verified and confirmed with the two advisors and experts in System Dynamics, supervising the present thesis: Akkermans (personal communication, 22.03.2019) and Moxnes (personal communication, 25.03.2019). Next, these concepts were grouped into *13 categories or themes*, to simplify their understanding and further comparison with Buddhism. *Table 4* presented below depicts the *first categorization* of the identified main concepts of SD. The number before every concept corresponds to its number in *Table 3* in *Appendix B*.

Table 4. Initial Categorization and List of the Main Concepts of System Dynamics

Category (theme)	Concepts within the categories
Characteristics of "normal" human thinking	1) Characteristics of "normal" human thinking; 17) Decision-making; 36) "Need for a new way of thinking"
A system	5) System, social system; 28) Systems elements; 29) Interconnections, interconnectedness; 27) Systems purpose, function; 41) Systems boundary
Feedback and feedback loop	11) Cause and effect; 43) Information, information links; 2) Feedback, feedback loop; 42) Open system / Feedback system; 13) Endogenous explanation (view)
Systems structure	3) Systems (feedback) structure;
Stock and flow	4) Stock and flow; 44) Conservation of matter; 45) Integration

Systems Behaviour (dynamics)	7) Dynamics (behaviour) of a system; 8) Modes (patterns) of behaviour; 9) Systems archetypes; 23) Loop dominance (shifting)
The idea of a model	6) Idea of a model; 33) Model boundaries, absence of real boundaries; 37) Model utility, validity, knowledge validation
Systems properties	10) Properties (principles) of systems; 12) Time, delays; 25) Hierarchy; 31) Systems constraints; 32) Non-linearity; 34) Resilience; 35) Self-organization
Systems thinking	14) Systems thinking; 49) Process thinking; 50) Systems thinking as a discipline
Systems ethics	38) Systems ethics
SD theory of decision-making and goal-oriented behaviour	30) Decision rule, decision; 47) Theory of decision-making; 46) Components of rates: goal, apparent condition (observation), discrepancy and action;
Systems problems and their management	16) Policy resistance; 22) Leverage point; 24) Messy problems; 26) System's (re)-design; 40) Systems management best practices; 48) Learning organization;
SD practice and model-building	15) Learning; 19) Purpose (of models and usage of SD); 20) Problem articulation; 21) Tools for systems thinking; 18) Model building, modelling process; 39) Scenarios' testing

Appendix D

Appendix D contains *the final list of the main concepts of SD as well as their categories* used in the present thesis. All initial categories and concepts from *Appendix C* were discussed with both thesis supervisors (Akkermans, personal communication, 27.05.2019; Moxnes, personal communication, 31.05.2019) as well as a side advisor and expert in research methodology - Inge Bleijenbergh (personal communication, 07.06.2019). Based on these discussions, a decision was made to shorten the list in order to avoid making the already broad scope of the thesis even broader and to delete some of the concepts and categories from consideration. Since the main interest of this thesis is the comparison of the main concepts underlying SD and its dynamic systems paradigm, the concepts which were arguably more closely related to the practical and simulation modelling part of SD were removed. In specific, these were all concepts which fell under the "Systems problems and their management" and "SD practice and model-building" categories. Additionally, three more concepts were deleted as eventually found to be neither relevant for the comparison with Buddhism nor crucially important for SD: 42) Open system / Feedback system; 44) Conservation of matter, and 50) Systems thinking as a discipline.

Table 5 below presents the final list with the main categories and concepts which were discussed and defined in *The Main Concepts of System Dynamics* chapter. In total, *36 concepts under 11 categories* were defined as the main concepts of SD and its dynamic systems paradigm, and included into the final comparison.

Table 5. Final Categorization and List of the Main Concepts of System Dynamics

Category (theme)	Concepts within the categories
Characteristics of "normal" human thinking	1) Characteristics of "normal" human thinking; 17) Decision-making; 36) "Need for a new way of thinking"
A system	5) System, social system; 28) Systems elements; 29) Interconnections, interconnectedness; 27) Systems purpose, function; 41) Systems boundary

Feedback and feedback loop	11) Cause and effect; 43) Information, information links; 2) Feedback, feedback loop; 13) Endogenous explanation (view)
Systems structure	3) Systems (feedback) structure;
Stock and flow	4) Stock and flow; 45) Integration
Systems Behaviour (dynamics)	7) Dynamics (behaviour) of a system; 8) Modes (patterns) of behaviour; 9) Systems archetypes; 23) Loop dominance (shifting)
The idea of a model	6) Idea of a model; 33) Model boundaries, absence of real boundaries; 37) Model utility, validity, knowledge validation
Systems properties	10) Properties (principles) of systems; 12) Time, delays; 25) Hierarchy; 31) Systems constraints; 32) Non-linearity; 34) Resilience; 35) Self-organization
Systems thinking	14) Systems thinking; 49) Process thinking
Systems ethics	38) Systems ethics
SD theory of decision-making and goal-oriented behaviour	30) Decision rule, decision; 47) Theory of decision-making; 46) Components of rates: goal, apparent condition (observation), discrepancy and action;

Appendix E

Appendix E contains the CLDs which illustrate all SD concepts which were found to be represented in Buddhist philosophy along with their Buddhist counterparts. The CLDs are presented according to the main sections of the *Comparison of System Dynamics and Buddhist philosophy* chapter.

"Dependent Origination 1": Mutual Causality (Feedback) and Systems View

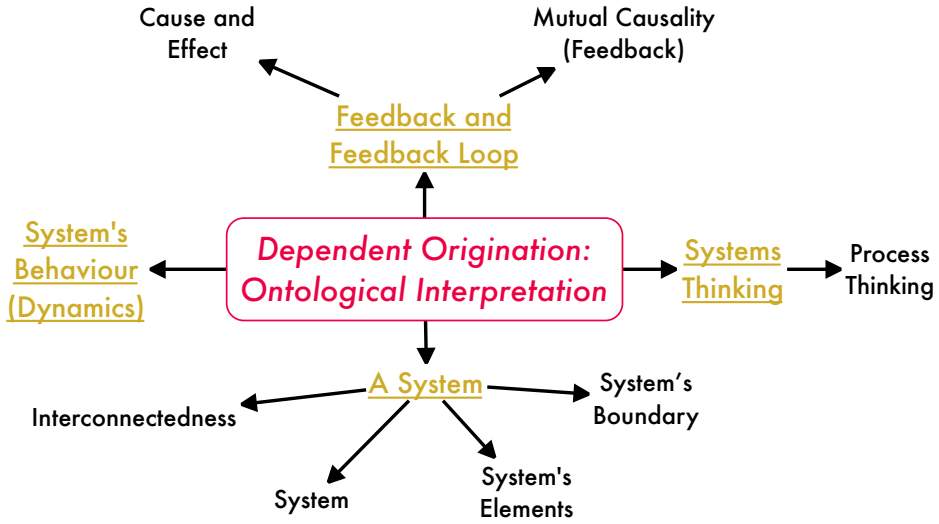

Figure 4. Mutual Causality and Systems View

"Dependent Origination 2": Mental Models and Relativity of Knowledge

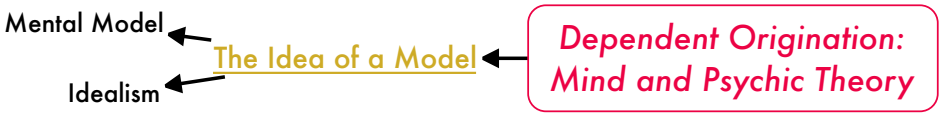

Figure 5. Mental Models and Relativity of Knowledge

"The Promise of System Dynamics" or how much Religion is there in SD?

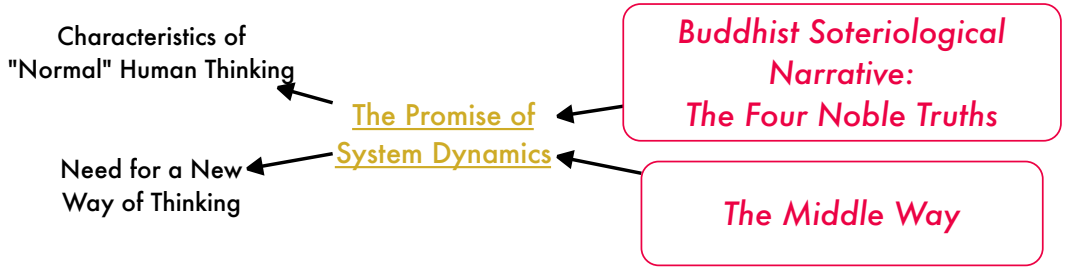

Figure 6. Soteriological Narratives

Non-Dualism in Buddhist Philosophy and System Dynamics

Figure 7. Non-Dualism

Systems and Buddhist Ethics

Figure 8. The "Interrelatedness Ethics"