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Original Research

A Shift in Discourse Towards 'Public Understanding of Sustainability Science' (PUSS)

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Abstract

Science represents the body of knowledge which has been shaping the world, and it forms the basis of every discipline ranging from the core science to philosophy. Fundamentally, the understanding of science is two-fold, where one is related to the science of the common people while the other is related to high-order scientific ideas, theories, and research. In this era of the fourth industrialisation, the challenge is not limited to the training of top scientists but to making science accessible to every one by bringing science to the lay public. This is where the 'Public understanding of sustainability science (PUSS)' represents a key concept as it aims at transforming the lay public into informed citizens with the appropriate knowledge, know-how, skills, attitudes, and values required to understand and face current and future challenges such as the energy crisis, climate change, emergence, and re-emergence of new epidemics, using an integrated approach. The 'Public Understanding of Science (PUS)', as a dimension, originated during the late 1980s from the concept of 'science literacy' as a response to the public deficit discourse at that time, where the focus of science was shifting from knowledge to attitudes. And during the last decade, the public deficit discourse on trust deficiency shifted the paradigm from PUS to 'science in-and-of society'. However, today the discourse

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has reached a new dimension where the public trust deficit is already being questioned and challenged. As a response to such discourse, this case study analysed the current public interrogations and challenges using the 'co-production of knowledge model' with the lens of the public deficit theory to better prepare the public to face current and future challenges. Consequently, the PUSS has been identified as the new paradigm to address the current public deficits.

Keywords: *Public deficit theory; Science literacy; Science in-and-of society; Sustainability science*

Introduction

Today, science has diffused and pervaded every sphere of our society in such a way that everything directly or indirectly depends on science. It is therefore imperative to transform the current population into a scientifically literate populace as a lack, or insufficient understanding of science excludes people from the discourse of modern society, from understanding the world within and around us, from understanding and responding to challenges and global issues (Atchia, 2019) such as climate change, energy crisis, emergence and re-emergence of epidemics.

Though there is a real need for trained scientists to understand, face and address such challenges, any attempt will be unsuccessful without the lay public (Wilsdon & Willis, 2004). Therefore, there is a real need for a scientifically literate population with the proper scientific understanding, skills, and attitudes. However, it is noted that despite several and continuous attempts to transform the lay public into a science-literate populace, in terms of 'science literacy', 'public understanding of science' and recently 'science in-and-of society', the lay public still lacks a proper understanding of science (Arifin & Zahiruddin, 2017). In fact, such lack is showcased not only by internationally recognised surveys such as PISA (Programme for International Student Assessment), TIMSS (Trends in International Mathematics and Science Study) and PIRLS (Progress in International Reading Literacy Study) but in the daily actions of common people or during crisis conditions. In fact, as Dhakal (2017) reported, transforming people's learning attitude is challenging in the case of teachers as well.

For instance, with the current COVID-19 pandemic, the lack of proper understanding of science is having a major impact on the life of people and the ability to contain the spread of the disease. Without a proper understanding of science, the public (i) cannot dissociate himself from the fake news that is flooding the social media and thus end up creating false panic crises, and (ii) cannot understand the underpinning logic behind the enforced sanitary measures (such as social distancing and wearing of masks) and thus indulge in actions that can be fatal for themselves and to the society. In fact, Marin (2020) stated that "the COVID-19 pandemic has been accompanied on social media by an explosion of information disorders such as inaccurate, misleading and irrelevant information" (p.79). Similarly, such irresponsible attitudes toward spreading fake news on social media have been associated with the anthropogenic effects on the environment for a long time back (Luo & Hancock, 2022).

Despite attempts to provide proper formal and informal science education to transform the public into a scientifically literate populace, both empirical data from surveys and people's attitudes show that the transformation has not been successful. Consequently, in the actual conjuncture, this case study analysed the current public interrogations and challenges using the 'co-production of knowledge model' with the lens of the public deficit theory to better prepare the public to face current and future challenges.

Literature Review

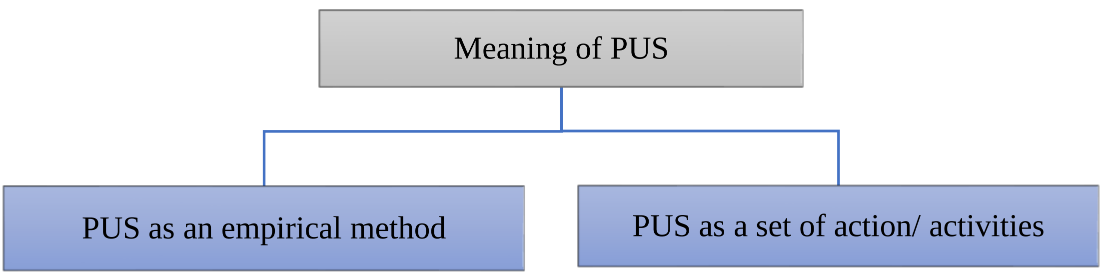
The 'Public Understanding of Science (PUS)' has become a standard dimension in studies and discussion at the international level. PUS has reached many spheres of research and is being used in terms of longitudinal trends, comparison across different publics and countries, and extensively to invoke policies and strategies for public engagement with science (Bauer et al., 2012; Bucchi & Trench, 2014, 2016). This section describes the meaning, importance and evaluation of PUS.

A: What is 'Public understanding of Science'?

Analysis of the three terms 'science', 'understanding' and 'public' is essential to capture the meaning of PUS. Though science is too diverse and too protean to be captured in a single definition, Ziman (2004), in his book '*Real Science: What it is and what it means*' has described '**science**' as 'the body of knowledge generated from several disciplines which lead to understanding and investigation of the natural world. Considering the word '**understanding**' in PUS, the focus is on comprehension of facts, situations, and processes and not on the mere remembering of facts. However, understanding science is subjective. It depends on many different factors such as the purpose, individual's level of education, occupation, interest, and responsibility. PUS, with the emphasis on '**public**', brings the focus on the predominantly non-scientific populist. Thus, PUS is basically related to attitudes, behaviours, opinions, skills, activities, and engagement that comprise the relations between the common people of the public to scientific knowledge and methods.

Furthermore, Bauer (2014) stated that the term 'public understanding of science' (PUS) has a dual meaning, as represented in figure 1.

Figure 1
Dual Meaning of PUS According to Bauer (2014)



The **first** meaning of PUS refers to social research that investigates, using empirical methods, what the public's understanding of science might be and how this might vary across time and context. The **second** meaning covers a wide field of activities that aim at bringing science closer to the people and promoting PUS in the tradition of public rhetoric of science.

B: Importance of PUS

Science represents the body of knowledge which has been shaping the world (Hillis, 2002) and is considered an auxiliary discipline for every other discipline ranging from Mathematics to philosophy (Wersig & Neveling, 1975). In fact, the world would not have been the same without science.

However, the biggest challenge today is not to produce scientists who master contents like genomics, proteomics, black holes, robotics, and nanotechnology as progress in these scientific fields is tangible and is paving the way forward to meet our quest to better understand the world. Today, the challenge is to make sure that science is taken seriously and accessible to **everyone** because science has been taken for granted for too long, breeding a widespread complacency. One way to overcome this complacency is to improve the 'public understanding of science' (Riesch & Potter, 2014), which aims at transforming the lay public into informed citizens with the necessary scientific knowledge and understanding and the 21st Century skills needed for decision-making, participation in civic and cultural affairs, economic productivity, and political debates (Turiman et al., 2012). Collins and Bodmer (1986) even stated that in a technology-driven society, the PUS is essential to derive maximum benefits for our health, wealth, and welfare from the continuing scientific revolution.

In fact, Atchia (2019) categorised the importance of PUS into four categories, namely individual, institutional, national, and international levels, as follows:

Importance of PUS at a personal level: The following are a few examples of how PUS is important for everyone. PUS transforms an individual into an informed citizen with the ability to (i) appreciate the nature of science, (ii) understand the world within and surrounding us, (iii) develop 21st-century skills and inquiry skills such as observation, analysis, exploration, evaluation, communication, creativity, and problem-solving in a systematic and scientific manner, (iv) develop scientific attitudes, values, and ethics and (v) make informed decisions based on reliable scientific analysis of data.

- PUS allows an individual to integrate scientific skills and know-how within his/her specific field activities. This interdisciplinary focus propels the individual into a higher-order sphere of involvement where everything may happen. For instance, the blending of science and entrepreneurship may lead to the development and creation of products of unimaginable market value. Thus, PUS provides multiple opportunities to the informed individuals.
- PUS improves the quality of one's life. Basically, the understanding of science informs one's decisions on a wide variety of personal issues with underlying scientific concepts such as dieting, smoking, vaccination, screening programs or safety at home and at work.
- Science and technology influence the individual's daily life in a variety of ways in our gadget-filled, technologically based society. Ignorance of elementary

science cuts off the individual from understanding and using such tools and services.

- PUS transforms people into the reflexive practitioner, bringing improvement in their daily tasks and activities.

Importance of PUS at the institutional and national levels: Analysis of the literature revealed that there is a strong positive ***correlation*** between public understanding of science and national prosperity. In fact, some benefits provided by PUS at the institutional and national levels are as follows:

- PUS has a crucial role in imbibing scientific knowledge, skills and attitudes in the people representing the workforce, higher public and private officers, policymakers, and politicians. Actually, the proper understanding of science by such stakeholders is fundamental to addressing institutional and national issues, which are often scientific issues with social and political implications or political and social issues with scientific implications. Some common examples are pollution, waste disposal management, water supply, vaccination, energy crisis, war, prescriptible drugs, ageing population and issues related to manufacturing or service industries. In fact, all national or public issues have scientific or technical dimensions.
- Strong economies depend on a strong but dynamic manufacturing industry, where there is daily emergence of new technologies to cater for the national economic demands. Thus, PUS has a compulsory role as the workforce needs to constantly adapt to such changes. In effect, resentment or indifference to science and technology by the workforce at any level (low, middle, and senior) weakens the nation's industry.
- PUS has a crucial function in providing empirical data to policymakers. Empirically and scientifically based policies are better accepted by the population and thus facilitate the implementation of policy decisions.

Importance of PUS at the international level: At the international level, all goals, targets and resolutions taken by international instances drive what is happening in the world. Whether the sustainable development goals of UNESCO or resolution from the G20, decisions and targets should be scientifically sound due to its implication for different countries of the world. Therefore, decision-makers at international levels need to have a good understanding of science to find solutions to international issues such as climate change and energy crises.

C: Evaluation of PUS

This section covers the 'Public Understanding of Science' as an evaluation tool, in line with the first meaning of PUS described in figure 1. It describes the main instruments used to collect data on PUS and the key findings obtained from the data analysis. Thus, it exposes PUS in the context of social research that investigates and evaluates, using empirical methods, what the public's **understanding** of science might be and how this might vary across time and context.

D: Instruments for measuring PUS

The use of reliable instruments to capture PUS is crucial as the data are used to inform and guide decision-makers in designing the appropriate action plans with the aim of transforming the public into informed citizens with the knowledge, skills, attitudes, and values needed to face actual and future challenges.

Among many instruments used to capture the PUS, Bauer (2008) listed some of the main and uncontroversial surveys used among the adult populations since the 1970s. These surveys were implemented on a significant sample size of 1000 or more adult participants. The most common surveys done on the PUS are (i) The United States National Science Foundation indicator series used since 1979, (ii) the Eurobarometer (Director General Research) series used since 1978, covering initially eight and recently 32 European countries, (iii) the national United Kingdom (e.g. Economic and Social Research Council, Office of Science and Technology, and the Wellcome Trust) and the French series (e.g. Centre for Political Research at Sciences Po 1989 and 1993) reaching back to mid-1980s and early 1970s respectively, and (iv) the four surveys carried out by the Commission of the European Communities (CEC) and by American organisations in eight countries of the European Community and Luxembourg, since 1977.

The earliest survey of this kind seems to date from 1957 in USA (Michigan: Withey, 1959). Later efforts came from Canada (Management Survey Team), New Zealand (Management Survey Team), Malaysia (Strategic Thrusts Implementation Committee), India (National Council of Applied Economic Research), China

(Management Survey Team, and the China Association for Science and Technology), Japan (National Institute of Science, and Technology Policy), Brazil (National Council of Scientific and Technological Development, and the São Paulo Research Foundation the) and Latin America in general (Network for Science and Technology indicators).

Many countries have set their own tools and instruments to measure the PUS in their specific context. However, they have been working in isolation until international instances have grouped different countries with the same cause. For instance, COPUS (Coalition on the PUS) is a grassroots effort linking universities, scientific societies, science advocacy groups, science media, science educators, businesses, and industry in a consortium having as its goal a greater public understanding of the nature of science and its value to society. In fact, 52 organisations have signed up to participate in COPUS and Year of Science 2009 initiatives.

As school plays an important role in PUS, the emergence of instruments to capture adolescents' understanding was inevitable. Indeed, national and international surveys emerged and culminated in an international assessment of scientific literacy. In 1995, the 'Trends in International Mathematics and Science Study' (TIMSS) was the first survey to be run among adolescents in the age group of 10 and 14 years old. The survey is implemented every four years on students. In the year 2000, a new survey termed PISA (Programme for International Student Assessment) was run and repeated on three years basis. The targeted group is fifteen years old students representing those reaching the end of compulsory secondary education. The implementation is managed by the Organization for Economic Cooperation and Development (OECD). Moreover, it should be noted that there are international moves towards the standardisation of the surveys. A complete inventory of relevant national and international surveys remains to be done.

E: Main findings on PUS

Analysis of the literature and reports on PUS surveys and interviews revealed several pertinent pieces of information, representing key baseline data that inform policymakers and other stakeholders on the way forward of PUS.

Several reports highlighted that the majority of the general public, both adults and adolescents, have limited basic scientific knowledge which was derived from what was acquired through their school science subjects. This supported Roth's (2004) propositions of rethinking science education as and for participation in the community for many, science literacy equates to school science knowledge.

However, it is noted that the public is more knowledgeable in some specific areas such as human welfare, especially medical science and food production, compared to areas such as space exploration and defense research, collaborating with the findings of Weinberg (1963). These specific areas are termed ‘public interest’ as the public is more informed on issues which interest them. Such public interest has been strongly correlated with the media (Croteau et al., 2006), which has a central role in informing the public about what happens in the world, particularly in areas such as science in which the public does not possess direct knowledge or experience.

Although the public showed greater interest in specific scientific fields, they highlighted that science has an important role in the life of everyone. In fact, analysis of the reports revealed two major schools of thought when considering the public perceptions of the importance of science in people’s life. The first school of thought represents optimism, where the public are convinced that science had been and would continue to be one of the most important factors in improving people’s daily life. The second school of thought represents the pessimistic perspective that science could also have very dangerous effects on society at large. Despite the apprehension, participants interviewed unanimously expressed their need to know more about science and to have a better grasp of the details of scientific and technical developments, processes, and methods. Basically, they believe that the proper understanding of science is crucial in both conditions as it prepares them for opportunities that science brings and, at the same time, prepares them to face challenges derived from the dangerous effects of science.

The reports also highlighted that the PUS is not static (Driver et al., 1996). It has a dynamism which evolved with scientific and technological advancements. Moreover, the dynamism in the understanding of science is ignited by different factors ranging from nationality, age, educational background, or political views of participants. Although the basic knowledge and understanding of science are easily captured by social research, the philosophy of science remains very subjective and difficult to be captured through the available instruments.

Among the many other conclusions derived from the PUS surveys, one of the most important remains undoubtedly related to discourses. It was indeed noted that there is a public deficiency in science understanding, attitudes and trust, leading to major discourses.

Theoretical Framework

To situate the discourse and understand the hurdles which are preventing the transformation of the Mauritian population into a scientifically literate populist with the basic scientific knowledge, know-how, skills, attitudes, and values needed to face current and future challenges, the 'co-production of knowledge model' articulated by Callon (1999) was used in this study. The model was derived from Callon's 'deficit' and 'public debate' models, as described below.

Figure 2

The Deficit Model

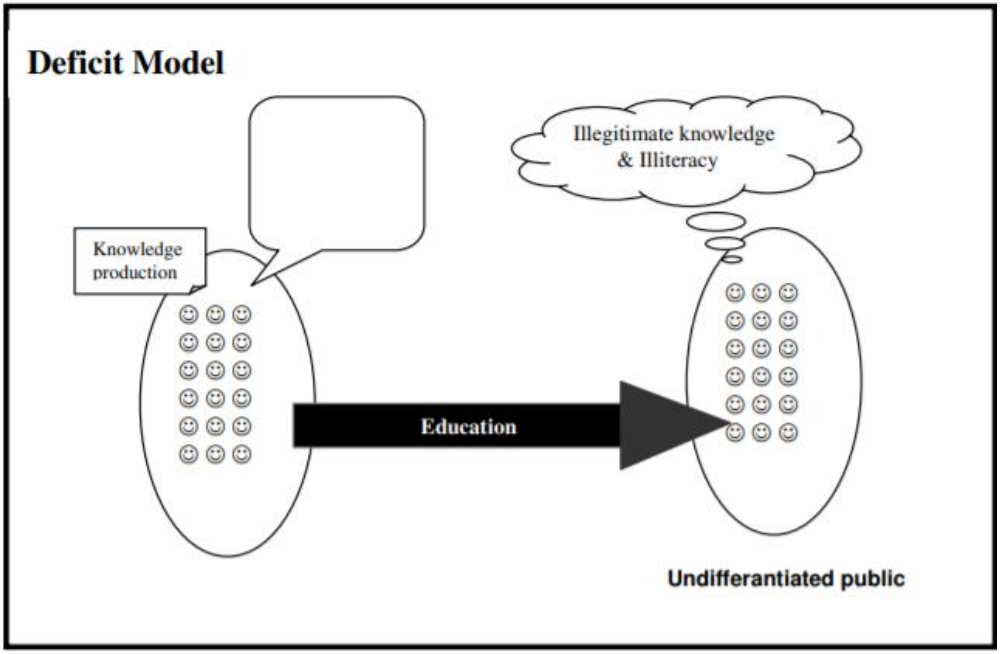


Figure 3

The Public Debate Model

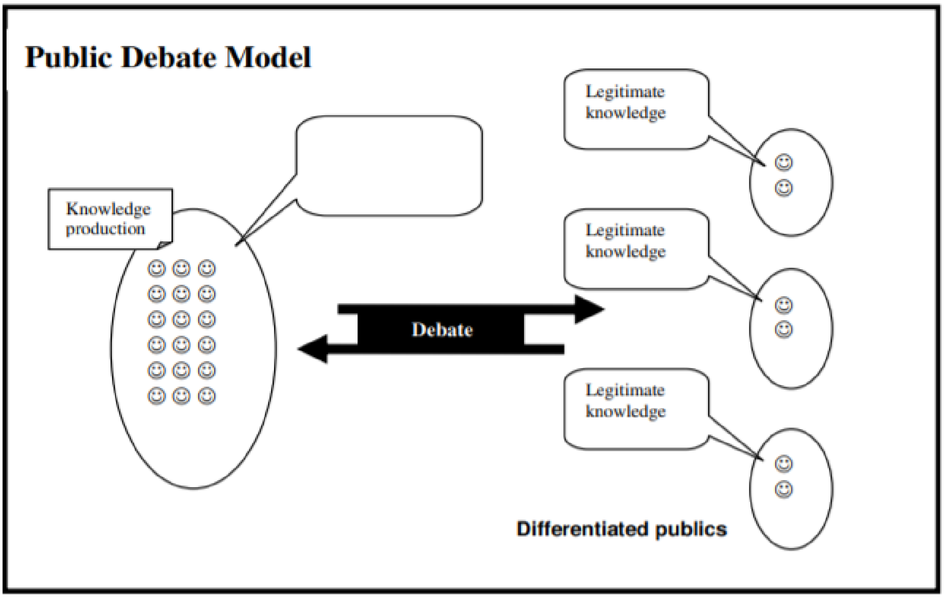
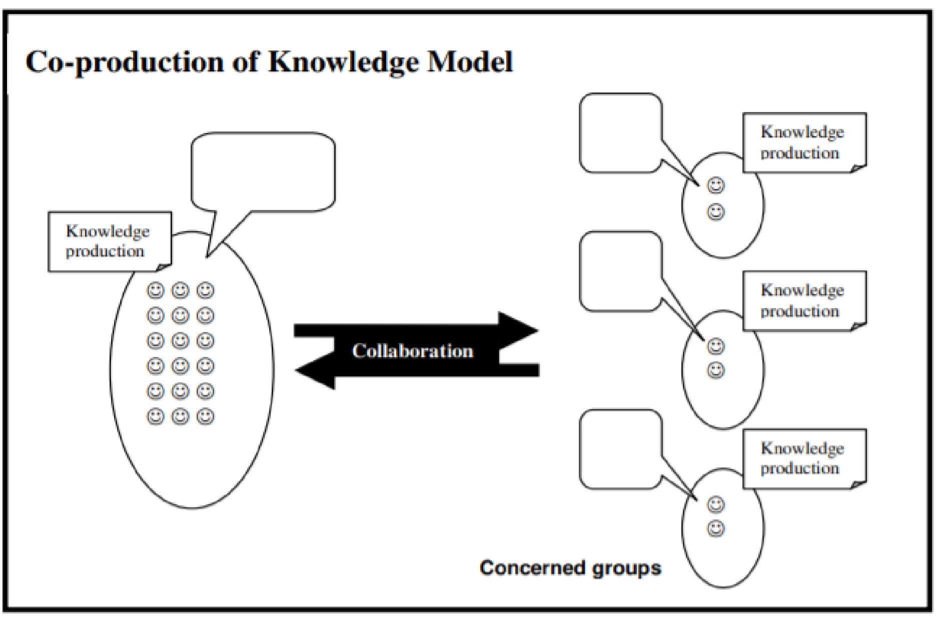


Figure 4

Co-production of Knowledge Model



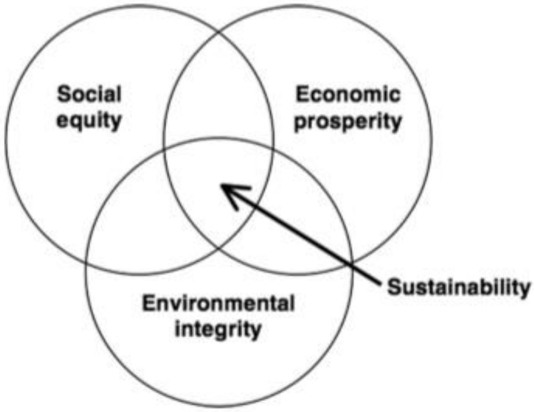
Though the three models focus on knowledge production, the flow of knowledge varies. The ‘deficit model’ with a unidirectional approach from scientists to citizens was replaced by the ‘public debate model’, which allows scientists and citizens to interact in spaces of public discussions. However, the latter does not necessarily allow citizens to express their views but instead forms sub-groups having occasionally divergent opinions (Pouliot, 2009). As both models do not recognise citizens’ competency in respect of the production of scientific knowledge, the ‘co-production model’ was articulated, which ascribes to citizens the cognitive and discursive competencies required for the creation of knowledge (Pouliot, 2009).

The methodology used in this study, aligned with the ’co-production of knowledge model’, brings scientists together with other citizens at par in the discussions to situate the discourse and identify the current public deficit which is preventing the transformation of the Mauritian society into a scientifically literate populist. In the study, the citizens -irrespective of their socio-economic status, level of literacy, job status, educational background, gender, and age, among others- are not only used as mere respondents but as stakeholders where their views and experiences are valued and taken on-board during the discussions.

In fact, the ‘co-production of knowledge model’ was used as a conceptual tool to capture citizens’ views and to enrich our understanding of the public deficit discourse. Moreover, the ‘sustainability framework’ as shown in Figure 5 below was used to formulate the new discourse based on data derived from the discussions organised in the study.

Figure 5

The Sustainability Framework



Each circle in figure 5 represents one of the constituent dimensions, and their area of mutual intersection is labelled “sustainability”.

Methodology

A: Epistemological stance

This study uses a qualitative approach to frame a controversy or discourse around the current hurdles that are preventing the transformation of the public into a scientifically literate populist. The voices of the citizens were captured using focus group discussions (FGD), and data were analysed to frame and situate the current discourse based on the identified public deficits.

B: Justification of using FGDs

Though there are various qualitative methods that have been used in recent research, the ‘focus group discussion’ was used in this study. In fact, Mansouri et al. (2017) stated that ‘focus group discussion is a valuable method for qualitative researchers. Moreover, Pope et al. (2002) and Vermeire (2002) highlighted that FGD was preferred over personal interviews (another widely used qualitative method) as the discussion with other participants allowed more in-depth exploration of the theme. Participants had the freedom to respond directly to each other until the theme was fully explored or a consensus was reached.

C: Sampling

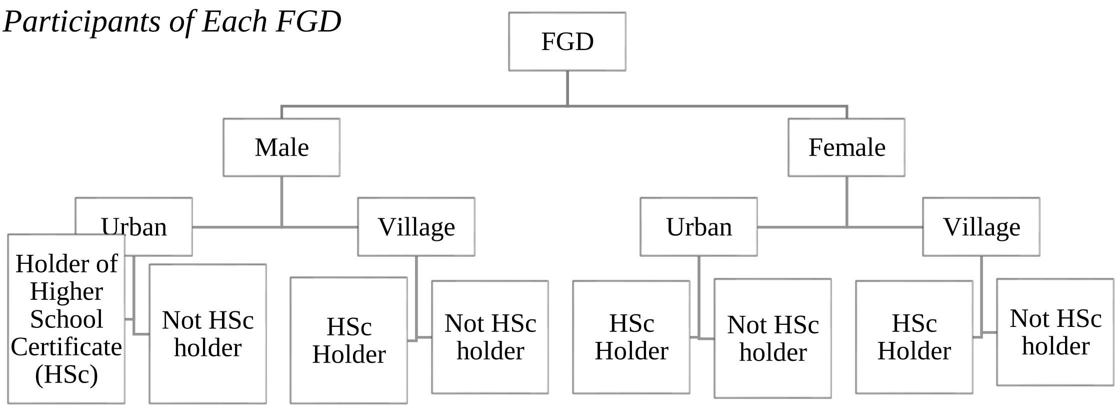
A purposive and systematic sampling procedure was used to select participants for the FGDs. The first step of the selection of participants included the use of the social media platform (Facebook) as a discussion forum. Several posts on the subject, that is, on public understanding of science, were posted on Facebook, and the responses of people were analysed to identify potential participants. Respondents who were actively indulged in relevant discussions were earmarked and short-listed as potential participants for the FGDs. The posts were reinitiated several times to ensure that the forum remained active until enough potential participants were earmarked. The active respondents were then contacted to explain the objectives of the study and to get their approval as potential participants in the FGDs.

The participants were then selected from the pool of active respondents based on (i) their ability to participate in the discussion, (ii) recommendations of colleagues

researchers who analysed their comments as a means of validation, and (iii) the demographic characteristics representative of the Mauritian population including participants of different academic/educational status, science literacy, gender and locations. Figure 6 below depicts the selection of participants for each FGD based on specific demographic characteristics. Eight participants per FGD was a manageable and facilitated recording of data. However, as a means of validating the data and capturing the voices of a larger sample, three FDGs with eight participants, as shown in Figure 6 were organised.

Figure 6

Participants of Each FGD



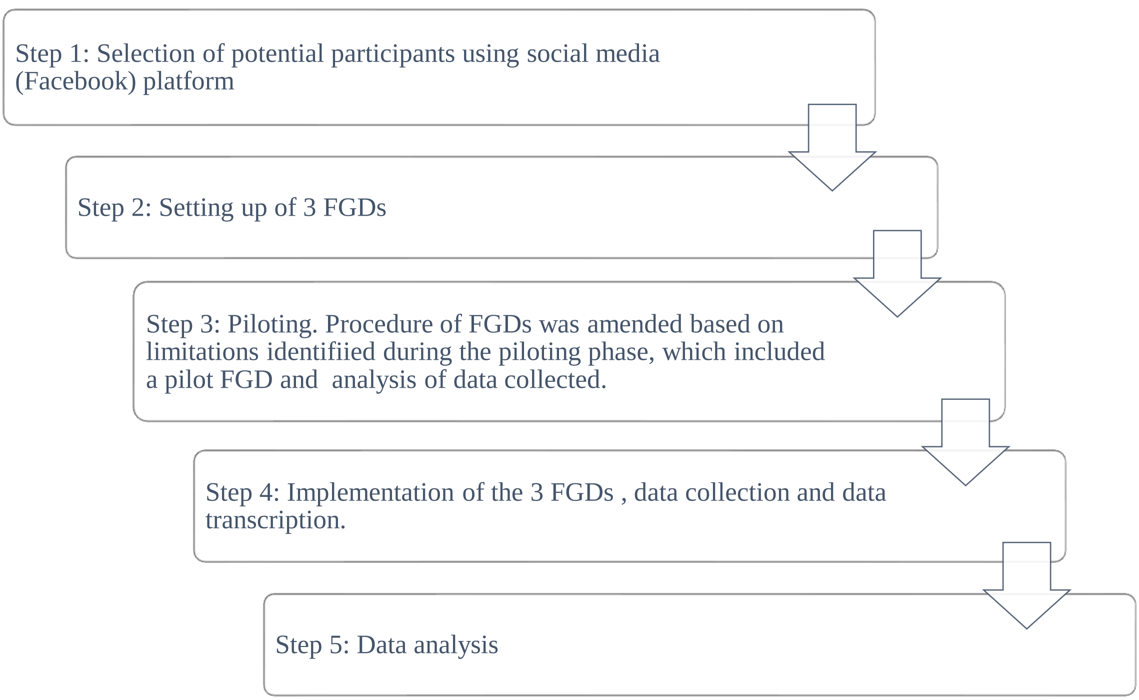
As the theme of the FGDs was centred around science, it was imperative to use purposive sampling to include participants with a scientific background. Thus, in addition to participants without a scientific background, the 24 participants of the three FDGs included students, educators, ministry officials, school administrators, scientists, and lecturers. In fact, to have a real representation of the population, each focus group included both participants with and without scientific backgrounds.

D: Research design

Figure 7 summarises the stepwise research design used in the study.

Figure 7

Research design



E: Implementation of focus group discussions

The FDGs were planned and implemented as follows:

Step 1: **Approval to act as participant in the FGDs**

After selection exercise, the researcher explained the project's aims and objectives, the nature of the research and their right to withdraw at any time. Participants were then given a letter of introduction and a consent form. Participation approval was then sought through signing a consent form before embarking in the focus group discussions.

Step 2: After collection of the consent form, a date for the FGDs was decided and communicated accordingly.

Step 3: Implementation of the FGDs

The three FDGs were organised on the Zoom platform (fully online). Implementation of each FGD started with a welcoming note followed by an explanation of the rules and regulations of the group discussions. This is a crucial step where participants are briefed about the way they interact to ease the discussion and data recording.

The researcher acted as the facilitator while two expert colleagues recorded the data manually as several participants were not agreeable to record the zoom sessions.

Step 4: The data collected were then compared, discussed, amended and validated between the facilitator and expert colleagues before data transcription.

F: Data Analysis (Analysis of transcripts derived from the focus group discussions)

The collected data was organised in the long table and analysed in a systematic, sequential, verifiable, and continuous way as stated by Yin (1989) and Krueger & Casey (2000). In fact, each transcript was examined, categorised as per the emerging theme, and eventually categorised into respective over-arching ideas. Table 1 below shows an example of how the emerging theme and overarching idea were derived from a respondent answer.

Table 1

Long Table Use in Analysis of Respondent Answers in Focus Group Discussion

Answers	Categories	Overarching ideas
T1: The reason why the population cannot be considered scientifically literate is that there is a lack of understanding and using scientific inquiry at the school level. Most students complete their secondary schooling by developing key scientific skills and thus cannot apply what they learnt in school in a real-life situation.	-Lack of inquiry skills -Schools are not successful in transforming people -Science literacy -Deficit	Public Deficit: Skill deficit

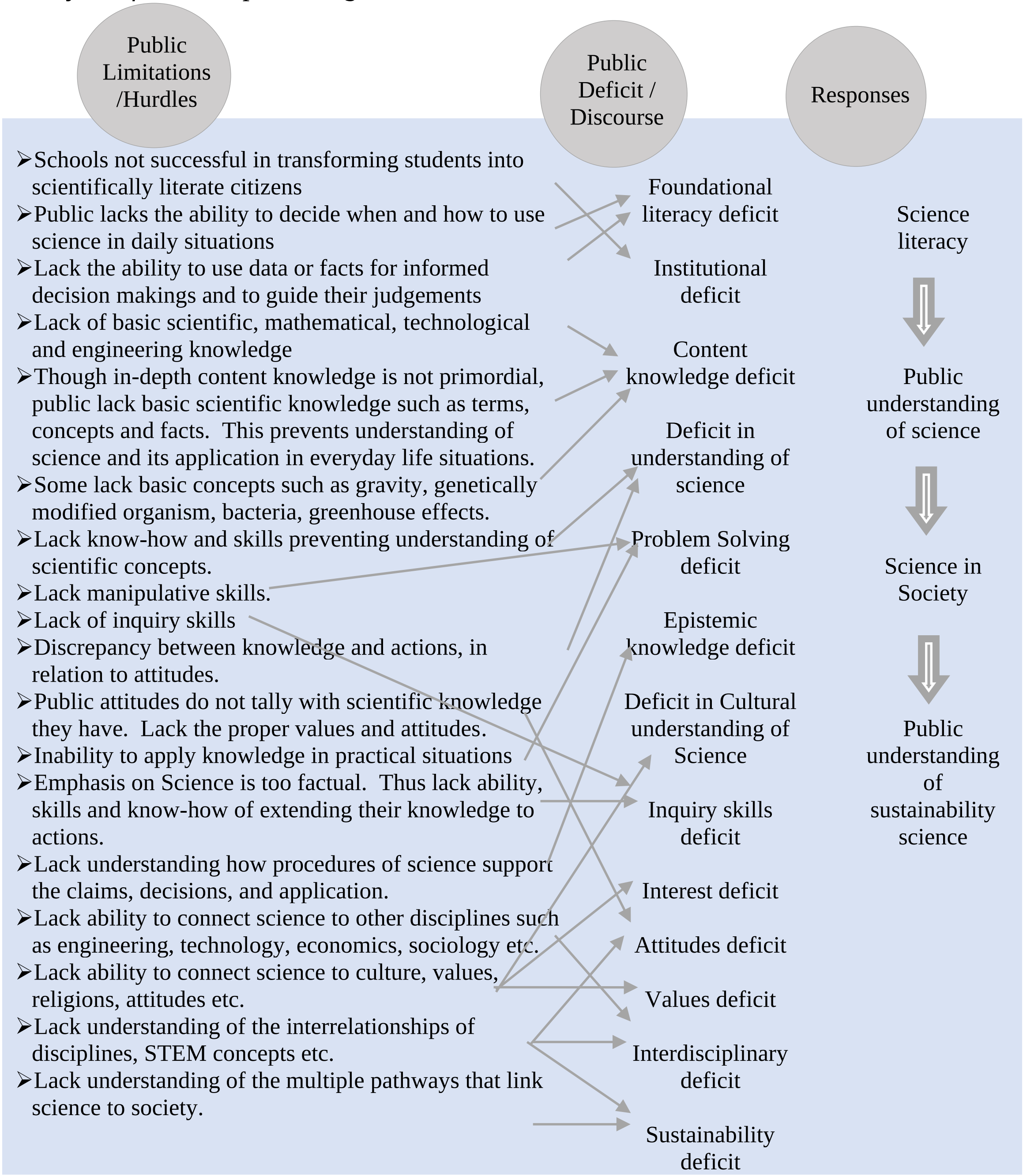
The use of this step is not limited to making sense of the individual quotes or understanding the concept behind the quotes. It also requires analysing the quotes to identify the relationship between them. To reduce subjectivity bias in the analysis and interpretation of the collected data, two colleagues (experts in qualitative research) were asked to recode the transcripts. The emerging themes and overarching ideas were then compared, discussed, and eventually agreed. This method is in line with Stolper et al. (2009) method of reducing bias in qualitative data analysis, which often falls into subjectivity.

Findings

The findings derived from the analysis of participants' transcripts, which emerged from the FGDs, have been compiled as shown in figure 8 below. In fact, the themes/categories and over-arching ideas derived from the interpretations of transcripts (example given in table 1) have been grouped into three discrete sets to align the data collected and analysed, with the objectives and the theoretical frameworks used in this study.

Figure 8

Analysis of Transcripts Emerged From FGDs



The findings were actually categorised into three sets, namely the 'Public limitations', 'Public deficit/discourse' and 'responses' as shown in figure 8. The first set that is 'Public limitations' grouped the hurdles which are preventing the transformation of the current population into a scientifically literate populist. The latter were then analysed and interpreted to identify the overarching discourse or controversy in line with the concept of the public deficit, forming the second set. Moreover, set 3, that is 'responses', grouped the proposals that were made by participants to overcome the discourses so that the population may be successfully transformed into a scientifically literate populist with the necessary knowledge, skills, know-how, attitudes and values needed to face the current and future challenges of the world.

Discussion

Based on data collected through the FGDs and data analysis presented in figure 8, this section comprises a discussion on the (i) Evolution of the discourse with time, (ii) the future of PUS, and (iii) Public understanding of sustainability science.

Evolution of the Discourse

The discourse around the paradigm shift from literacy, via PUS, to Science-in-society, was clearly evidenced in the data collected from the FDGs, which are in line with the findings of Bauer et al. (2007), who analysed data derived from 25 years of PUS survey research. Basically, each of these three concepts that emerged from the FGDs is moved by a societal discourse (Bauer, 2008), attributing a particular deficit in line with Callon's deficit model (1999).In fact, contrary to the rhetoric of polemicists, there is no narrative of progress but one of multiplication of discourses.

In fact, the following statements derived from the FGDs clearly evidenced the first discourse on the limitation of scientific knowledge and ignorance.

> *"….despite a large proportion of the population have completed their basic education due to free access to education, their science literacy is limited to the content knowledge developed during the science subjects lessons…" (FGD 1, participant 4)*

> *"…….the large percentage of the educated population remains scientifically illiterate"…. (FGD 2, participant 1)*

"……completing basic school science education does not transform people into a scientific literate person…many remains scientifically ignorant" …. (FGD 3, participant 7)

Actually, this discourse is dated back to the early 1960s, which was later explained by Jon Miller (1983, 1987, 1992, 1998), who highlighted that this literacy idea attributed a knowledge deficit to the public, calling for increased efforts in science education where scientific facts and cognitive knowledge became the key to success. The aim was to produce a literate scientific populist with informed citizens, where the lay people have the basic scientific knowledge to face current challenges and to indulge in current debates and decision makings. In the quest to transform the population into informed science-literate citizens, the role of the school was challenged and reviewed to provide students with learning opportunities that develop scientific skills in addition to knowledge.

The following selected statements that emerged from the participants of the FGDs were aligned with the existing discourse leading to the paradigm shift from science literacy to PUS.

"…… the current and future challenges, such as climate change, the emergence of epidemics, and energy crisis, cannot be faced only by scientific knowledge and scientists. Scientific attitudes are crucial. To face such challenges, the common people need to understand the implications of our acts. Actually, attitude is directly linked to an understanding of science…." (FGD 1, participant 3)

".....in addition to producing scientists, doctors, and engineers, we have a moral responsibility of educating the common people to develop knowledge, skills and attitudes needed to face current and future challenges…" (FDG 2, participant 7)

"……the education system should produce science-literate citizens with the appropriate scientific knowledge and attitudes capable of bringing the necessary advances in science and technology…" (FDG 2, participant 6)

In fact, the competition for more factual knowledge and enhanced science literacy was maintained till the second half of the 1980s, when new concerns emerged under the title of 'public understanding of science'. This transition was marked by the influential report of the Royal Society of London (1985), which stated that the public does not show sufficient support for science. The Society took the view of many of its members and assumed that better knowledge would be the driver of positive attitudes. Thus, the research agenda moved away from knowledge to that of attitudes, which is fore-grounded in the concept of PUS. Unlike the previous concept of science literacy, the public deficit is not on knowledge but on attitudes. Through the PUS, the focus is on the (a) understanding of scientific concepts rather than remembering of facts, (b) application of science, and (c) development of 21^{st} century and inquiry skills and (d) development of proper attitudes (Daamen & VanderLans, 1995; Einsiedel, 1994; Evans & Durant, 1995).

However, the concept of PUS and the public deficit model of attitude deficiency were challenged during the 1990s. The discourse around the deficit model shifted from attitude deficiency to trust deficiency. On the basis of today's debate on positive and negative attitudes of people in the society, the participants challenged the concept of PUS, supporting the paradigm shift from PUS to 'science-in-society' described by Miller (2001) and Bauer et al. (2007). Evidence of negative attitudes to science, such as testing of GM foods in poor African countries, use of harmful biological weapons and food crises, led to the diagnosis of a 'crisis of confidence', where science and technology stand in a relationship with society. The discourse between society and science led to the concept of science-in-society, where the focus is on planning interventions to reverse the deficit of trust.

The Future of PUS

Examination of the findings of this study and the existing debates and discourses around PUS using the lens of the 'public deficit theory', 'public debate model' and the 'co-production of knowledge model', we posit that the concept of PUS will undoubtedly require some reengineering in the future.

In fact, the previous decades witnessed the paradigm evolution from 'scientific literacy' to 'PUS, where the former was based on the public deficit in **knowledge** and the latter on the deficit in **attitudes**. Presently, with the discourse of public deficiency in **trust**, the current decade is testifying to the evolution of 'PUS' to 'science in-and-of society'. The emergence of this paradigm may be explained by the fact that the public has lost faith in science due to its misuse by some powerful few and the wrong attitudes of the public towards science. For instance, science is being used as a destruction tool to harm others in different parts of the world. Thus, the concept of 'science in-and-of society' emerged to restore the trust in science in terms of its benefits to society and the common people. Consequently, the key question is now: How to rebuild the trust?

Most researchers in the field believe that trust may be restored by actively involving the public in activities which connect science to society**.** The agenda of 'science in-and-of society' is, in effect, grounded on **actions** (Bauer et al, 2007). However, it would be unfair to conclude on the note that PUS is a passive phase that needs to be replaced by 'science in-and-of society', which presents an active standard. In fact, the focus of 'PUS' has never been limited to 'data capture' to understand and situate the current public understanding of science. PUS also has the important objective of providing activities to bring science closer to the public (Miller, 2001). However, in most contexts, the latter was reduced to extra- and co-curricular activities at the level of schools, such as educational tours, visits to museums and science competitions. Despite the dual meaning, PUS has therefore been reduced to a data capture exercise only. This led to people losing trust and interest in science and the agenda of PUS, leading to the emergence of 'science in-and-of society' as a new paradigm. However, the second school of thought explained that the 'science in-and-of society' is not in an approach of replacing the agenda of PUS, but to further the concept of PUS by laying more emphasis on interventions and actions in addition to data capture and analysis (Bauer, 2008). The focus is on public deliberation and participation where activities such as hearings, citizens juries, national debates, opinion polling, 'tables rondes', conferences and science quests, competitions and festivals are organised. Through this agenda, the public is engaged in understanding and developing scientific knowledge, know-how, skills, attitudes, and trust.

Though a laudable move to overcome the public deficit in trust, the agenda of 'science in-and-of society' is currently being challenged, leading to new discourses. The questions that are presently arising are (a) What is the effectiveness of such interventions in building back the trust in science? (b) What is the cost-effectiveness of such interventions? (c) Do such costly events not compromise the concept of trust? (d) Are there any unintended consequences that are better avoided? (e) How are these interventions overcoming the public deficiencies in knowledge, attitudes, and trust? and most importantly (f) How are such interventions benefitting the society and the common people? and (g) Are such interventions not targeting members of the public who are well versed in science instead of the common people?

Such interrogations indicate that the agenda of ‘science in-and-of society’ has been unsuccessful in overcoming the public deficit in trust. Moreover, in the actual conjunctures of major environmental, economic, social, and political crises, the agenda of ‘science literacy’, ‘PUS’ and ‘Science in-and-of society’ as discrete components do not suffice to overcome the public deficits. Today, the debate is on how scientific knowledge, know-how, skills, attitudes, and values may enhance the life of the common people, society, and our environment in an integrated and sustainable manner. The interrogations and crises legitimately pave the way toward a new discourse on public deficiency in ‘sustainability science’. In fact, the following statements that emerged from the FGDs support this new discourse of a paradigm shift from PUS and ‘Science in-and-of society’ to PUSS, that is, public understanding of sustainability science’, which is based on **sustainable and integrated actions**.

> *“………the transformation of the current society into one which is based on social justice and sustainability will only be shaped if knowledge, attitudes, trust, and actions are brought together in an integrated and holistic approach….” (FGD 1, participant 5)*

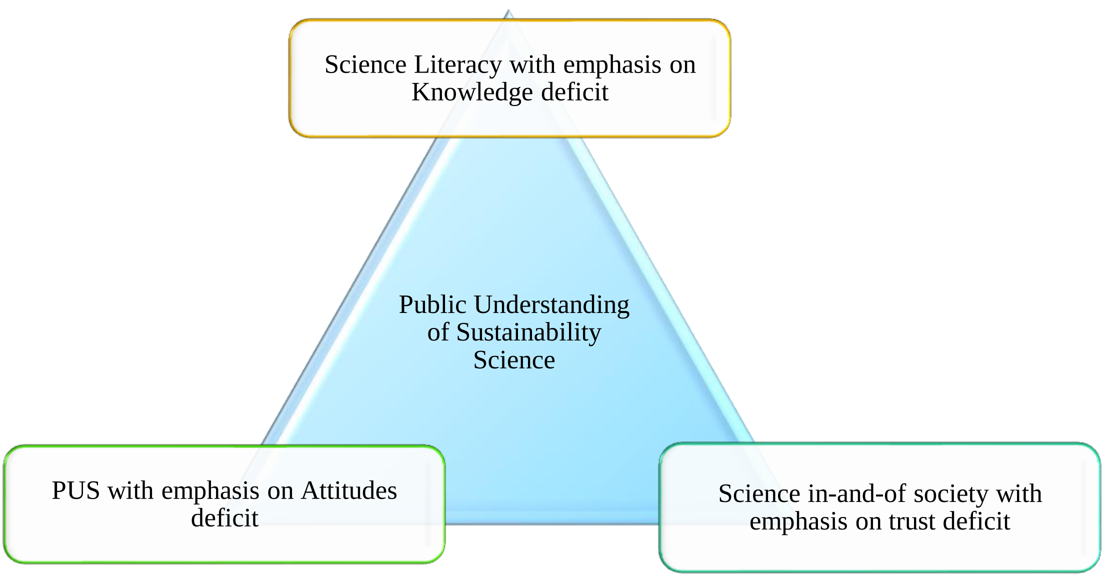
> *“…….just like society has several dimensions such as economic, environmental, cultural, and political, among others, the lay public should reflect these dimensions. This can only be shaped if the focus of understanding science is grounded in the concept of sustainable development…”(FGD 1, participant 8)*

> *“… the progress of a society cannot be achieved by the discrete emphasis on knowledge, attitudes, trust and actions. Challenges should be analysed and solved using integrated and sustainable approaches…” (FGD 3, participant 1)*

In fact, this study showcases a paradigm shift as a response to the current discourses of public deficit towards ‘sustainability science’. However, the proposed shift will be far from the chronological paradigm shifts where the latter supersede the former. The new paradigm will have an integrated approach where the public deficits in knowledge, attitudes, trust, and sustainability are not discretely targeted. The paradigm will have an integrated and sustainable approach targeting the different public deficiencies in a holistic manner. The agenda will accompany the existing concepts of 'science literacy', 'PUS', and science in-and-of society, instead of replacing them. This scenario will prove to be more beneficial as the public deficiencies in knowledge, attitudes and trust have never completely subsided and tackled to date. In fact, to be able to restore the image of science and gain the trust of the public, the amalgamation of the three concepts as a whole is needed. Figure 9 is a schematic representation of how the concepts of 'science literacy', PUS and 'Science in-and-of society' may be merged to coin a new concept termed **'Public Understanding of Sustainability Science', PUSS.**

Figure 9

Public Understanding of Sustainability Science



Public Understanding of Sustainability Science (PUSS)

i: What is PUSS?

To understand the concept of PUSS, it is imperative to capture the meaning of 'public', 'understanding' and 'sustainability science'. As explained earlier, the term 'understanding' lays emphasis on comprehension and application of knowledge instead of mere remembering of facts, while the term ‘public’ focuses on the understanding of the concept of ‘sustainability science’ by the non-scientific common people. Finally, ‘Sustainability science’ is the science that is primarily use-inspired, with significant fundamental and applied knowledge components and commitment to moving such knowledge into societal action (Robert Kates, 2012).

Thus, the focus of PUSS is to ensure that the common people understand the concept of ‘sustainability science (SS)’ and can transform their actions for the benefit of the society through the application of scientific knowledge, know-how, skills, attitudes and values. Unlike the concepts of ‘science literacy’, ‘PUS’ and ‘science in-and-of society’, PUSS addresses the discourses of the public deficiency in knowledge, attitudes, trust, and sustainability, in line with the public deficit theory. In addition to the perspective of social research, where data on public understanding and perceptions of ‘sustainability science’, PUSS will focus on bringing the concept of sustainability science to the common people.

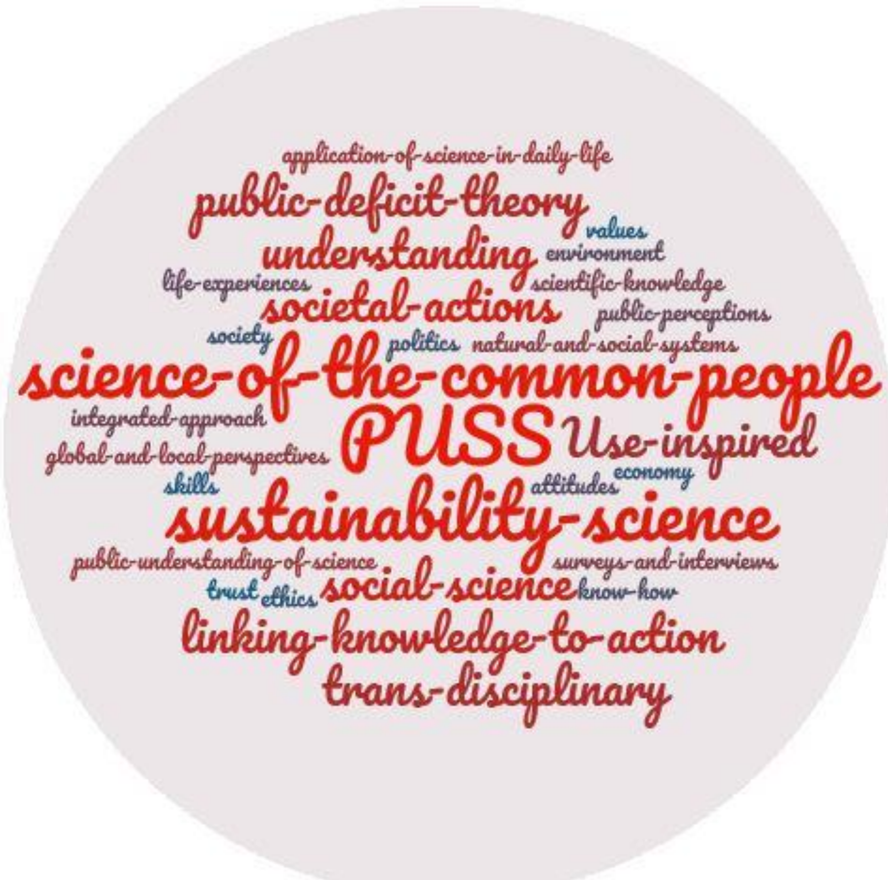
PUSS is a ‘move’ and a ‘mode of life rather than a concept. The main aim of PUSS is to ensure the engagement of the common public in applying their scientific knowledge, know-how, skills, and attitudes in all spheres of life, including the environment, economy, society, and politics, in a trustworthy way. PUSS as a move will not only cater for the current discourses and public deficits in science. It will bring people together to face future challenges in line with the concept of sustainability.

ii: Elements of PUSS

The elements of PUSS, represented in figure 10 as a word cloud, form the basis of the PUSS agenda. The elements are the key concepts that inform the different stakeholders including the policymakers, so that relevant and effective policies and action plans are developed. However, the elements are not part of an exhaustive list, and amendments will be accommodated during the journey of making PUSS an effective mode of life.

Figure 10

Word Cloud of the Key Elements Associated With the Concept of PUSS



The size of letters is proportionate to the level of implications of the concept to PUSS.

Way Forward and Conclusions

As a first step towards the agenda of PUSS, action plans based on the following objectives may be planned at the country level.

i. To amend the existing instruments to capture 'public understanding of sustainability science'.

ii. Implement the data capturing instruments as a diagnostic and formative tool, where the data are analysed to (a) understand and situate the public understanding of sustainability science and related public perceptions and (b) monitor the progress of PUSS.
iii. To set multileveled action plans (based on data analysis) to ensure that PUSS becomes the new mode of life of the common people.
iv. To develop continuous monitoring of the progress of PUSS and bring appropriate amendments wherever needed.

This study brings forwards the voices of different stakeholders of the public to examine and reflect on the existing discourses around the paradigm shift from 'science literacy', PUS, and 'Science-in-and-of society'. Based on the discussions, a new paradigm shift coined Public Understanding of Sustainability Science (PUSS) was proposed. PUSS, which posits the need for the common public to understand sustainability science, targets the transformation of the current society into one which is based on social justice. PUSS bring knowledge, attitudes, trust, and actions together in a holistic and integrated approach to face current and future challenges.

As the present study deals with public perceptions, a multifaceted knowledge management framework is necessary to connect all core arguments. Information availability and information filtering (with reasoning and trust) based on the current mindset (both individual and collective levels) are two fundamental aspects. In brief, these represent the "knowing" and "understanding" dimensions of how the public views science. Furthermore, a large-scale and complex information process to change public perceptions should be considered on three sides: within-discipline (e.g. scientific research and experts on PUS), out-of-discipline (e.g. open-mindedness and collaborations with other fields), and disciplined process (e.g. misinformation monitoring and regulation). These are the necessary basis for achievable sustainability.

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