What Do We Know About Renewable Knowledge and Sustainable Societal Growth? A Scoping Review

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Abstract. This paper presents a qualitative evaluation of the possible transition from basic knowledge to renewable knowledge, addressing knowledge assets as renewable resources. The paper elaborates on positioning knowledge, acquired from various actors in Society, at the core of its processes, fostering sustainable societal growth. A scoping review of the literature is presented, to explore the value and relevance of the "renewable knowledge" topic within the lens of the socio-technical agenda. The paper evaluates existing literature and extracts actionable knowledge for societal development, business performance, and further development of intelligence in systems. Our findings produce a first intention to formalize a knowledge base for data commons to help in the production of renewable knowledge. Further, using technology and automation artifacts, human actors may combine their skills to create new knowledge in the form of Information Common Goods. Data exchange, management, re-use, sharing of information and responsible management of common data are key drivers of the evolution of societies, the progress of humanity and competitiveness.

Keywords: knowledge · renewable knowledge · information common goods.

1 Introduction

Knowledge is a universal natural resource and a global public good [46]. Unlike most other resources, knowledge is not just abundant; it is infinite. As Thomas Jefferson once famously wrote: "*... an individual may exclusively possess [an idea] as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of every one, and the receiver cannot dispossess himself of it. Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it ...*[3]". Since Tavistock Institute of Human

[3] http://press-pubs.uchicago.edu/founders/documents/a1_8_8s12.html

Relations in London formulated for the first time the socio-technical ideas, in the 30s, scholars have considered the advancement of action research aimed to increase human knowledge while improving practice in work situations [53], [17]. For some, knowledge simply defines an awareness or familiarity gained by experience of a fact or situation. For others, knowledge has become the most important renewable resource [15]. The Knowledge-Stream model, introduced in [13], is grounded on three analytical levels: the (socialized) individual; the social structure (both at micro scale - any community, and at the macro scale - the whole society itself); and the human genre, where we situate Knowledge (in whatever form). Processes belonging to these three dimensions show a different essential nature, but all of them take part in the same flow "in the sea" of knowledge production, the Human Knowing. Today, there are many attempts to connect the socio-technical based thinking to different classes of renewable (natural) resources, such as energy, that is to be regenerated or replaced by ecological processes on a relevant timescale [23]. Starting with the celebration of the International Day of Education, on 24 January 2020, the definition of "renewables" extends to include education and the learning induced by its processes as the "greatest renewable resource" at the societal level. Socio-technical design principles must leverage knowledge sharing between and across actors in a system to democratize their skills and improve on their abilities, whereby, information must go to contexts of action and become actualized during change [17]. The socio-technical approach provides that social and digital would interfere consciously and naturally. The idea of the "*Social utility of Digital*" introduced in [26] represents the very legitimacy of digital in the eyes of society, presenting the notion that "*the parties involved need a common cognitive basis to appreciate the contributions of others and to be relevant to co-construct the practices that will be exercised through digital means*".

Digital age advocates prescribe considerations of how technology empowers societies to collect, diffuse, and interpret knowledge. These socially situated knowledge artifacts influence social practice and develop into building blocks of socio-technical systems for improving the common good of society through the democratization of knowledge [14]. Thus, knowledge artifacts, created and used in social and economic practice, are the constituent elements of a sustainable societal system [44]. These artifacts are products of their moment and hold an expiration date; they must be renewed and updated to remain of relevant value. New ideas propel prosperity, and societal and scientific progress rely on knowledge. Knowledge is endlessly renewable. Over time, knowledge needs updating. Case studies have demonstrated the usefulness of combining material, human and symbolic resources in organizations to enhance the renewal of knowledge [48]. However, the lack of continuity and adequate knowledge-retention in societies can lead to a decrease in tacit knowledge, the fall of societal opportunities for growth and loss of sustainability [7]. In sustainable societies, it may lead to the demise of the societal opportunities for growth [30]. This is a paradigm shift from succinct knowledge elements of a finite physical resource to one of the infinite potential of renewable knowledge.

Section 2 presents the motivation of the scoping review on exiting literature and the working methodology of this endeavour. Section 3 details main findings and draws some considerations on the connection between renewable knowledge and data commons. Section 4 introduces a short discussion on actionable knowledge extracted for the production of renewable knowledge and its transformation to information and knowledge commons. Section 5 concludes the paper.

2 Review of the Existing Literature

The study of renewable knowledge is hampered by the lack of holistic research on the existence of validated methods for assessing renewable knowledge, the knowledge management systems used, the creation and piloting of effective methods for operationalizing knowledge management systems and their adequacy to the reality of today. Based on this premise, this article argues that the literature is deficient, to some extent, in terms of the correlation between theory and practice. The article focuses on how certain paradigmatic and methodological trends in the re-search of renewable knowledge are identifiable, how they emerged and how they were validated by researchers, and proposes a review of the main specialized works, which may represent a valuable source of inspiration for practitioners in the field.

2.1 Scoping Review

First, we frame our introduction in the context of renewable knowledge. Then, we conduct a review of the literature by searching for papers written in the English language including *renewable knowledge* as a keyword. We have searched relevant electronic databases (Google Scholar, Scopus, Web of Science, PubMed, Scite-Press, IEEEexplore), grey literature, and discipline-based white papers, with no defined date range. After isolating 181 articles and publications, we read them, in full, then check for relevance, rejecting patents and citations, removing duplicates, and restricting the review to papers relevant to our study. We have found that the literature often confuses the terms "*renewable energy knowledge*" with the term "*renewable knowledge*". The first refers to knowledge about renewable energy and the latter indicates the "renewable" attribute of knowledge. In Miremadi et al. [32], for example, the authors use the term "renewable knowledge" referring to knowledge about renewable resources. We pay specific attention to distinguish these two forms of use. In our search, we focus on the meaning of the expression "renewable knowledge" that specifically point to the "renewable" attribute of knowledge. Consequently, we single out 28 papers for our work, as they treat directly concepts of "renewable" as an attribute of knowledge. We then collate and summarize the research map according to key themes by grouping the findings into contexts of use. We use these papers to formulate our discussion.

2.2 Data Charting Observations

From an initial analysis, the concept of "renewable knowledge" had gained increasing interest with two thirds of the identified papers published over the last decade (2010 – 2020). Publications are mostly case studies (24), balancing being conceptual work (3) and literature reviews (2); appearing in journals, conference papers, industry white papers and books. The context is universal (United States; GCC & Middle East; Asia Pacific; Europe; Africa; IEA Countries and New Zealand / Australia). The setting is varied, including education, social studies and human development, technology management, enterprise and business management, manufacturing and product development, public services an NGOs, medicine, disease and disaster management. Notably, the findings connect renewable knowledge to big data and the concept of information common (Appendix Table 1).

3 Findings

"Renewable knowledge" is a term that refers to knowledge assets as a renewable resource [33], [4], [5]. A renewable resource is subject to environmental interactions that cover a range of activities, from the extraction of raw materials for production and distribution, through the use, and reuse [25]. Therefore as a renewable collective asset [12], knowledge takes a hierarchical structure consisting of: data, information, knowledge and wisdom [28]. Findings are summarized according to key themes that represent *the context of use* (CofU) of the expression "*renewable knowledge*":

- (**CofU 1**) For Societal Development: Education, literacy and skill building, social interaction, and for sustainability and disaster preparedness:
- (**CofU 2**) For Business Performance and Competitiveness; powering a knowledge economy and sustainable economic development
- (**CofU 3**) Implementation of Expert Systems in Support of Renewable Knowledge

3.1 CofU1 - Renewable Knowledge for Societal Development

The transformation from basic knowledge to renewable knowledge serves as catalyst to the process of social development [8] and an essential element in conflict resolution [50]. The youth has become increasingly interested in social is-sues, following news and information sources on customs and traditions and keep up with the fast moving knowledge landscape that drives inherent societal values in seeking renewable knowledge [2]. Biao underscores the need to motivate the citizens' continuous learning, "*providing them with flexibility in acquiring some amount of renewable knowledge necessary to lead both a productive and fulfilled life*" [9]; a new national education system that combines formal and non-formal learning to keep abreast with fast societal changes, would be necessary, he argues. Research on improving societal participation has promoted programs that

build the required thinking skills required to address the flood of renewable knowledge [39]. "*The ability to think clearly and rationally is essential whatever human beings choose to do, hence, knowledgeable thinkers are more likely to achieve success, solve problems and make correct decisions for life than ordinary people*" [ibidem]. Viewing renewable knowledge as a promoter of value of the human capital, some educational institutions regard knowledge "*as a coherent body of concepts, principles, theories and research methods raising the learner's ability to discover self-renewable knowledge and to produce new knowledge*" [29]. Action research, for instance, is both professional development and knowledge production [52], providing not only a renewable knowledge base for teaching, but also the foundation and vehicle for assessment of teaching practice. In sustainable societies, reducing the economic and social impact of disasters is critical. Our exploration has found that renewable knowledge is essential in improving the ability to take actions that to rapidly determine the nature of the impacts and chart ways for remediation. These disastrous events require a continuously renewable knowledge base to compensate for the complexity and variability of the conditions [10].

3.2 CofU2 - Renewable Knowledge for Business Performance

The economist Paul Romer showed how knowledge and information as a resource create economic growth [42]. Knowledge is a business product. "*Educational and innovative intellectual products and services can be exported for a high value return or as a productive asset*" [28]. Our review shows evidence that "*renewable knowledge*" drives the knowledge economy [3], for a sustainable economic development [34] that ensures the permanence of innovative organizations, and does not deplete by use. The need for renewable knowledge varies by industrial sector, often determined by technological, organizational and environmental factors. Our search has found examples in the pharmaceutical [24], veterinary [31], healthcare [45], education [40] and construction [16] contexts, where companies constantly search for available and renewable knowledge, from various sources, to advance their initiatives, research and value contribution. The resource-based view perspective supports the notion that possession of unique knowledge can be seen as a strategic resource, which provides the foundation of competitive advantage [22]. Firm activities emphasize sustainable, renewable knowledge-based barrier to competition, improving client base [55] with positive impact to employee performance and customer satisfaction [43]. From an organizational learning perspective, knowledge is the product of a learning process, which ensures continuous adaptation [6]. Information integration is an important issue in supporting integrated and concurrent product development of which renewable knowledge is an essential dynamic component [54].

3.3 CofU 3- Renewable Knowledge for Intelligence in Systems

Knowledge is a kind of human capital simultaneously produced and consumed [35]. This notion of renewable knowledge suggests a convergence of social-cultural

and technical systems [45]. Expert systems support renewable knowledge and are enabled by the perpetual cycle of knowledge creation. Our review uncovered examples of renewable knowledge in online learning knowledge engine [15] and intelligent search engines providing access renewable knowledge in library systems [27]. The literature has indicated improvement in effectiveness and efficiency of online learning support technologies using Artificial Intelligence (AI) techniques to drive renewable knowledge in the online learning knowledge engine and explore the economic value of reusable online support [15]. Elsewhere, evidence that construction processes use expert system to renew the knowledge base [16], surveillance systems seamlessly integrate modelling for data conversion, research and analytics that create new models with increased accuracy [51]. Such system integrates 2D and 3D models of facilities, virtual reality, knowledge management, geographic information systems, live camera feeds, chemical plume modeling, emergency text-messaging notification, and intelligent agent technologies. Knowledge regarding the factors of disease management and epidemics is essential to treatment and must be managed with continuous knowledge renewal so it could be easily and effectively exploited by the parties concerned.

3.4 The Concept of Data Commons

Knowledge is valuable when produced and held collectively by people working in groups referred to as communities of practice [12]. Renewable knowledge bases provide key guidance for industry and society with the formalization of the knowledge base for a data commons [4], [5]. Baarbé found that an "agricultural data commons" model would give greater support to the "*three key stakeholders in agricultural data: data contributors, who need engagement, privacy, control, and benefit-sharing; small and medium-sized-enterprise (SME) data collectors, who need sophisticated legal tools and an ability to brand their participation in opening data; and data users, who need open access*" [5]. This "data commons" concept is a collection of knowledge artifacts that must be renewed, and made continuously available for exploitation by the concerned parties. For instance, firms and large producers collect and organize information about food security into renewable knowledge base to support smaller farmers and distributors [4]. A renewable data set that is current constitutes a collective knowledge source to the community of practice, ensuring access equity to a meaningful and sustainable system for smart working [7]. These commons could form intelligent elements in support of human intelligence to maintain a sustainable ecosystems [33]. Humanity has often relied on organizing information from a renewable knowledge base to ward off disasters and ensure a minimal sustainability. In disaster management and preparedness, timely, accurate and current (i.e. renewed / renewable) knowledge of a disease for instance is essential to the success of treatment of pandemics and seasonal outbreaks [19]. The use of knowledge management system that is replenished, curated, analyzed and transformed into useful information is crucial. A cumulative knowledge stock give insight into temporal changes in information [10], enriching the ability to predict certain anomalies, events and

disasters. Data sources might range from sensors and automated devices (IoT devices for instance), to include social media feeds, scientific studies, news bulletins and public service agents. Further, changing economic, social and environmental situations give rise to non-traceable changes in knowledge [1], presenting significant challenges to usefulness of the knowledge artifacts. Major hurdles for renewable knowledge are connectivity, collaboration, content and capacity of the actors in the knowledge ex-change ecosystem [41].

4 Discussion

4.1 Production of Renewable Knowledge

The production of renewable knowledge relies on complex socio-technical systems: "*systems that involve both complex physical-technical systems and networks of interdependent actors*" [18]. The notion of renewable knowledge production is a process that cycles data elements, collected by some actors in the system, processing them through analysis by intelligence actors (such as artificial intelligence algorithms, machine language processors). Using technology and automation artifacts, data elements are organized, then transformed into information. Driven by the need to consume this new information, the human intellect converts it into explicit knowledge for exploit by other stakeholder actors in the system. Explicit knowledge converts to tacit [36], thus growing the skills and capabilities of the stakeholder actors through knowledge integration [49]. The human actor/host reinvest these skills into their ecosystem through societal, scientific and economic contribution creating new knowledge in the form of "information common goods" , that can be integrated in a dynamic information management system, designed for the target population of the community of practice [19]. The cycle restarts with new data entering the cycle and moving through the stages of transformation, renewing the information and knowledge assets while building new skills and increasing the contribution (Fig. 1).

Considered as a renewable knowledge fund, common data can help monitor and assess citizens' impact and response to decisions and actions, and can help improve citizens' participation in the use of data with benefits for transparency, responsible civic response and, finally yet importantly, to a better return on in-vestment of long-term effort and resources.

4.2 Information and Knowledge Common Goods

Building new "common knowledge" has its origins in collective action, free exchange of ideas, and collaboration in the interest of the common good [11]. In philosophy, economics, and political science, the common good refers to either what is shared and beneficial for all or most members of a given community or achieved by collective action, and active participation of citizens and stakeholders [37]. The commons paradigm refers to a set of social norms and rules and legal mechanisms that allow people to share ownership and control over re-sources

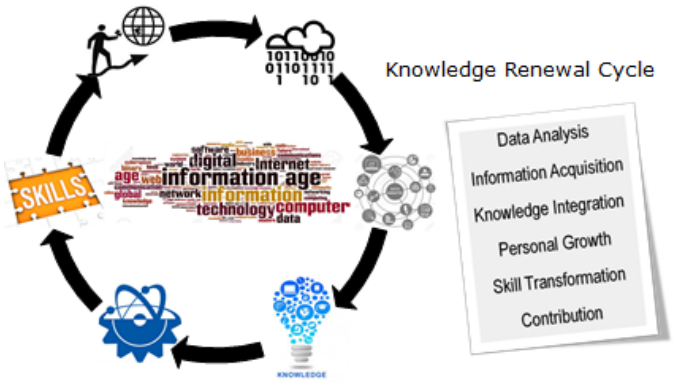

Fig. 1. Knowledge Renewal Cycle.

[38]. The public good evaluation matrix concerns a set of complex, qualitative and humanistic criteria, such as moral legitimacy, social consensus and equity, and transparency in decision-making.

Data commons could be an infinite source of data for practice in science and research in the form of data science as a service [21]. Database management systems turn unorganized data into purposeful data, used by applications and systems to process data into understandable information. Human actors in society consume these information elements, and only then, we achieve knowledge integration and create value. The notion of "common knowledge" offers extensive opportunities to introduce a new narrative needed to convince decision-makers and the public of promises of an approach that is neither private nor governmental, but based on collective actions and interests and equitable access, free expression and correct use of a shared knowledge base and various knowledge assets. Knowledge commons are not synonymous with open access, although the content and community network of the open access movement, according to Suber [47] and Ghosh [20], are types of Commons. Knowledge, which may seem so ubiquitous in its digital forms today, is, in fact, more vulnerable than ever. Renewable knowledge become the main component of an information common goods ecosystem. The future social-technical systems for knowledge management depends heavily upon the rapid emergence of information common goods and the capacity of different components of the systems to integrate human, machine and event generated data into meaningful, renewable knowledge artifacts, that are fit for use and purpose.

5 Conclusions - Looking into the Future

This paper explores in the aim of clarifying: ***What do we know about renewable knowledge***? Our paper is a scoping review of the published works using the term "renewable knowledge" in an effort to gain more insight into its

use, meaning, implications and context. In the age of digital, understanding and addressing common knowledge continues to raise many dilemmas. Knowledge in the age of globalization and democratization of information with the support of technology involves a conscious and balanced relationship between common knowledge and knowledge shared in a distributed system, to ensure the preservation of the heritage of knowledge, democratic access to it, but also respect for property rights rules. In order to maintain the competitive advantage, organizations have understood that it is more efficient to invest in a coherent process of knowledge development, establishing a harmonious relationship between process design, product development and the skills, values and knowledge base of human actors.

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6 APPENDIX

Table 1. Data Charting.

Timeline	**# Studies**	**Geographical context**	**# Studies**
2000 & Prior	1	United States	6
2001 - 2005	3	GCC & Middle East	5
2005 - 2010	2	Universal	4
2006 - 2010	4	Asia Pacific	4
2011 - 2015	11	Europe	4
2016 - April 2020	7	Africa	3
		IEA Countries	1
		New Zeeland / Australia	1
Study Type	**# Studies**	-	-
Case Study	23		
Conceptual	3		
Literature review	2		
Publication Type	**# Studies**	**Industry Setting**	**# Studies**
Journals	13	Education	6
Conference papers	8	Enterprise and business management	4
White papers	3	Technology management	4
Books	2	Manufacturing & product development	3
Position papers	2	Social studies & human development	3
		Public services and NGOs	3
		Big Data & the information common	3
		Medicine, Disease & Disaster management	2